

CHAPTER 10

THE NETWORK DEVELOPMENT LIFE CYCLE

Concepts Reinforced

Top-down model
Business process reengineering

Cost/benefit analysis

Concepts Introduced

Network development life cycle
Comprehensive systems and networking budget model
Integrated computer assisted network engineering
Network analysis and design methodology

Physical network design
Logical network design
Total cost of ownership
Return on investment
IT project portfolio management

OBJECTIVES

Upon successful completion of this chapter, you should:

1. Understand how the network development life cycle (NDLC) relates to other systems development architectures and life cycles and, consequently, how the network analyst/designer must interact with analyst/designers involved in these related processes.
 2. Understand the network development life cycle including: overall issues, process structure, detailed activities for each step of the process, coping with the reality of today's multiprotocol, multivendor environments.
 3. Understand how one remains focused with a business perspective throughout the network development life cycle.
 4. Understand what automated tools are available to assist in the NDLC process as well as the cost justification necessary for the acquisition of such tools.
 5. Understand the current shortcomings of these automated tools as well as possible proposals for solutions to these shortcomings.
 6. Understand the role of vendors at various stages of the NDLC and how to maximize the effectiveness of these vendors.
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■ INTRODUCTION

This chapter is perhaps the most important chapter in this entire book. Although a process-orientation and top-down approach have been taken throughout the entire text as data communications concepts and technology have been introduced, the focus of this chapter is solely on the data communications process known as the network development life cycle. All of the concepts and technology mastered in previous chapters will serve as available resources for the actual network development process outlined in this chapter. Simply stated, this chapter should tie together much of the material covered to this point in the text, which talked *about* data communications by explaining how to *do* data communications.

In addition, this chapter provides a business context for the technically oriented network development life cycle. Important concepts such as alignment of IT projects with strategic business initiatives and the calculation of total cost of ownership and return on investment are stressed.

This chapter does not include instruction in network traffic engineering. Although this is an introductory text, an appropriate level of complexity will be presented for the more technical aspects of network design. Reemphasizing the practical aspect of this chapter, techniques for effective interaction with consultants and vendors who possess the technical expertise to perform network traffic engineering are stressed.

■ WHERE DOES NETWORK DESIGN FIT IN OVERALL INFORMATION SYSTEMS DEVELOPMENT?

To be able to fully understand the importance of a properly designed network to a smoothly operating information system, one must first understand how the network design process relates to other information system development processes. The top-down model, which has been a constant strategic framework throughout the text, is an appropriate way to portray the relationship between the network development process and other information systems-related development processes. This relationship is illustrated in Figure 10-1.

As can be seen in Figure 10-1, the network development life cycle depends on previously completed development processes such as strategic business planning, applications development life cycle, and data distribution analysis. If an implemented network is to effectively deliver the information systems that will, in turn, fulfill strategic business goals, then a top-down approach must be taken to the overall information systems development process, as well as to the network development life cycle.

Cooperative Application and Network Development

As applications have been increasingly deployed on a globally distributed basis over network links of limited bandwidth or uncertain reliability, it has become essential for application developers and networking specialists to work more closely together during the early stages of the application development process. Automated application monitoring and simulation tools discussed later in the chapter are now available to show application developers how distributed applications will actually perform

Top-Down Model	Information Systems Development Process
Business	<ul style="list-style-type: none"> • Strategic business planning • Business process reengineering
Application	<ul style="list-style-type: none"> • Systems development life cycle • Systems analysis and design • Application development life cycle
Data	<ul style="list-style-type: none"> • Database analysis and design • Database distribution analysis
Network	<ul style="list-style-type: none"> • Network development life cycle • Network analysis and design • Logical network design
Technology	<ul style="list-style-type: none"> • Physical network design • Network implementation • Technology analysis

Figure 10-1 The Top-Down Model and the Network Development Life Cycle

over a variety of different network conditions. In this manner, application developers and networking specialists can cooperatively ensure that applications are developed in a proactive manner with assurance that the deployed application will operate successfully and meet stated business objectives.

Understanding Systems Development: Process and Product

Two key components to any systems development effort are the **process** and the **product** of each stage of that development life cycle. Simply stated, the process describes activities that should be taking place at any point during the development cycle, and the product is the outcome or deliverable from a particular stage of the overall cycle.

A focus on the process allows one to visualize what they will be or should be doing at any point in the development life cycle. The product, meanwhile, could be interpreted as a milestone or deliverable, indicating completion of one stage of the development cycle and a readiness to proceed with subsequent stages.

A focus on product and process facilitates understanding of any systems development life cycle, not only the network development life cycle. Alternatively stated, by staying focused on the questions: “What are we supposed to be doing?” and “How will we know when we are done?” we are more likely to be productive. Identification of process and product can be beneficial on high-level or summarized development cycles as well as on more detailed methodologies. Figure 10-2 takes the high-level processes identified in Figure 10-1 and lists possible products, or outcomes, from each of the corresponding processes.

Figure 10-2 clearly points out the need for significant analysis and design, and associated products or deliverables, before the commencement of any network analysis and design activities. As has been stated many times in this text, network analysis and design cannot be successfully performed in a vacuum. Rather, network analysis and design is but one step in an overall comprehensive information systems development

Information Systems Development Process	Product or Milestone
Strategic business planning Business process reengineering	<ul style="list-style-type: none"> • Strategic business plan • Long-range business goals • Business process models, methods, or rules
Systems development life cycle Systems analysis and design Application development life cycle	<ul style="list-style-type: none"> • Information systems design • Applications program design
Database analysis and design Database distribution analysis	<ul style="list-style-type: none"> • Database design • Database distribution design
Network development life cycle Network analysis and design Logical network design	<ul style="list-style-type: none"> • Network requirements document • Network design proposal
Physical network design Network implementation Technology analysis	<ul style="list-style-type: none"> • Detailed network diagram • Network product specifications • Network circuit diagrams

Figure 10-2 Understanding Systems Development: Process and Product

cycle, commencing with business layer analysis and concluding with an analysis of the technology currently available to implement the system as designed.

■ THE NETWORK DEVELOPMENT LIFE CYCLE

The key model behind the network design process is known as the **network development life cycle (NDLC)** as illustrated in Figure 10-3.

The word “cycle” is a key descriptive term of the network development life cycle as it clearly illustrates the continuous nature of network development. A network designed “from scratch” clearly has to start somewhere, namely with an analysis phase.

Existing networks, however, are constantly progressing from one phase to another within the network development life cycle. For instance, the monitoring of

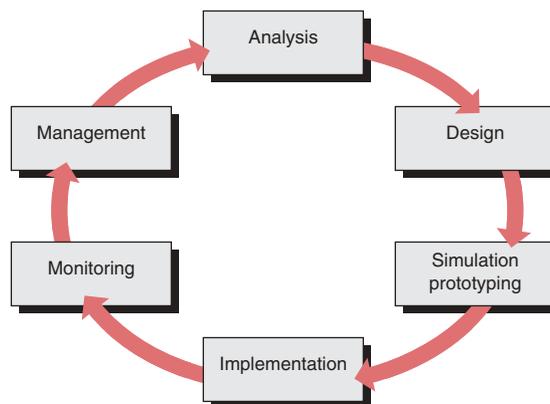


Figure 10-3 Network Development Life Cycle

existing networks would produce management and performance statistics perhaps using a network management protocol such as SNMP. Qualified network analysts would then analyze these performance statistics of this existing network. Design changes may or may not be implemented based on the analysis of these performance statistics. As will be described later in the chapter, network designs may be physical or logical in nature. **Physical network designs** involve the arrangement and interconnection of the physical network circuits and devices, whereas **logical network designs** involve configuration and definition of services that will run over that physical network such as addressing schemes, routing schemes, traffic prioritization, security, and management. Many times, proposed network design changes are first simulated using sophisticated network simulation software packages or prototyped in a test environment, safely removed from a company's production network, before being deployed or implemented.

This cycle of monitoring, management, analysis, design, simulation, and implementation is ongoing. Just as demands on a network are in a constant state of change due to changes in business, application, or data requirements, so must the network design itself be of a dynamic nature to successfully support these changing requirements. The network development life cycle serves as a logical framework in which this dynamic network design is able to thrive.

■ STRATEGIC ALIGNMENT OF THE NETWORK DEVELOPMENT LIFE CYCLE

It is important to understand the business-oriented nature of the environment in which the network development life cycle must operate. Network design projects are not undertaken at random or on the whim of any network manager. Rather, network design projects must be aligned with strategic business initiatives and/or the strategic development of the overall corporate IT infrastructure. Figure 10-4 illustrates the overall alignment of the network development life cycle with strategic business and IT infrastructure initiatives.

IT Project Portfolio Management

All networking projects or IT projects are not of equal strategic importance to the enterprise. Some projects may depend on other projects. Some projects may be focused on basic infrastructure improvements, whereas others may be tied to specific business units or projects. Funding for network projects is limited and must be budgeted with a view toward those projects that can have the greatest positive impact on the enterprise and that are most closely aligned with corporate business strategy and the overall strategy of the IT infrastructure. Given the multitude of projects seeking funding, today's chief information officer (CIO) often views individual projects as potential investments and the sum total of all potential projects as a project portfolio, much like a stock portfolio. Some percentage of investment must be with "blue chip" conservative projects with more likely but more modest returns, whereas another percentage of investment must be with more risky projects with potentially greater payback to the enterprise. Determining how much to invest in which types of projects is a difficult job with serious consequences.

From a strategic process standpoint, as illustrated in Figure 10-4, a given network design project must be aligned with the overall strategic plan of the IT infrastructure as a whole, as well as with the strategic business initiatives of the

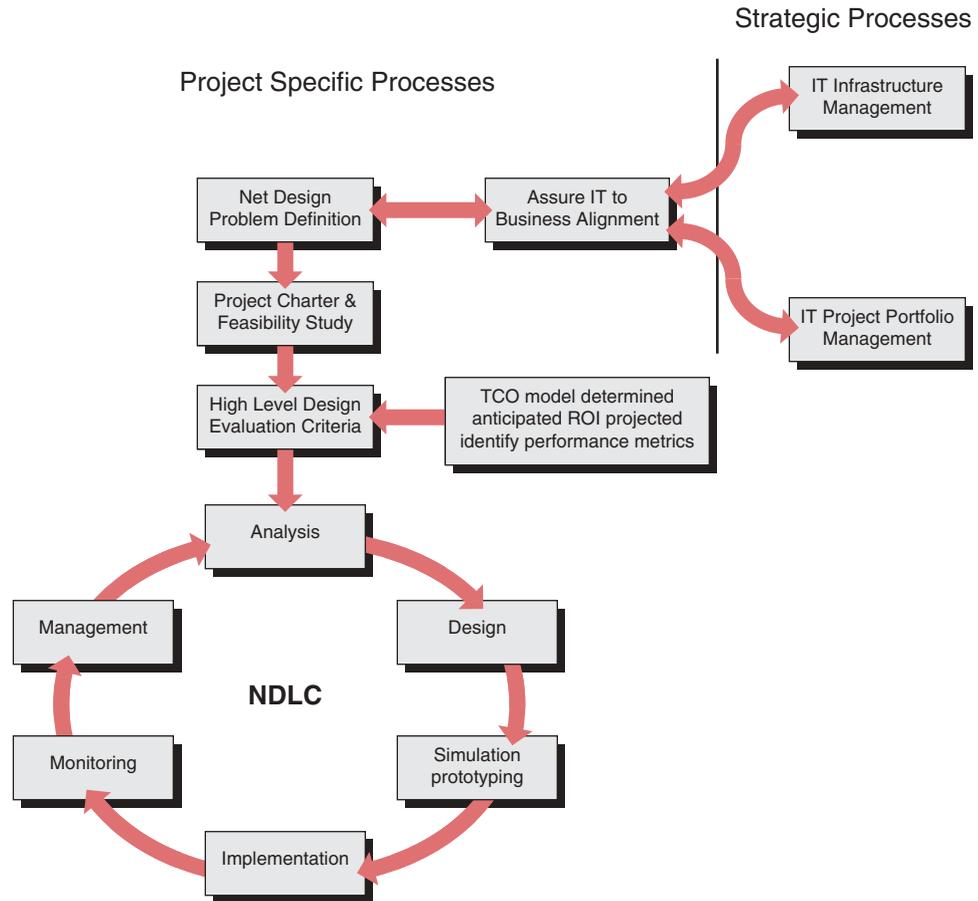


Figure 10-4 Alignment of Network Design Projects with Strategic Business and IT Infrastructure Initiatives

corporation. A process known as **IT project portfolio management** often manages the overall strategic development direction of the IT infrastructure. In such a process, all potential IT-related projects from component architectures such as network, application development, computing platforms, or data management are evaluated for potential support and funding. In today's business climate, it is simply unrealistic for all IT-related projects to be funded. Tough choices must be made according to a defined process using justifiable criteria. The exact process used for IT portfolio management varies from one organization to another. Some processes are more quantitative and others are more subjective. Figure 10-5 illustrates one potential strategy for IT portfolio management.

As illustrated in Figure 10-5, the two criteria chosen in this case to evaluate potential IT projects are "alignment with business initiatives" and "projected return on investment." The actual criteria chosen vary from one situation to another depending on corporate circumstances and priority. Other possible choices include

- Maturity level of technology
- Alignment with current IT infrastructure

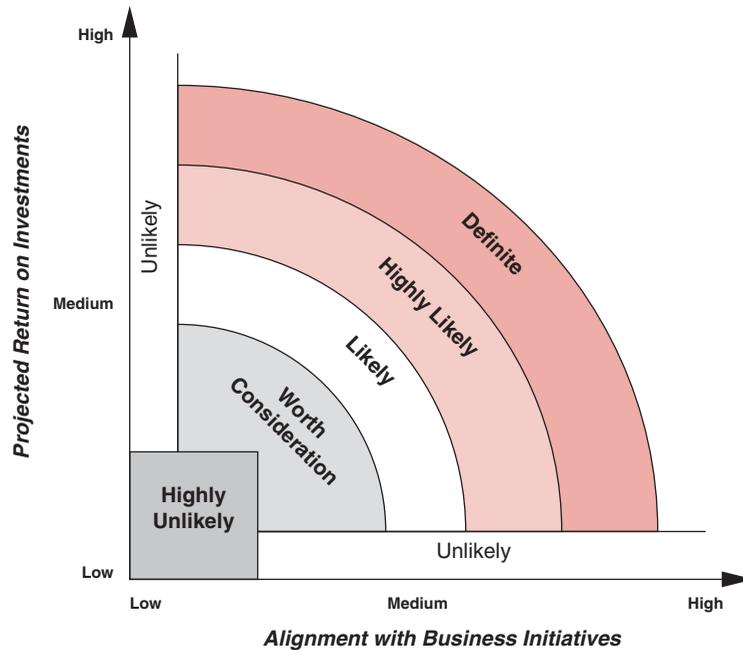


Figure 10-5 IT Project Portfolio Management

- Required support and management
- Initial investment cost
- Long-term expense

Each potential project is evaluated according to each of the chosen criteria in a qualitative manner by assigning a value of low, medium, or high. Quantitative methods can be used as a justification for the assignment of these values. Once each project is evaluated in terms of both criteria, the intersection of those assigned values will place each project in one of the portfolio management ranges of the grid. Again, the exact number, arrangement, and assigned names of each section of the grid will vary by organization. In the example shown in Figure 10-5, this organization has decided that if projects score low in either alignment *or* return on investment, then it is unlikely that these projects will be pursued. Furthermore, any project that scores low in alignment *and* return on investment is highly unlikely to be pursued. Other categories of recommended actions are arranged according to relative strengths of alignment with business initiatives and return on investment.

Project Specific Processes

As illustrated in Figure 10-4, once a project has been deemed as properly aligned with both the overall IT infrastructure and with the strategic business initiatives of the corporation, it goes through a number of project management steps before the initiation of actual network design activity. Each of these project-specific processes and the overall critical success factors are explained next.

Critical Success Factors of the Network Development Life Cycle

Also associated with the overall network development process, rather than with any specific step of the process, are several key behaviors or things to remember that can be of critical importance to the overall successful outcome of the network development life cycle. These **critical success factors** are summarized in Figure 10-6 and explained next.

Identification of All Potential Customers The best source of information for system performance requirements is the people who must use the system most frequently. However, all user groups and levels of management must be consulted during the analysis and design phase to ensure that no individuals or groups feel left out of the development process. Although one would like to think it isn't true, the best designed systems can be doomed to failure owing to the effective internal sabotage of disenchanted users.

Political Awareness At the very least, it is imperative to be aware of the so-called corporate culture of an organization. Corporate culture is sometimes described in terms related to network design. For instance, corporate cultures can be described as "hierarchical" or "distributed" or "open." If the corporate culture of the organization in which a network analyst is working is hierarchical, then it would be a mistake to make an appointment to interview an end-user without first interviewing and seeking approval of the required levels of management. On the other hand, "open-door" corporate cultures are less concerned with hierarchies of authority, thereby allowing quicker and simpler access to end-users.

Critical Success Factor	Explanation
Identification of All Potential Customers and Constituencies	No one likes to feel left out or that his/her input does not matter. It is better to include too many as representative user groups than to inadvertently exclude anyone.
Political Awareness	Awareness of the corporate political environment as well as the overall corporate culture can have a large impact on a project's success.
Buy-In	As each stage is concluded, buy-in or agreement as to conclusions from all effected customer groups is of critical importance.
Communication	Do not assume others know what is going on with the project. Write memos or newsletters, send e-mail, or communicate with key people in person.
Detailed Project Documentation	Document every phone call and every meeting. Keep the project well organized from day one with copies of all correspondence.
Process/Product Awareness	As a simple means of staying focused and on track, keep in mind the process and product for each step in the network analysis and design methodology
Be Honest with Yourself	Be your own harshest critic. Identify weak points in your proposal and address them accordingly. Play "devil's advocate" with your proposal and prepare for the possible objections.

Figure 10-6 Critical Success Factors of the Network Development Life Cycle

Unfortunately, so-called “back room” politics can play an important role in systems design as well. The best researched and planned network design may go unimplemented if the company president’s brother-in-law or golf partner is in the computer business and has a different idea. Sad, but true. The best way to defend against such situations is to first be aware of any such possible political situations. Specific strategies for ensuring the objectivity of the analysis and design process will be highlighted as the overall network analysis and design methodology is described further.

Buy-In All of the critical success factors listed in Figure 10-6 are important. However, one of the most important yet easiest to accomplish is **buy-in**. After having chartered the project and identified all potential customers and constituencies, it is imperative to gain buy-in from each of these groups for the deliverable or product of each stage of the overall network analysis and design methodology.

By reaching consensus on the acceptability of the results or deliverables of each and every stage, one avoids having initial assumptions or work on earlier stages brought into question during the presentation of the final proposal. In other words, the approved results of one stage become the foundation or starting point for the next stage. If buy-in from all affected parties is ensured at each stage, the presentation of the final proposal should be much smoother with a minimum of back-tracking or rework required.

Communication Many of the other critical success factors listed in Figure 10-6 depend on effective communication, both verbal and written. Often in network or systems development projects, it is assumed that because network analysts and designers are aware of the project status, everyone must be fully informed as well. Unfortunately, this is not the case. As previously pointed out, no one likes to feel left out. More important, networks often cross the “territory” or authority of numerous individuals and departments. To keep these people supportive of the project, it is imperative to keep them informed and to make them feel that they are an important part of the process.

Communication can take many forms. Newsletters, project status reports, web sites, and e-mail are all suitable means of keeping people informed and up-to-date. More ambitious communications schemes such as videoconferencing or the production of a VCR tape or CD-ROM might be appropriate for critical tasks, public relations, or training opportunities.

Detailed Project Documentation A project manager must not only manage the overall network analysis and design project effectively with task schedules, project lists, and to-do lists, but also document every aspect of the project. During every conversation, by phone or in person, notes should be entered into a log book indicating such things as date, time, persons involved, topics of conversation, and required follow-up. E-mail messages should be printed and filed. Meetings should be documented in a similar fashion, with agendas and action item assignments included in a project binder as well as being sent to responsible parties and key managers.

Organization of this project documentation is of equal importance. A large binder with several sections for different portions of the project can be a very effective way to be able to quickly access any piece of project documentation required.

This documentation is of particular importance in the latter stages of the project when consultants and vendors become a part of the project. Document everything in writing and take no action on any agreement until it has been presented in writing.

Process/Product Awareness As a facilitator in meetings of end-users trying to define system requirements, it is the network analyst's job to keep the participants focused and the meeting on track. To accomplish this goal, it is important to have a clear understanding of the process involved at that particular stage of the network analysis and design methodology as well as the nature of the product or deliverable that is to be the outcome of this process.

Meetings can easily get off on tangents and aggressive users can easily sway meetings toward personal agendas. By remaining focused on the proper topics of discussion and a clear visualization of the product of that discussion, a facilitator can maximize the effectiveness of the analysis and design process. As the leader of the meeting, it is important not to go overboard on controlling the discussion of the meeting however. With practice and patience, experienced facilitators can direct meetings that foster imaginative solutions and proposals without either stifling creativity or allowing discussion to wander ineffectively.

Be Honest With Yourself One of the greatest advantages of being totally honest with oneself is that no one else knows the potential weaknesses or areas for improvement in a proposal better than the person who wrote it. The difficulty comes when forcing oneself to be totally honest and acknowledging the potential weaknesses in a proposal to either correct them or be prepared to defend them.

Peer review and egoless programming are other systems development techniques employed to identify potential weaknesses in programs or proposals before implementation. Not all weaknesses can necessarily be corrected. Financial or time constraints may have restricted potential solutions. If that is the case, an honest self-review of the proposal will allow one to prepare an objective explanation of such weaknesses in advance.

Critical Success Factors Are Learned Behaviors Although many of the critical success factors listed in Figure 10-6 may seem to be nothing more than common sense, it has been the author's experience that more network analysis and design projects suffer from difficulties caused by a failure to address one or more of these critical success factors than from any other cause of failure. These critical success factors must be applied throughout the entire life of the network development project and are therefore best seen as habits or behaviors, rather than discrete events to be scheduled or planned.

■ NETWORK ANALYSIS AND DESIGN METHODOLOGY

Although the Network Development Life Cycle is useful as a logical model of the overall processes involved in network development, it is not at all specific as to how the various stages within the life cycle are to be accomplished. What is required is a more detailed step-by-step methodology which compliments the overall logical framework as outlined by the Network Development Life Cycle.

The **Network Analysis and Design Methodology** is a practical, high-level, step-by-step approach to network analysis and design and is illustrated in a summarized fashion in Figure 10-7.

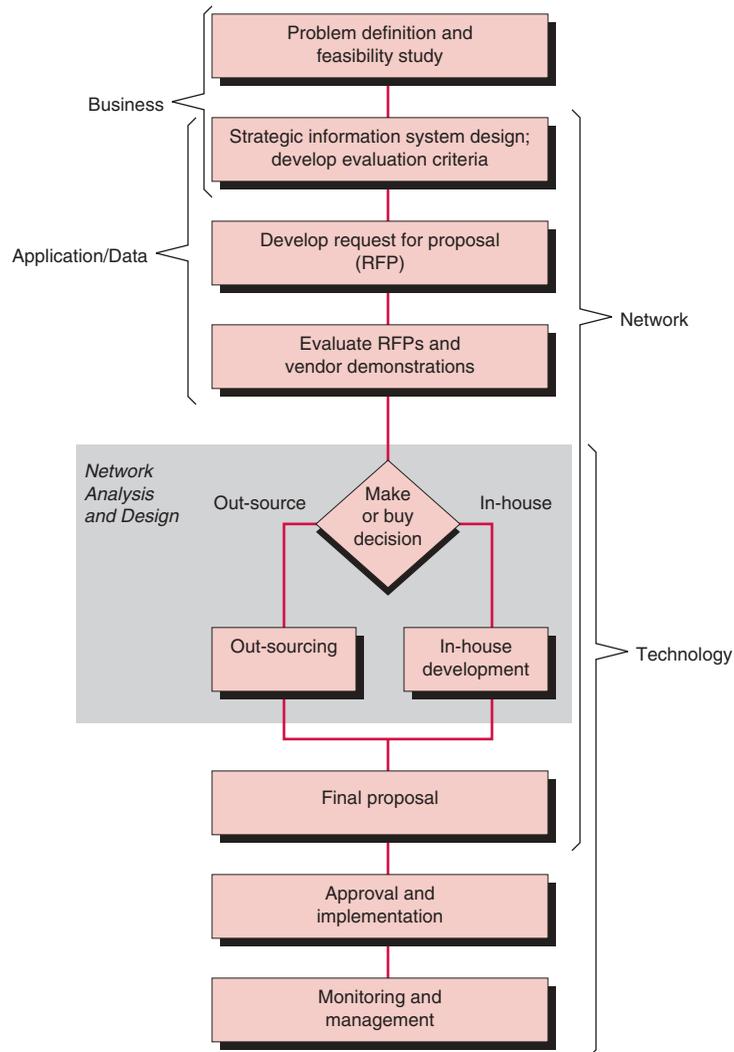


Figure 10-7 Network Analysis and Design Methodology

Overall Characteristics

Before describing each of the major categories of the methodology as illustrated in Figure 10-7 in detail, a few important characteristics of the overall methodology are worth noting.

- First, the Network Analysis and Design Methodology is consistent with previous information systems development models in that business, application, and data requirements definition are prerequisites to network design activities.
- Second, this methodology treats both in-house personnel as well as outside consultants as potential service providers by clearly documenting requirements in a formalized RFP (Request for Proposal) and expecting compliance

with those requirements by whomever may be eventually chosen to perform network development duties.

- Finally, although any diagram of a systems development methodology would indicate that activities are of a serial nature, occurring one after another, with discrete starting and ending points, such is very often not the case. In fact, activities from various stages of the methodology often take place simultaneously. In addition, network analysts often must backtrack to previous activities when new or contradictory information is uncovered as the development process progresses.

Thus, the network analysis and design methodology as illustrated in Figure 10-7 should be looked upon as an overall guideline to the network development process rather than a step-by-step cookbook-style set of instructions.

Net Design Problem Definition

A network cannot very well provide effective solutions to problems that have not been clearly defined in objective terms. To attempt to implement networks before everyone agrees to (buy-in) the exact nature of the problem to be solved is somewhat akin to hitting a moving target. The network will never satisfy all constituencies' needs because no one agreed what those needs were in the first place. All network development efforts start with a problem as perceived by someone, be they management or end-users. At some point, management agrees that a problem exists that is worth expending resources to at least investigate. The responsibility for conducting the investigation may be given to in-house personnel or to an outside consultant or facilitator.

The first job of the facilitator is to identify all parties potentially affected by the perceived problem. Next, representatives of each of these constituencies are selected and convened for brainstorming sessions to determine the nature of the problem and perhaps, the requirements of a solution. To make these problem definition sessions as productive as possible, it is important that representatives do their "homework" before the meetings.

Project Charter and Feasibility Study

To effectively control multiple projects simultaneously in large organizations, it is essential that all projects requiring allocation of manpower, technical, or financial resources be carefully planned. A **project charter** is the mechanism by which a project is organized and initial expectations are documented and agreed on. Network-related projects are likely to interact with numerous business units and other areas of IT such as application development. It is important to get involvement and buy-in from all affected organizations in the form of project sponsorship. When all parties can agree before the project is launched what the expected outcomes of the project are and what it will take to reach those objectives in a given amount of time, then that project stands a much greater chance of success.

Among the sections that could be included in a project charter are the following:

- **Description:** Two or three sentences briefly describing what, why, how, and when this project will be accomplished.
- **Objectives:** Often divided into separate categories of business and technical objectives. Objectives should be measurable and serve as the evaluation criteria for the completed project.
- **Scope:** Often divided into “within scope” and “out of scope” sections to assure that the project remains on target and is not subjected to “scope creep,” where side issues and amendments to the project charter cause the project to lose focus.
- **Phases:** What are the major logical sections of the project? Give some thought as to what must be accomplished in each phase in order to move on to the next phase. This is where initial thought to overall process design for the project is considered.
- **Deliverables:** Can be either presented as overall project deliverables or phase by phase deliverables. What tangible work or documents will the project team actually be producing?
- **Stakeholders and Key Reporting Relationships:** Which departments or business units within an organization or corporation will be impacted by this project? Which departments will have to supply personnel to complete this project? Which individuals have budget responsibility for these departments and will have to approve the participation of team members? Who will provide technical leadership, project management, and technical team participation?
- **Project Schedule:** When will milestones, phases, and overall project be completed?
- **Project Budget:** What is the anticipated budget for the project?
- **Assumptions, Concerns, and Constraints:** Any other issues (technical, business, political) that could have an impact on the project that should be shared with all concerned before project kick-off.
- **Sponsor Approval Signatures:** Executive level approval to proceed with the project as described in the previous charter.

Understand Strategic Business Objectives Once the group has been assembled, it is time to remember the top-down model. To keep the problem definition session and the subsequent solution proposal session on track, it is vital to start with the strategic business goals of the organization as articulated by senior management. Whenever the author consulted as a user group facilitator, he always strived to have either the chief executive officer or chief financial officer (or both) present at the initial meeting to say a few words about the importance of the user group’s work and the strategic direction of the corporate business goals. In addition, if strategic corporate goals had been prepared in writing, these were shared with the group, as allowed by company policy. In this way, the whole group starts off with the same focus and strategic business direction with the proper attitude about the overall process.

Importance of Baseline Data To measure the eventual impact, hopefully positive, of the installed network, one has to have baseline data, or the current status of the system and network, from which to measure that eventual network impact. This baseline data can often be collected from the various customer groups or constituencies of the information system and network who are chosen to attend the problem definition sessions. Depending on the extent, in terms of both geography and sophistication, to which current systems have been implemented, a structured framework may be required to record this systems information in a standardized manner. Fortunately, the top-down model is an excellent example of such a framework. Chapter 11, Network Management, provides more detailed information on the technology and processes involved with network performance baselining.

Top-Down Model Organizes Baseline Data Using the top-down model as a framework for organizing the baseline data to reflect the current system and network status does not necessarily imply that a separate top-down model must be completed for every corporate location attached to the network or that every layer of the top-down model must be filled in for every location. Just enough data should be collected at this point in the network analysis and design methodology to clearly define the problem in measurable terms.

Information that is gathered in the top-down models at this stage should relate directly to the problems as perceived by the user groups. It is hoped that the problems have some business layer impact; otherwise this whole process may be a waste of time. In other words, although the source of the problem may be in the application, data, network, or technology layers, if it has no impact on the business layer, why should time be spent studying it?

Questions should deal with business problems or situations. Once these business problems are identified, the sources of these business problems within the lower layers of top-down model would be subsequently investigated as part of the problem definition process. Conversely, these same lower layers of the top-down model will be redesigned to become the source of business solutions as delivered by the new network.

Feasibility Studies and Buy-In Once sufficient information has been gathered to document the current status of the systems and networks in objective, measurable terms, the required product for this process, the problem definition, has been completed and it is time to ensure buy-in. The problem definition and its associated alternative recommendations for further study are sometimes referred to as a **feasibility study**.

The need for buy-in on a problem definition or feasibility study will vary from one case to another. Much of the need for management buy-in and the associated approval to proceed depend on the nature of the original charge from management.

In other words, if management's initial charge were, "Look into this problem and get back to me," then a feasibility study followed by management buy-in and approval before further study is clearly appropriate. Conversely, if management's charge were, "Figure out what's wrong and fix it," then a formalized feasibility report with formal presentation may not be called for. However, remember one of the key critical success factors—communications. Even if a formal feasibility report is not required, timely management reports should be completed and submitted on a regular basis to keep management abreast of progress and in tune with overall project strategic direction. Figure 10-8 summarizes the key points (process and product) of the problem definition phase.

Process	<ol style="list-style-type: none"> 1. Problem is perceived. 2. Management perceives problem as worth investigating. 3. Management delegates responsibility for problem definition. 4. User/constituency groups are identified and representatives chosen. 5. Representative groups are convened. 6. Senior management commitment and priorities are conveyed to representative group. 7. Representative groups produce baseline data of current system status. 8. Depending on the extent of the current system and network implementation, the top-down model may be used to organize this baseline data into a standardized format. 9. Buy-in.
Product	<ol style="list-style-type: none"> 1. Baseline data describing current system status in objective, measurable terms. Can be organized into multiple top-down models. 2. A formalized feasibility study may be required depending on the initial charge/direction from management.

Figure 10-8 Key Points of Problem Definition and Feasibility Study

High-Level Design Evaluation Criteria

The problem definition phase provided a starting point of baseline data for the new system, and the strategic information systems design provides the operational goals for the new system to attain. Just as the baseline data have to be objective and measurable, so must the evaluation criteria associated with these operational goals.

These goals may have a direct impact on network design when defined in terms such as maximum response time, transactions/second, or mean time between failures. By producing objective, measurable goals or performance evaluation criteria and getting subsequent management buy-in on those goals, one helps to ensure the objectivity of the entire network analysis and design process. For example, if a substandard system is suggested solely because of “back-room” politics, it is simply evaluated against the evaluation criteria as previously agreed on by all appropriate levels of management. Figure 10-9 summarizes the key points of the strategic information system design phase in terms of both process and product.

Total Cost of Ownership

Evaluation criteria based on performance are an important starting point for an overall assessment of a project’s relative success or failure. However, performance criteria consider only whether the project was successful from a technical perspective. It is equally important to consider a project’s relative success from a financial perspective. Cost-oriented evaluation criteria must also be established. Today, IT projects are often evaluated from a financial standpoint in terms of **total cost of ownership**. Total cost of ownership implies that all cost aspects of a project are properly identified including ongoing costs such as support, management, and maintenance. Hidden costs such as those included in budgets other than the IT department are also an important component of an accurate total cost of ownership. Projected total cost of ownership figures should be completed for every proposed project and used as a financially oriented set of evaluation criteria during project development and after project implementation.

Process	<ol style="list-style-type: none"> 1. Review strategic corporate objectives. 2. Define the overall characteristics of an information system that can successfully support/achieve these objectives. 3. Break the overall business down into major functional areas. 4. List the business processes performed under each functional area. 5. Highlight the decision points in the listed business processes and list information required to make informed decisions at each decision point. 6. Highlight the opportunities for improvement in listed business processes and list information required to take advantage of these opportunities for improvement. 7. Prepare performance evaluation criteria. 8. Prioritize the various aspects of the strategic information system as designed. 9. Buy-in.
Product	<ol style="list-style-type: none"> 1. Strategic information systems design. 2. Performance evaluation criteria in objective measurable terms.

Figure 10-9 Key Points of Strategic Information System Design

A **comprehensive systems and networking budget model**, presented in Figure 10-22, would be a suitable instrument for developing a total cost of ownership model for a network development project. Costing models for ongoing network services provided to business units or end-user organizations require a different type of costing model. Such an activity-based costing model is introduced in Chapter 11, as part of the discussion of service management and costing.

Return on Investment

Increasingly, networking and information systems professionals are being called on to quantify the positive impact of their projects and implemented systems in financial terms. A variety of options exist for this quantification. **return on investment (ROI)** is perhaps the most traditional approach to measuring cost/benefit and is well suited to incremental upgrades of existing systems. However, for entirely new or innovative projects, although costs may be accurately projected, projected benefits are more intangible and are far more difficult to quantify in real terms. **Return on opportunity (ROO)** attempts to quantify benefits that may be unanticipated or indirectly related to the immediate investment. This methodology recognizes the fact that improvements in IT infrastructure aimed at one project may enable unanticipated benefits and uses not related to that initiating project.

In a similar manner, **total benefit of ownership (TBO)** tries to quantify the usability and associated benefits of technological options. TBO attempts to quantify productivity increases as well as cost reduction. However, to properly quantify increased productivity, one must first measure current levels of productivity by developing evaluation criteria so that baseline data can be gathered.

Performance Metrics

Performance metrics refer to quantifiable, measurable performance criteria by which the success of an implemented system can be judged. Performance metrics must be

defined in both business terms and IT infrastructure terms. Given that the alignment of a given IT project with a strategic business initiative has already been assured, the performance metrics required to validate that alignment should be able to be defined. Business-oriented performance metrics that reflect the achievement of the intended business outcomes must first be defined. The ability to report on the status of these business performance metrics should be embedded within the components of the IT infrastructure supporting this new initiative.

On a technical level, the performance levels required from each element of the IT infrastructure, in order for the overall system to achieve its business objectives, must be individually identified. Technology-specific performance metrics must be identified for each technical component of the overall system. The definition, monitoring, and management of these performance metrics are part of an area of IT known as service management. Definitions of required levels of service from the IT infrastructure to achieve intended business goals are delineated in service level agreements. Service management and service level agreements are explained further in Chapter 11.

■ DESIGN AND ANALYSIS PROCESSES

Identify Overall System Characteristics

The word *strategic* is used in the context of information systems design to portray the top-down, strategic business goal orientation of the entire information design process. As can be seen in Figure 10-9, the strategic information systems design process starts with a review of the strategic business goals as articulated by senior management.

With these strategic business goals in mind, the next step in the process is to describe the overall characteristics of an information system that could fulfill these strategic business goals. Examples might be the following. To fulfill our corporation's strategic business goals, this information system must:

1. Enable delivery of improved customer service
2. Enable improved inventory control
3. Allow for more flexible pricing
4. Enable shorter shelf restocking cycles
5. Allow for more efficient use of manpower

Many other examples could have been included. The point of these overall characteristics, in terms of the top-down model, is to ensure and specify that the application layer solutions will deliver on the business layer requirements. As can be seen from Figure 10-9, one of the key products of this strategic information system design phase is the performance evaluation criteria. The overall required system characteristics as listed previously serve as one set of evaluation criteria for proposed information systems designs. Other more objective evaluation criteria will be developed further along in the overall design process. However, the importance of the strategic system performance evaluation criteria lies in their ability to measure the extent to which proposed information systems designs deliver on strategic business goals.

Identify Major Business Functional Areas

Once overall system performance characteristics have been established, the overall business can be broken down into large functional areas. These functional areas may correspond to corporate departments or divisions. Examples might include manufacturing, inventory control, project management, customer service, accounting and payroll, and human resources.

In practice, each of these identified major **business functional areas** can be written on a separate large sheet of flip-chart paper and taped over the walls of the room in which the user groups were meeting. It is not important to argue about which functional areas deserve their own sheet of paper at this point. Consolidation and editing take place later in the process.

Identify Business Processes Associated with Each Business Functional Area

Once the major functional areas of the business have been established, the business processes that take place in each major functional area are listed. This presents a wonderful opportunity for **business process reengineering**. Oftentimes, user groups are made up of individuals from various business units who have not had the time to really understand each other's jobs and responsibilities. As business processes are described, brainstorming quickly takes over and problems that seemed deeply imbedded in current systems are solved as new or modified business processes are defined for the new strategic information system design. This process is repeated for every major business functional area identified in the previous step.

It is important for the facilitator of this process to keep the discussions on a fairly strategic level, thereby avoiding lower level implementation issues such as screen design and report layouts. Continuing with the flip chart scenario, each major business functional area should now have its own flip chart(s) with detailed business processes described for each large business functional area.



THE NETWORK ANALYST AND BUSINESS PROCESS REENGINEERING

As current business processes are discussed during the network development life cycle, opportunities abound for improvement of those business processes. It is important, however, to take an organized approach to business process improvement, more popularly known as business process reengineering. Part of that required organized approach hinges on maintaining one's common sense. For example:

- If it isn't broken, don't fix it: In searching for opportunities for improvement, concentrate on the processes that are in the greatest need of improvement.
- How will you know if the new process is better if you never measured how bad the old process was? Baseline data must be gathered to document the performance of current processes before redesign takes place. These same evaluation criteria and methods must be used to evaluate the new processes to objectively evaluate improvement levels.

- Learn from others' mistakes: Pay attention to other business process reengineering efforts, especially those in closely related industries that have failed. What lessons can be learned and what mistakes can avoid being repeated?
- Don't be afraid to admit mistakes: If the reengineered business process does not produce anticipated results based on objective evaluation criteria, don't be afraid to admit the mistake early and make corrections as soon as possible to minimize negative impact.

As information systems and networking professionals are increasingly called on to justify their budgets and corporate contributions in the face of outsourcing alternatives, it is imperative that network analysts understand the importance of a realistic approach to business process reengineering.

Identify Decision Points and Opportunities for Improvement

Recalling that one of the primary goals of a well-designed strategic information system is to deliver the right information to the right decision-maker, the next logical step in the design process is to identify the key **decision points** in all of the documented business processes where decision-makers must make decisions.

Once identified, each decision point is then analyzed as to what information (the "right" information) is required for the decision-maker to make an informed decision at each respective decision point. This analysis process often brings out the fact that decision-makers are getting much more information than they need to make informed decisions. Entire reports hundreds of pages long may contain only one or two pieces of information that are of critical importance to a decision-maker at any given decision point.

One of the key areas in which user group members can contribute is in the identification of **opportunities for improvement** that can be enabled by this strategic information system design. Opportunities for improvement may imply improvement in any one of a number of areas: financial, productivity, inventory control, accounts receivable collections, customer service, customer satisfaction, repeat customers, employee retention, etc.

The important thing to remember is that if these opportunities for improvement support the strategic business goals of the corporation then they should be identified along with the information required to turn these opportunities into reality. Figure 10-10 illustrates the relationship of the various processes described thus far in the strategic information system design.

Prioritization

Once the strategic information system has been designed as described previously, priorities can be assigned to each of the major functional areas, business processes, decision points, and opportunities. These priorities may assist in the evaluation process by identifying those systems that exhibit the most important elements of the strategic information systems design. A simple yet effective approach to systems design prioritization is known as the **three-pile approach**. In this prioritization scheme, there are only three priorities, defined as follows:

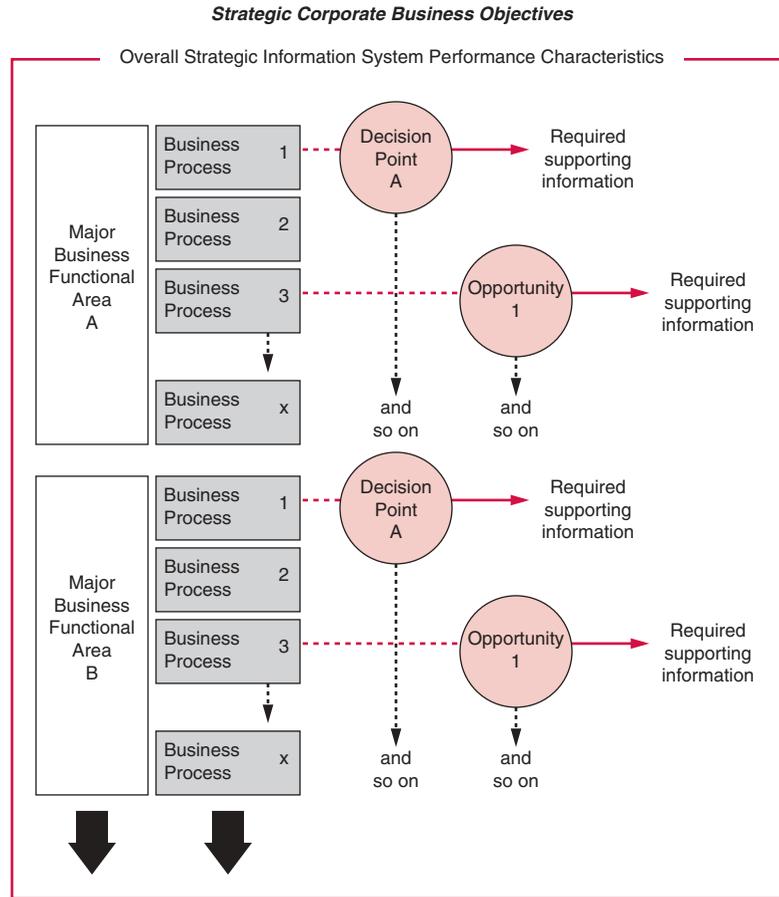


Figure 10-10 Process Relationship of Strategic Information System Design

- Priority 1 items are so important that the system is simply not worth implementing without them.
- Priority 2 items can be lived without or “worked around” but really need to be implemented as soon as possible.
- Priority 3 items would be nice to have but can be lived without.

One important point to remember is that these priorities should be considered in terms of business impact. At this point, a strategic, or high-level, information system design has been completed. Many details need to be added to this requirements document before proposals can accurately reflect their ability to meet not only the business and application layer system requirements, but the data and networking requirements that must support this strategic information system as well.

Finding and Managing Required Technical Talent

Once a clear understanding of system requirements and evaluation criteria have been established, the next major task is to find the technical talent required to produce the designed system. This talent may be either in-house or may be hired from the outside, often referred to as outsourcing. The overall process for finding system development talent is illustrated in Figure 10-11 and explained in the following sections.

Request for Information (RFI)

Before sending out a detailed request for proposal to numerous potential vendors, it is often prudent to narrow the field of potential respondents by issuing a **request for information (RFI)**. The purpose of an RFI is to gather enough information about potential vendors that they can be quickly and easily evaluated as to their suitability for further consideration. The RFI should be easy to comply with for the potential vendors and easy to evaluate the responses from for the corporation issuing the RFI.

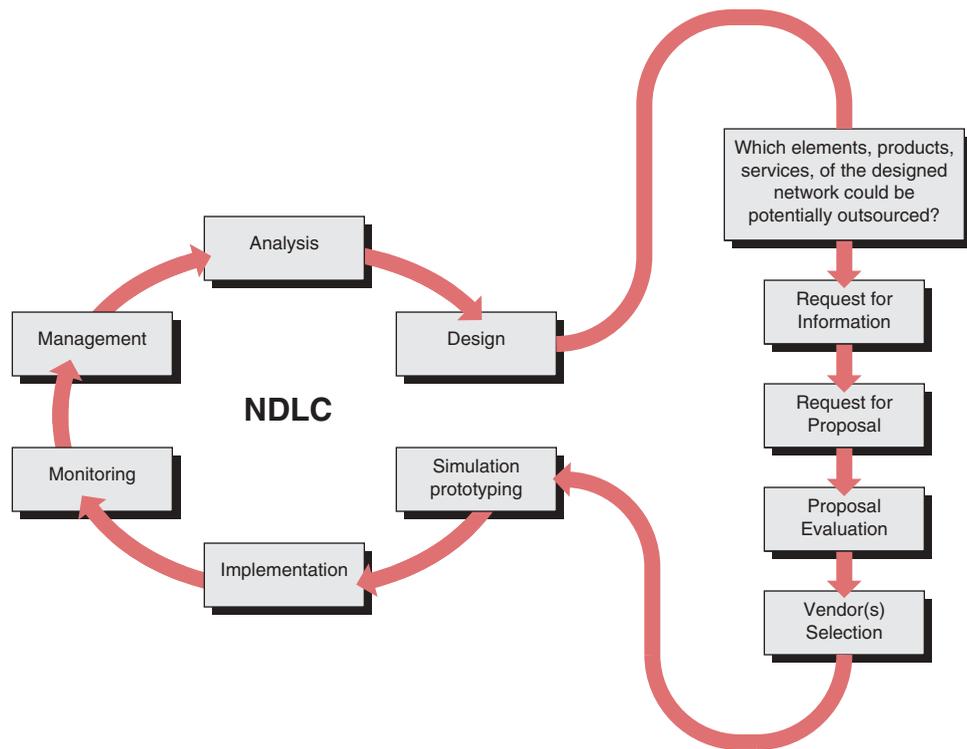


Figure 10-11 NDLC and the Proposal Process

Among the sections that could be included in a request for information are the following:

- **Technical requirements:** a high-level description of technical performance requirements that must be met by the proposed technology or system. These requirements should be of high importance to the overall system. In other words, vendors that cannot meet these technical requirements will not be considered further.
- **Business requirements:** ask for price structure of technology or services in order to gauge whether or not potential vendors are even in the ballpark of your budget. Do not share your budget with potential vendors at this point.
- **References:** the purpose of this section is to gauge the experience of this vendor in supplying this technology or service. How many have been sold or installed? Will you be their first customer for this new technology or service?

Remember, the overall purpose of the RFI is to narrow the field of vendors that will be sent the RFP so that you are not wasting time with nonqualified vendors. Keep the RFI short, to the point, and ask questions regarding those system or business requirements that you regard as absolute necessities or “show-stoppers”.

Request for Proposal (RFP)

By organizing the strategic information system design information into an understandable format and by adding detailed information concerning performance evaluation criteria for the data and network layers, a document known as a **RFP (request for proposal)** is produced. It is important to understand the benefits of an RFP to be able to justify the work that goes into it.

By taking the time to prepare a detailed RFP, a company ensures that its priorities and unique business processes and requirements are fulfilled by the information system and network that is eventually installed. All vendor proposals are measured against the users’ predefined requirements regardless of whom the vendor may be related to. If a vendor’s proposal does not meet minimum standards for meeting the requirements of the RFP, it is dropped from further consideration regardless of how nice the screens look or how colorful the brochures are. The RFP ensures that the delivered system, whether developed in-house or purchased from an outside vendor, will be flexible enough to change as business needs and requirements change. Unfortunately, the alternative is all too often the case, in which businesses are forced to mold their business practices according to the constraints of the purchased information system and network. Figure 10-12 summarizes both the processes and products involved in the RFP preparation phase of the network design.

Examine Each Corporate Location Now that the strategic information system design has been completed, the next step is to carefully examine each corporate location at which the information system will eventually be deployed. The purpose of gathering all of this data about each of the corporate locations is to compile an accurate representation of the scope and requirements of the network over which this strategic information system will be implemented.

As each location is examined, the information gathered will help determine the unique data and processing requirements for those locations. This detailed

Process	<ol style="list-style-type: none"> 1. Examine each corporate location 2. Produce evaluation criteria for application and data layer considerations as required 3. Survey all existing system resources: people, hardware-software-media, data, network, physical plant 4. Prepare preliminary overall project schedule 5. Determine information required from vendor 6. Determine potential vendors 7. Determine percent-of-fit goal 8. Compile and distribute RFP to selected vendors
Product	<ol style="list-style-type: none"> 1. Formalized request for proposal 2. Percent-of-fit goal

Figure 10-12 Preparing the Request for Proposal

location-specific information is distinct from the high-level information gathered in top-down model format as part of the problem definition phase.

Some corporate locations may be regional offices, concentrating data or transactions from several branch offices. These, along with many other facts must be recorded to accurately define data and network layer requirements for the overall information system. Although each company may differ in what location-specific statistics are important in terms of strategic network design, many of the points in Figure 10-13 may warrant consideration:

The information gathered in such location-by-location surveys adds to the evaluation criteria of any potential system proposal. Any need identified must be met by a proposed system solution in accordance with the determined priority of each of these requirements. It is of critical importance that this survey is done as accurately as possible because this is the data upon which the initial network design will largely be based. Buy-in by all affected groups at this stage is especially important, as outside vendors and in-house staffs will be using this data to prepare detailed application, database, and network designs.

Final RFP Preparation The two major components of the RFP that should have been completed at this point are

1. Strategic information systems design.
2. Corporate location survey results.

To put the finishing touches on the RFP, a few more pieces of information must be either supplied to or requested from potential system and network suppliers. This additional information is often included in a section of the RFP known as the **management abstract** or executive summary. Figure 10-14 illustrates a sample table of contents from an RFP including the items that might be included in a management abstract.

Information Supplied to Vendors Among the information included in the management abstract that should be supplied to potential vendors to give them as accurate a description as possible of the opportunity are the following items:

Category	Questions/Issues
People	<ul style="list-style-type: none"> • Number of total employees • Number of employees performing each business function as listed in strategic information system design • Feeling about the “new” system • Key political situations • Number of network-oriented/technically-oriented employees • Training needs
Hardware-Software-Media	<ul style="list-style-type: none"> • Current level of computerization • Current applications software • Current networking status • Local phone company • Availability of data services from local phone company • Software performance requirements <ul style="list-style-type: none"> ○ Maximum time for customer look-up ○ Maximum time for part number or pricing look-up ○ Maximum time for order entry • How “mission-critical” is each application? • Must backup systems be ready at a moment’s notice?
Data	<ul style="list-style-type: none"> • Number of customers • Number of inventory items • Number of open orders • Need for sharing data with other locations, regional offices, corporate headquarters • Special security needs for data or transmission
Network	<ul style="list-style-type: none"> • Current network configuration • Network traffic volumes • Network protocols • Network monitoring and management technology • Current problems with network to be corrected • Expected growth of network, traffic volume, user community
Physical Plant	<ul style="list-style-type: none"> • What is the condition of each remote site? • Will additional electrical, heating, data wiring, space, or security systems be required at any sites to accommodate the new systems?

Figure 10-13 Possible Location-Specific Statistics

- **Company profile:** A brief description of the company issuing the request for proposal. Number of corporate locations, approximate yearly sales, anticipated growth rate, and a brief statement concerning the current state of computerization or networking could all be elements of this section.
- **Statement of the problem:** From a business perspective, what was the source of the initiation of the problem definition process and what did the problem definition team conclude?
- **Overall system characteristics:** It is important to include overall system characteristics at the beginning of the RFP as some of these requirements may be beyond the capabilities of possible vendors and their systems. In this way, these vendors won’t waste their time or yours in submitting a

Management Abstract	<ul style="list-style-type: none"> • Company profile • Statement of the problem • Overall system characteristics—anticipated outcomes • Project phase prioritization • Proposed project schedule summary • Constraints • Contact information • Evaluation criteria for proposals • Legal-terms and nondisclosure agreements • Information requested from vendor; system development experience; hardware, software, networking experience; references; pricing; support; training and documentation; vendor background
<hr/>	
System Design	<ul style="list-style-type: none"> • Summary review • Details of geographic locations • System requirements of each software module

Figure 10-14 Sample RFP Table of Contents

proposal that can't meet these basic overall requirements. Figure 10-15 lists some possible overall system characteristics that might be included in an RFP. Although some of the requirements listed in Figure 10-15 may seem obvious or unnecessary, it is important not to assume anything when shopping for information systems.

- **Project phase prioritization:** If some modules (business area computerization plans) of the overall strategic information systems design are more critical than others, this prioritization should be conveyed to potential vendors. Often, a vendor may be able to supply some, but not all, of the information systems modules. If the vendors have a sense of which modules are most important, they will be better able to know whether or not to submit a proposal.
- **Proposed project schedule summary:** Figure 10-16 illustrates a sample proposed project schedule with key events that may be of concern to potential vendors listed. Before taking the time to prepare detailed proposals, many vendors appreciate knowing the implementation timetable of the proposed project. If the vendor already has projects underway or anticipated, he/she may lack sufficient staff to meet this RFP's proposed implementation schedule.

Information Requested from Vendors At least as important as the information supplied to potential vendors is the information required from potential vendors. To avoid being sent standard proposals with preprinted product literature and brochures, it is advantageous to list specific information required from vendors and to evaluate only those proposals that supply the requested information.

Figure 10-17 lists some of the information that may be requested of vendors, although the list is by no means authoritative or exhaustive. Information requested

1. Source code must be owned by the client company.
2. The system must be easy to use and maintain and must contain on-line help as well as extensive input editing and verification to help prevent errors.
3. The system must require a minimum of training.
4. The system must be easy to install (hardware and software) to expedite installation throughout all corporate locations.
5. The system must allow multiple users simultaneous access to information. The system must have the capability to ensure information integrity through record locking and must have adequate security to ensure against unauthorized access to information.
6. The system must have windowing capabilities allowing drop-down menus and screens to allow simultaneous access to multiple files and/or modules.
7. The system must be easily transportable to numerous hardware and operating system platforms on both minicomputers and microcomputers.
8. The system must have the ability to output and input ASCII data files to ensure necessary informational ties to regional centers.
9. The system must have database/file rollback capabilities to ensure data integrity in the event of a system failure or power outage.

Figure 10-15 Possible Required Overall System Characteristics

should satisfy corporate policies as well as business layer concerns from initial problem definition analysis. The overall purpose of this section is to ensure that

- The vendor has significant experience in developing and implementing systems of a similar nature to the one described in the RFP.
- The vendor has a sufficiently large organization to support the smooth and successful implementation of such a system.
- The vendor is financially solvent so as not to be likely to declare bankruptcy in the middle of the project implementation.

Event	Proposed Completion Date
Requests for Proposals Sent to Selected Vendors	07/29/04
Proposals Due to Consultant from Vendors	08/29/04
Selection and Notification of Vendor Finalists	09/14/04
Presentation/Demonstration by Vendor Finalists	09/21/01–10/07/04
Make-or-Buy Decision	10/14/04
Pilot Test	12/14/04
Projected System Implementation Date	04/01/05

Figure 10-16 Proposed Project Schedule Summary

System Development	<ul style="list-style-type: none"> • Vendor's experience in client's industry • Number of installed systems • Date of first installation • Integration with related manufacturing and financial modules • Scope of installed systems
Hardware/Operating Systems/Software	<ul style="list-style-type: none"> • Which hardware platforms does system run on? • Multiuser? • Operating systems • Programming languages • 4GL/DBMS experience • Ease of/availability of customization • Source code availability
References	<ul style="list-style-type: none"> • Names, addresses, and phone numbers of three customers with similar systems implemented
Pricing	<ul style="list-style-type: none"> • Hardware: If vendor will supply hardware, list cost by component including manufacturer and model number • Software: List cost per module, additional per user license costs, source code costs, cost for software customization, cost for maintenance and support agreements, cost for operating or runtime systems
Training	<ul style="list-style-type: none"> • Include information regarding: facilities, courses, materials, instructor availability, schedule, media used, cost
Support	<ul style="list-style-type: none"> • Hours—hotline available? • Cost—800 number? • Experience of support personnel • Software guarantees • Bug fixes—turnaround time • Software updates—maintenance
Vendor Background	<ul style="list-style-type: none"> • Number of employees • Yearly sales (approximate) • Growth pattern • Strategic direction • Research and development

Figure 10-17 Information Requested From Vendor

Percent-of-Fit Goal The RFP should now be fairly complete and ready to send to prospective system vendors. In addition to the RFP itself, one other important product of this phase of the overall network analysis and design methodology is known as the **percent-of-fit goal**. This is an especially important element if in-house development of the system and network is a possibility. The percent-of-fit goal is a rather arbitrary percentage that is determined by the user representative group preparing the RFP and is subject to the same overall buy-in as the RFP itself.

The purpose of the percent-of-fit goal is to set a minimum threshold of compliance for vendor proposals to warrant further consideration and invitations for

demonstrations. As an example, perhaps the users group feels that any proposal that meets at least 50% of the priority 1 features deserves further consideration.

This percent-of-fit goal offers an element of objectivity to the proposal evaluation process. The percent-of-fit goal, combined with the specific descriptions of required features in the RFP, constitutes an objective, comprehensive evaluation mechanism for evaluating proposals according to what is important to the corporation. By having this evaluation mechanism clearly defined before receipt of the first proposal, evaluators are less likely to be swayed by fancy brochures or systems' "bells and whistles."

If an in-house systems development group feels that they should rightfully be developing and/or implementing this system, they must submit a proposal in compliance with the requirements outlined in the RFP. Their proposal will be evaluated along with all of the outside vendors' proposals.

The percent of fit of a particular proposal can be easily calculated. Recalling that all features or requirements of the RFP were given a priority of 1, 2, or 3, by merely counting how many features of each priority are present in a given proposal, an overall objective "score" can be determined for each proposal. The process is fair, objective, and, to a large extent, eliminates politics from the proposal evaluation process.

Proposal Evaluation and Vendor Selection

Having determined a percent-of-fit score for each proposal as well as a percent-of-fit goal for proposals to warrant further consideration, invitations to selected vendors might be the next logical step. However, before selected vendors are invited for demonstrations, it is important once again to gain buy-in from all effected parties, especially management, on not only the selected vendors, but perhaps more important, the vendor selection process. Only when all groups agree that the vendor screening and proposal process has been fair and objective should the overall process move forward to the vendor demonstration stage.

At vendor demonstrations, it is important once again for the users, rather than the vendors, to be in charge. Have a copy of the vendor's proposal at the demonstration and ask to see each and every feature demonstrated that was described as included or supported in the vendor's initial proposal. Score should be kept on those features successfully demonstrated, and this score should be compared to the score received based on the proposal evaluation.

After all of the vendor demonstrations, it is time for the **make-or-buy decision**. Were any of the vendors' systems worth further consideration, or should the system be developed in-house? Once again, before proceeding, buy-in of the vendor demonstration evaluation and the make-or-buy decision should be assured.



OUTSOURCING

Outsourcing allows information systems and networking administrators to hire outside contractors to operate and maintain corporate information systems and networks. This option has become increasingly popular with companies whose primary business is not related to information systems or networking. Early ventures into outsourcing were not always ideal, as corporations and outsourcing vendors wrestled with where one entity's control terminated and the other's began.

As corporations have gained more experience with outsourcing, the delineation of control has become clearer. Corporations should maintain control over which services can be subcontracted by the outsourcing vendor and should maintain the right

to exclude certain subcontractors. The relationship between the corporation and the outsourcing company should be viewed as a strategic partnership rather than as a typical supplier–customer relationship. Partnership agreements can be written to include mutual benefits for mutually achieved goals or shared successes. In this manner, both the client and outsourcing company stand to gain by working together to reach mutually beneficial goals—a truly win–win situation.

■ NETWORK ANALYSIS AND DESIGN

Although it may seem as if a great deal of analysis and design have been done already, it is important to note that the network layer requirements are now ready to be addressed, having designed satisfactory solutions for business, application, and data requirements. As stated several times before, a network cannot be designed in a vacuum, but rather must be designed to deliver solutions and performance in response to specific and well-defined data, application, and business layer requirements.

The term *network analysis and design* really refers more specifically to wide area network analysis and design. LAN design considerations and internetworking (LAN to LAN) connectivity issues were covered in their respective chapters. In this chapter, a more corporate-wide view of networking is taken by designing a network that will effectively support the strategic information system design across geographically dispersed corporate locations. Figure 10-18 illustrates the key points, both process and product, of the network analysis and design phase. Each of these steps is explained in detail.

The overall network analysis and design process can be broken down into three major steps:

1. **Data traffic analysis** examines all aspects and characteristics of the traffic that will be passed between corporate locations over the proposed network. Since this data traffic is what the network must carry effectively, it is important to start with a thorough analysis of the data traffic to design an effective network. As an analogy, it would be equally wise to understand the driving

Process	<ol style="list-style-type: none"> 1. Data traffic analysis <ul style="list-style-type: none"> • Flow Analysis • Payload type analysis • Transaction analysis • Protocol stack analysis • Time studies • Mission critical analysis • Traffic volume analysis 2. Circuit analysis and configuration alternatives 3. Network hardware analysis and configuration alternatives
----------------	--

Product	<ol style="list-style-type: none"> 1. Data traffic analysis report for each geographic location 2. Alternative network configuration diagrams including circuit and network hardware details
----------------	--

Figure 10-18 In-House Network Analysis and Design

patterns and transportation needs of an urban area before designing a new highway system.

2. Once the nature of the data traffic is thoroughly understood, **circuit analysis and configuration alternatives** explores the possibilities for delivering that data traffic in a reliable and effective manner. Although there are often alternative ways to transport data from point A to point B, it is important to document alternative network configurations along with an understanding of the advantages and disadvantages of each alternative.
3. Finally, given the nature of the data traffic, especially its protocol-related characteristics, and the possible circuit configurations over which that data may be transported, **network hardware analysis and configuration alternatives** explores the possible data communications hardware devices that may be required to tie the various circuit configurations together into a reliable, manageable network.

Baseline Existing Network Infrastructure

In most cases, network design projects are actually upgrades or additions to existing networks. As a result, it is essential to be aware of the existing network infrastructure to which the new network or upgrade must interface. Hopefully, detailed records and network diagrams have been kept up to date documenting current network configuration and layout. If this is not the case, then the existing network infrastructure must be thoroughly analyzed and documented to ensure accurate baseline information.

Data Traffic Analysis

The exact types of analysis performed in the major step known as data traffic analysis may vary from one networking design to another. Figure 10-19 details some of the possible types of data traffic analysis. The required outcome from this step is a data traffic analysis report that will form the basis for circuit and networking hardware selection. It is the obligation of the network analyst to perform whatever types of data traffic analysis are necessary to ensure that the data traffic analysis report is as complete as possible while forming the foundation on which to build a network design.

Flow Analysis The first step toward a thorough understanding of data traffic analysis is to analyze the flow of that data. Understanding the source and destination of each data “conversation” and the nature of the data in that conversation is fundamental to a proper network design. Flow analysis may involve the identification and classification of different types or groups of users of information and the sources of the information that they must access. Traffic flow can vary greatly depending on the types of applications or equipment at either end of a traffic flow. Among some of these types are:

- SNA traffic from mainframes to dumb terminals
- Client/server traffic from client applications to back-end servers
- Server-to-server traffic between transaction and/or database servers
- Browser-to-Internet traffic between client browsers and Internet-based servers

Data Traffic Analysis Category	Description
Flow Analysis	Flow analysis is concerned with which workstations and servers are talking to each other. In other words, who is talking to whom? Who are the “top-talkers”? It is important to identify not only the amount of traffic to be transmitted but the end-points of these transmissions. Only in this manner can proper traffic consolidation be achieved.
Payload Type Analysis	Most locations will require at least voice and data service. Videoconferencing and multimedia also may need to be supported. All payload types should be considered and documented before selecting circuit and networking hardware.
Transaction Analysis	Use process flow analysis and document flow analysis to identify each type of transaction. Analyze detailed data requirements for each transaction type. Some types of transactions, database replication for example, may be especially bursty.
Time Studies	Once all transaction types have been identified, analyze when and how often each transaction type occurs.
Traffic Volume Analysis	By combining all known types of transactions with the results of the time study, a time-sensitive traffic volume requirements profile can be produced. This is a starting point for mapping bandwidth requirements to circuit capacity.
Mission-Critical Analysis	Results of this analysis phase may dictate the need for special data security procedures such as encryption or special reliability/fault tolerance features such as redundant circuits and networking components.
Protocol Stack Analysis	Each corporate location’s data traffic is analyzed as to protocols that must be transported across the corporate wide area network. Many alternatives for the transport of numerous protocols exist, but first these protocols must be identified.

Figure 10-19 Data Traffic Analysis

Only after documenting all flows to be handled by a given network can the various types of flows be summarized or conglomerated in an optimal manner.

Payload Type Analysis For the most cost-effective network design, voice as well as data requirements should be considered during the network analysis and design phase. Videoconferencing, imaging, and multimedia requirements should also be considered due to their bandwidth-intensive transport demands. Digitized video and voice represent streaming data and often require isochronous transmission, whereas inter-LAN data tends to be of a more bursty nature. These data characteristics may have a major impact on network design decisions.

Transaction Analysis To determine the actual data traffic requirements from a given corporate location, the network analyst has to examine the source of that data: transactions

of one type or another. Examples might include customer entry or inquiry, order entry, inventory receipt, order fulfillment, part number or pricing lookup, etc.

Each of these different transaction types should be identified from the business process definitions of the strategic information systems design. **Process flow analysis** and **document flow analysis** are also employed to identify and analyze transaction types. Once each transaction type has been identified, the amount of data required to complete that transaction is calculated and documented. Some transactions such as credit card verifications or ATM machine transactions are composed of short bursts of data that must be handled quickly and accurately. Some nightly backup or file transfer applications may not require the same type of high-speed, high-priority transmission. The difference in the characteristics of these transactions may warrant a difference in the network design in each case. Perhaps one type of transaction is better suited to a packet-switched approach, whereas the other may require a leased line.

Time Studies Once all transaction types have been identified, the next step is to analyze when and how often these transactions are executed. One method of determining both the frequency and time distribution of these transactions is through a time study. Simply stated, a time study merely counts how often and at what time of day, week, or month a given transaction or process is executed. For instance, a retail store's daily close-out procedure is executed once per day. However, is it the same time each day and are all stores executing the same process at the same time each day? What are the network implications of month-end closing procedures? The answers to these types of questions can have a major bearing on bandwidth requirements and the resultant network design.

Traffic Volume Analysis Traffic volume analysis could be looked on as the product of transaction analysis and time studies. By knowing the data and network requirements of every transaction type and by further knowing the frequency and time distribution of the execution of a given transaction type, a time-sensitive traffic volume requirements profile can be constructed. Such a profile shows average network bandwidth requirements as well as peak or maximum requirements. Seasonality of transaction volume should not be overlooked. The transaction frequency of retail businesses can easily double or even triple during the Christmas shopping season. An undersized network must not be the cause of poor customer service during important periods of increased customer activity. As another example, power companies must design voice and data networks that can easily accommodate higher than normal demand to provide adequate customer service during power outages or other emergencies.

Traffic volume analysis should also be viewed from a location-oriented perspective. To have an accurate representation of overall traffic volumes, one must consider the average and peak traffic volume levels between all identified corporate locations or network nodes. Such point-to-point traffic volume analysis data can then be fed into network design and simulation software packages for further analysis and what-if scenario development.

Mission-Critical Analysis Although all data could be considered important, some transactions are so important to a business that they are known as mission critical. Electronics funds transfer is a good example of a mission-critical transaction. The mission-critical nature of some transactions can spawn further analysis and design in two other areas. Data security may require investigation. Encryption of data transmitted over wide area networks may be a requirement. If so, this fact should be stated as part of the overall data traffic analysis report.

Second, it is a fact of life that data circuits fail from time to time. If certain mission-critical transactions cannot tolerate an occasional faulty data circuit, then redundant links may need to be designed into the initial network design configuration.

Protocol Stack Analysis As has been seen in both the LAN and internetworking design processes, protocol stack analysis is of critical importance. Some protocols, such as SNA, are extremely time sensitive. Some protocols are routable, but others are not. Others, such as SNA and some LAN protocols are very “chatty,” sending constant status-checking and keep-alive messages onto the network and occupying precious bandwidth. As each corporate location’s data traffic is analyzed, special attention must be paid to the various protocol stacks of that data.

Will the wide area network be required to support more than one protocol? What are the bandwidth and network hardware implications of a multiprotocol WAN? Is TCP/IP encapsulation an option, or is SDLC conversion a more appealing alternative? Before reaching any conclusions as to how various protocols are to be transported over the corporate network, those protocols must be accurately identified and documented. This is the role of the protocol stack analysis.

The type of network design concerned with the proper accommodation of all necessary protocols is referred to as logical network design.

Physical Design Concepts

As opposed to logical network design, physical network design is most concerned with the specification of the transmission and switching elements that must be combined to deliver analyzed levels of traffic to its proper destination. Some of the key activities involved with physical network design are described next.

Circuit Analysis and Configuration Alternatives

A thorough data traffic analysis should produce sufficient information to configure various network design alternatives that will effectively support the strategic information system design to all corporate locations. Evaluating alternative network configurations and computing circuit capacity are beyond the reasonable expectations of a person who may be using this textbook in support of a first course in data communications. Upper level courses in traffic engineering, wide area networking, or network analysis and design would better prepare a person to perform such a task.

Wide area network design software has greatly simplified the design process but is relatively expensive. In most cases, even using the software requires a great deal of network design expertise. As a result, in most cases, only companies that can afford to have full-time network analysts and designers on staff are likely to own copies of network design software. The various categories of network design software are explored in greater detail later in this chapter.

A second alternative for circuit analysis and network configuration would be to hire a data communications/networking consultant. This too may be a very expensive alternative. Furthermore, there is little or no regulation as to the level of expertise required to call oneself a telecommunications consultant.

Third, telecommunications companies, both local carriers and interexchange carriers, have the ability to design networks according to customer data requirements. The network design process is part of preparing a quote and is done at no charge. Therefore,

it may be advisable for the small company or novice data communications person to let the experts design the network. Talk to several carriers and get a network design proposal with associated costs from each. If the carriers design the network and quote a price, they can be held accountable for delivering service at a quoted price in accordance with the data traffic analysis and performance evaluation criteria.

Consideration of Network Alternatives

It is important to consider more than just the data traffic analysis when considering network configuration alternatives. The detailed survey of existing system resources should also be considered. For instance, local carriers servicing some remote corporate locations may be limited in their ability to offer certain data transmission services. This should be documented in the survey of existing system resources.

Regardless of who actually designs the network configuration alternatives, it is important to ensure that sufficient bandwidth has been allocated to handle sudden increases in demand. More gradual increases in bandwidth demand due to expanding business opportunities can usually be accommodated with upgrades to higher capacity lines and their associated data communications equipment.

A second performance evaluation criterion for network configurations involves reliability. Based on the data traffic analysis study, sufficient redundancy should be implemented in the network to properly support mission critical applications. Third, is the data transmission provided by these circuits sufficiently secure? The overall goal of this portion of the network design is to find a network configuration that has sufficient bandwidth to reliably deliver the data as described in the data traffic analysis report in a secure manner at a reasonable cost.

Alternative configurations must be understood in terms of both performance and costs. Comprehensive methodologies for project budgeting are presented later. However, the point remains that the choice of a given network configuration may come down to a business decision. That decision may be that a given network configuration is all a company can afford, and, as a result, that company will have to live with the associated performance and reliability. Conversely, the business decision may be that the business requires optimum network performance, regardless of cost.

In any case, it is not the role of the network analyst to dismiss network design alternatives on the basis of cost. The network analyst's job is to deliver network design alternatives capable of delivering required network functionality. Only senior management should determine the feasibility of any particular network design in terms of its affordability. The person presenting the various network configurations to senior management for buy-in must know the pros and cons of each configuration. The ability of each configuration to handle expansion or business growth should be anticipated.

Network Hardware Analysis and Configuration Alternatives Before describing the process of network hardware analysis, it is important to first reiterate the information gathered thus far that will assist in the decision-making process. Two key products of earlier analysis efforts form the basis of the supporting material for selection of the particular networking devices that will be placed throughout the corporate wide area network. These two key products are

- Data traffic analysis reports for each corporate location.
- Circuit configuration alternatives diagrams.

Recall briefly the process involved in producing each of these products. The data traffic analysis report was based on a detailed study of numerous aspects of the data traveling to or from each corporate location. The circuit configuration alternatives were designed, in turn, based on a careful study of the required bandwidth and delay sensitivity of the transactions performed at each corporate location as identified in the data traffic analysis study. If the results of these two analysis efforts are valid, then the networking devices chosen to tie the network together that are based on these results should also be valid.

Use of the I-P-O Model The actual decision-making process for network device selection utilizes a model of data communications that was first introduced very early in the text. By compiling the results of the data traffic analysis report and the circuit configuration diagram in an I-P-O diagram, the required processing ability of the sought-after device can be documented. Once the performance characteristics of the required network device have been identified, product specifications can be reviewed and vendor presentations can be scheduled to find the proper networking device for each location.

As with the data traffic analysis and circuit analysis, the network device analysis were done on a location-by-location basis. Figure 10-20 shows a sample use of an I-P-O diagram as a tool for network device analysis.

Figure 10-20 is not meant to be all-inclusive. Rather, it attempts to portray that by knowing the data characteristics of the local data, with particular attention paid to the protocol stack, and by knowing the circuit alternatives available for carrying that

Input	Processing	Output
Local Data Characteristics	Required Network Device Characteristics	Wide Area Network Circuit Characteristics
Transport protocols	Host-terminal data	Circuit-switched WAN services
SNA	Cluster controllers	POTS
TCP/IP	STDMs	ISDN
IPX/SPX	T-1 MUXs and switches	Switched 56K
Payload types	X.25 MUXs and switches	Leased WAN services
LAN data	Frame relay MUXs and switches	DDS
Voice	ATM access devices and switches	T-1
Video	LAN data	T-3
Fax	Routers	SONET
Imaging/multimedia	Switches	Packet/Cell Switched Services
Internet access	Voice	X.25
	T-1 channel banks	Frame relay
	Video	ATM
	Inverse MUXs	MPLS
	Internet access	
	Modems	
	ADSL devices	
	Cable Modems	

Figure 10-20 I-P-O Diagram as Tool for Network Device Analysis

data over the wide area network, the choices among network devices that can join the two are relatively limited.

Careful analysis of the available alternatives that can join the input and output characteristics can then be further analyzed from a business or strategic planning objective. Additional information to assist in this evaluation may come from the detailed reports of each corporate location that were part of the preparation of the RFP.

Review of Overall Network Analysis and Design Process

Once the network hardware analysis, circuit analysis, and data analysis have been completed, the finishing touches can now be put on the final proposal. Before doing so, a brief review of the network analysis and design process is in order.

Notice that the network design process did not start with a discussion of network hardware device alternatives. To do so would have been to ignore the importance of the top-down model, a central theme of this book. Many so-called data communications experts still start with their favorite hardware alternative and adjust data and circuit characteristics to match the chosen network hardware.

In this case, just the opposite approach was taken:

- Determine data characteristics based on a thorough examination of the transactions that generate the data.
- Determine circuits based on required bandwidth and delay-sensitivity as determined by the data analysis study.
- Determine the networking hardware devices capable of transporting this data over these circuits while remaining responsive to business and location-specific influences.

Preparing the Final Proposal

Figure 10-21 summarizes the key points of wrapping up the network analysis and design methodology. After preparing and presenting the final proposal, buy-in is sought from all affected constituencies, followed, it is hoped, by final approval and funding by senior management. One element of the final proposal process deserves further explanation.

Preparing a Comprehensive Budget

It has been the author's experience that senior management can accept well-organized, comprehensive budgets representing large sums of money. What has been found to be unacceptable are the so-called hidden or forgotten costs of network and systems implementation often left out of budgets.

As a result, a comprehensive budget format needed to be developed that would help to identify as many elements of potential implementation and operation costs as possible. Figure 10-22 illustrates a sample budget page from the

Final Proposal	Process	<ol style="list-style-type: none"> 1. Prepare a detailed comprehensive budget 2. Prepare detailed implementation timetable 3. Prepare project task detail 4. Prepare formal presentation 5. SELL!
	Product	<ol style="list-style-type: none"> 1. Comprehensive systems and networking budget model 2. Project management details 3. Presentation graphics
Approval	Process	<ol style="list-style-type: none"> 1. Final buy-in by all affected parties 2. Contract negotiation—outsourcing only 3. Executive approval
	Product	<ol style="list-style-type: none"> 1. Detailed list of tasks and responsible parties with due dates 2. Identify and satisfy needs for management, support, and training on new system/network
Implementation	Process	<ol style="list-style-type: none"> 1. Pilot test 2. In-house trial—outsourcing only 3. Performance evaluation 4. Prepare deployment schedule 5. Roll-out
	Product	<ol style="list-style-type: none"> 1. Detailed list of tasks and responsible parties with due dates 2. Identify and satisfy needs for management, support, and training on new system/network

Figure 10-21 Final Proposal, Approval, and Implementation

Proposal Number	Description:			
	Acquisition	Operation	Incremental Change/ Anticipated Growth	TOTALS
Hardware	Data center: Network operations: Application development:			
Software	Data center: Network operations: Application development:			
Personnel	Data center: Network operations: Application development:			
Communications	Data center: Network operations: Application development:			
Facilities	Data center: Network operations: Application development:			
TOTALS	Data center: Network operations: Application development:			

Figure 10-22 Comprehensive Systems and Networking Budget Model

comprehensive systems and networking budget model. Along the vertical axis, major budget categories are listed including

- Hardware/equipment
- Software
- Personnel
- Communications (carrier services)
- Facilities

There is nothing sacred about these categories. Change them to whatever best reflects your situation. The important point is to organize the budget grid in such a way that all possible costs are identified in advance.

The horizontal axis has three columns representing the major categories of costs with respect to time. Networking and systems budgets typically focused only on the **acquisition costs** of the new system. Even within the acquisition category, costs associated with personnel additions, changes, and training were often omitted. Likewise, costs involved with facilities upgrades or changes such as electrical wiring, cabinets, wiring closets, or security systems were also likely to be overlooked or unanticipated. Preventing surprises such as these requires a two-step approach:

- Required or anticipated facilities upgrades and personnel needs are identified during the location-by-location survey as part of the final preparation of the RFP.
- Any legitimate need that was identified in the location-by-location survey should be budgeted for in the comprehensive systems and networking budget model.

Even a budget that identifies all acquisition costs is still neither complete nor accurate. Two other major categories of costs must be accounted for:

- Operations
- Incremental change/anticipated growth

Operations Costs **Operations costs** include estimated monthly costs for leased-line or dial-up line usage, as well as the estimated cost for the additional electricity required to run new equipment. If additional cooling, heating, or environmental control is required as a result of system implementation, these costs should be included as well. Service contracts, maintenance agreements, or budgeted time and materials for repairs should be also be considered as operation costs. Also, don't forget budgeting for taxes, contingency or "rainy day" funds, and other hidden costs.

ANTICIPATING AND BUDGETING FOR NETWORK GROWTH

Another aspect of project budgeting often overlooked at proposal time is the cost associated with the anticipated growth of the system during the first 3 to 5 years after implementation. These **incremental change costs** may be significant if certain elements of the system or network design are not expandable or only moderately so. As an example, perhaps a remote site starts with a four-port STDM as its networking



device. To add four more users, an upgrade kit could be installed for \$1,300. However, to add a ninth user would require replacing the entire STDM with a higher capacity unit at a cost of \$5,000. Although the costs in this example may not be precise, the point of the example remains. Anticipated growth should be budgeted. In some cases, this budgeting process of the anticipated growth may cause changes in the equipment choices at acquisition time.

To accurately budget for anticipated systems and network growth, the network analyst must have access to strategic business plans that outline the anticipated growth of the business. After all, the implemented system and network are a direct result of the business requirements, including the required ability to respond to changing business conditions in accordance with the overall business vision as articulated in a strategic business plan. Depending on the corporate culture, network analysts may not be allowed access to such strategic business planning information.

As shown in Figure 10-22, each budget category that is formed by an intersection of a column and row can be further subdivided if such department budgeting is required within the overall project budget. In Figure 10-22, the three abbreviated categories stand for three typical departments within an overall M.I.S. operation: DC (data center), NO (network operations), and AD (application development). Make this budget grid fit your business. If departmental or cost center budgeting is not required for your business, ignore these subcategories. If other departmental designations are more appropriate, substitute them.

■ THE NETWORK IMPLEMENTATION PROCESS

Although specific details of an implementation process will vary from one project to the next, there are a few general points worth making. Perhaps most important, regardless of how well designed an information system or network may be, it is still essential to test that design in as safe a manner as possible. “Safe” in this case could be defined as the least likely to have a tragic effect on production systems or networks.

Pilot tests are a popular way to safely roll out new systems or networks. For example, bring one retail store on-line and monitor performance, fix unanticipated problems, and gain management experience before deploying the system on a wider scale. Honest feedback and performance evaluations are essential to smooth system implementations. User groups can be a helpful feedback mechanism if managed skillfully to prevent degeneration into nothing more than gripe sessions.

Project Management

Another important skill to a smooth implementation process is effective project management. Detailed task lists including task description, scheduled start and finish dates, actual start and finish dates, and responsible parties are at the heart of good project management. Some systems and network professionals use project management software. The author has used project management software on occasion but found, in general, that loading and maintaining all of the project detail in the project management software was more work than managing the project manually. Although perhaps overly simplistic, the general rule of thumb as to when to use project management software is when a project is too complicated to manage manually, then you may benefit from the use of project management software.

People Are Important

Despite this book's focus on networking hardware and software, people are the most important element of any systems implementation. Buy-in at every stage by all affected parties was stressed throughout the network analysis and design process to ensure that everyone gets behind the new system and network and that everyone feels that they had an opportunity to make their thoughts known. The best designed network will fail miserably without the support of people.

Therefore, a key element of system and network implementation is to ensure that people-related needs such as management, support, and training have been thoroughly researched and appropriately addressed.

■ AUTOMATING THE NETWORK DEVELOPMENT LIFE CYCLE

Sophisticated software packages now exist to assist network analysts in the analysis and design of large and complicated networks. These software tools can vary greatly in sophistication, functionality, scope, and price.



THE BUSINESS CASE FOR COMPUTER-ASSISTED NETWORK ENGINEERING

The entire network development life cycle is sometimes referred to as **network engineering**. The use of software tools of one type or another to assist in this process is known as **computer-assisted network engineering (CANE)**. Companies must be able to make a strong business case for the payback of this computer-assisted network engineering software when the prices for the software generally range from \$10,000 to \$30,000 per copy. Besides the obvious use of the software for designing new networks “from scratch,” several other uses of computer-assisted network engineering software can offer significant paybacks.

By using analysis and design software to model their current network, companies are able to run **optimization routines** to reconfigure circuits and/or network hardware to deliver data more efficiently. In the case of optimization software, “efficiently” can mean maximized performance, minimized price, or a combination of both.

When current networks have grown over time in a somewhat helter-skelter manner without any major redesigns, network optimization software can redesign networks that can save from thousands of dollars per month to millions of dollars per year depending on the size of the network.

Another important use of analysis and design software on a corporation's current network is for **billing verification**. Most analysis and design packages have up-to-date tariff information from multiple regional and long-distance carriers. By inputting a company's current network design in the analysis and design software and by using the tariff tables to price individual circuits within that network, prices generated from the tariff tables can be compared to recent phone bills. Such verification often uncovers discrepancies in billing amounts, some of which can be significant.

Either of the two previous uses of computer-assisted network engineering software could pay back the cost of that software within six months to one year. Another very common use of this type of software with a less tangible short-term financial payback but significant future benefits is **proactive performance assurance**

Figure 10-23 illustrates the various categories of computer-assisted network engineering software along with a few examples of each type. Many other software

Top Category	Examples
Application Monitoring	<ul style="list-style-type: none"> • OPNET IT Guru • Compuware Vantage
Network Monitoring	<ul style="list-style-type: none"> • Lucent Vitalsuite
Network Management	<ul style="list-style-type: none"> • Tivoli/IBM TME • CA—Unicenter • HP—Openview
Network Simulation	<ul style="list-style-type: none"> • OPNET Modeler
Network Design	<ul style="list-style-type: none"> • OPNET Mainstation • OPNET SP Guru • NetCracker Professional

Figure 10-23 Computer-Assisted Network Engineering Software

packages are available in each category that offer a range of features at a range of prices. Differentiation between network design tools, network simulation tools, and network management tools is not as definitive as Figure 10-23 might imply. In fact, most network design tools now include at least some network simulation and management capabilities, as well as network design intelligence to actively assist in the network design.

In addition, recognizing the interdependence between application performance and network performance, many network-based analysis and monitoring tools are able to monitor and/or simulate application performance on a given network. This capability is essential if applications and networks are to be designed in an optimal fashion. Otherwise, network designers fall prey to the rule of thumb of network design: “when in doubt, over-provision the bandwidth until the application performs acceptably.” Unfortunately, for latency-constrained applications, no amount of bandwidth will produce acceptable performance results. However, financial consequences of such a network design philosophy could be disastrous.

Analysis and Design Tools

Figure 10-24 lists some of the more common elements of network design tools in an input-processing-output model format.

Following is a listing of some of the important features to look for when considering network analysis and design tools:

- **Tariff databases:** How current are they? How many carriers and types of circuits are included? How often are the tariff databases updated? Is there an additional charge for tariff database updates? Tariff structures have become very complicated and are calculated in a variety of different ways. Confirm that the tariff database in the analysis and design software includes all necessary tariffs.
- **Response time calculation:** Does the software consider the processing time of the particular host computer that may be a part of the network? Can user-defined elements be taken into account in the response time calculation, for

Phase	Network Design Tool Features
Input	<ul style="list-style-type: none"> • Input requirements definitions • Drop network objects • Auto-discovery on existing networks from enterprise network management packages such as HP's Openview, IBM's NetView, or CA-Unicenter • Assign traffic characteristics and distribution • Link objects with circuits • Assign attributes and protocols to network devices and circuits • Build a computer-assisted network model • Accept input (traffic data) from network analysis tools or sniffers
Processing	<ul style="list-style-type: none"> • Validate the design (which objects can be connected to which other objects) • Roll up and simulate a fully loaded network • Ensure protocol compatibility • Assess reliability and security • Test alternative configurations for cost and performance optimization • Conduct what-if testing
Output	<ul style="list-style-type: none"> • Detailed network equipment requirements by vendor • Detailed transmission circuit requirements • Detailed protocol design • Bill of materials listing all items to be purchased

Figure 10-24 Input-Processing-Output Model for Network Design Tools

example, applications programs of various types, different types of networking equipment?

- Multiple transport protocols: Can the software consider the effect of various transport protocols on response time? How many protocols are included? SNA, DECNET, ISDN, TCP/IP, X.25, frame relay, ATM, satellite, microwave, cellular?
- Multiple topologies: How many different topologies can the software model? Examples: hierarchical, hub and spoke, mesh, point-to-point multipoint, concentrated, packet-switched, multiple host.
- Circuit design: Can the software configure circuits for a combination of simultaneous voice and data traffic, or must voice and data circuits be designed separately? Can multiplexers be cascaded? Are tail circuits allowed?
- Financial: Can the software roll up costs for network equipment as well as for circuits? Can costs and performance be optimized simultaneously? Can costs be compared across multiple carriers?
- Input/output: Can protocol analyzers or network monitoring or management systems be interfaced directly to the analysis and design software for automatic input of current system performance data? Can analysis and design results be output directly to spreadsheet, database, and word processing packages?
- Operating platforms: What platform does the design software run over? NT, Unix, SunOS, Win'95/98/2000?

- Design platforms: What types of networks can the software design? LAN only, WAN only, LAN/WAN and internetworking?
- Product library: Different network design packages can contain varying numbers of network device objects that contain manufacturer-specific information and specifications.
- Design validation: The software should validate that all devices are accounted for, that all segment lengths conform to standards, and that all hardware is properly matched according to protocols.

Simulation Tools

Simulation software tools are also sometimes known as **performance engineering** software tools. All simulation systems share a similar trait in that the overall network performance that they are able to model is a result of the net effect of a series of mathematical formulas. These mathematical formulas represent and are derived from the actual performance of the circuits and networking equipment that make up the final network design.

The value of a simulation system is in its ability to predict the performance of various networking scenarios otherwise known as **what-if analysis**. Simulation software uses the current network configuration as a starting point and applies what-if scenarios. The benefits of a good network simulation package include

- Ability to spot network bottlenecks such as overworked servers, network failures, or disk capacity problems.
- Ability to test new applications and network configurations before actual deployment. New applications may run well in a controlled test environment, but may perform quite differently on the shared enterprise network.
- Ability to recreate circumstances to reproduce intermittent or occasional network problems.
- Ability to replicate traffic volume as well as traffic transaction type and protocol mix.

The key characteristics that distinguish simulation software are as follows:

- Network types: Which different types of networks can be simulated? Circuit-switched, packet-switched, store-and-forward, packet-radio, VSAT, microwave?
- Network scope: How many of the following can the simulation software model either individually or in combination with one another: modems and multiplexers, LANs, Internetworks, WANs, MANs?
- Network services: How many of the following advanced services can be modeled: frame relay, ISDN (BRI and PRI), X.25, ATM, SONET, MPLS.
- Network devices: Some simulation systems have developed performance profiles of individual networking devices to the point where they can model particular networking devices (bridges, routers, switches, MUXs) made by particular manufacturers.

- Network protocols: In addition to the network transport protocols listed in the analysis and design section, different router-to-router protocols can have a dramatic impact on network performance. Examples: RIP, OSPF, PPP, BGP.
- Different data traffic attributes: As studied in previous chapters, all data traffic does not have identical transmission needs or characteristics. Can the software simulate data with different traits? For example: bursty LAN data, streaming digitized voice or video, real-time transaction-oriented data, batch-oriented file transfer data.
- Traffic data entry: Any simulation needs traffic statistics to run. How these traffic statistics may be entered can make a major difference in the ease of use of the simulation system. Possibilities include manual entry by users of traffic data collected elsewhere, traffic data entered “live” through a direct interface to a protocol analyzer, a traffic generator that generates simulated traffic according to the user’s parameters or auto-discovery from enterprise network management systems.
- User interface: Many simulation software tools now offer easy-to-use graphical user interfaces with point-and-click network design capability for flexible “what-if” analysis. Some, but not all, produce graphical maps that can be output to printers or plotters. Others require users to learn a procedure-oriented programming language.
- Simulation presentation: Some simulation tools have the ability to animate the performance of the simulated network in real time, and others perform all mathematical calculations and then play back the simulation when those calculations are complete.

Object-Oriented Technology Meets Network Engineering As network simulation software has shifted its intended audience from network engineers well versed in the intricacies of network performance optimization to network analysts most familiar with networking requirements, the designers of that software have had to make some fairly radical changes in the ease of use as well as the sophistication of the software.

The mathematical formulas representing the performance characteristics of individual networking elements become the methods of the network objects, and the attributes describe the details such as manufacturer, model, price, and capacity. By merely clicking on one of these network objects representing a particular network device or circuit, the user automatically adds all of the associated methods and attributes of that network object to the network simulation. Particular applications programs or transport protocols can also be represented as network objects and be clicked on to be added to the overall network simulation. In this way, all seven layers of the OSI model can be included in the final simulation run.

Management: Proactive LAN Management

Sophisticated proactive network management software has the ability to monitor network performance on an ongoing basis and to report unusual network conditions or activities to a network management workstation. The term *unusual network*

conditions is really user definable. **Thresholds**, or desired limits of certain performance characteristics, are set by the user. In some cases, the user may have no idea where to set these thresholds. To aid in such a situation, some management systems can record “normal” performance characteristics over an extended time to gather valid **baseline data**.

Some management software systems even have the ability to feed this “alarm data” back to certain simulation systems that can simulate the “threshold crossing” and allow what-if analysis to be performed in order to diagnose the cause of the problem and propose a solution.

■ THE FUTURE OF THE AUTOMATED NETWORK DEVELOPMENT LIFE CYCLE

Some of the trends mentioned in previous sections will continue as computer-assisted network engineering software tools continue to evolve and mature. The key word in terms of the future of these various tools that make up the automated network development life cycle is integration. The real potential of network engineering software integration has just barely scratched the surface and only in a few vendor-specific cases.

For instance, certain protocol analyzers such as Network General’s Distributed Sniffer have the ability to interface directly into certain network simulation systems. In such a scenario, actual traffic statistics from the current network configuration are fed directly into the mathematical engines underlying the simulation software. Such vendor-specific, product-specific integration is significant. However, to have true transparent integration of all computer-assisted network engineering tools, a more open and standardized approach must be undertaken.

Horizontal Integration

Figure 10-25 illustrates, on a conceptual level, how such a standardized open architecture offering seamless **horizontal integration** might be constructed. Rather than having to know the intricacies and, in some cases, the trade secrets of how each other’s products work, vendors of computer-assisted network engineering software merely pass the output from their particular software product to a “neutral” data platform known as **CNIP** or **common network information platform**. Any other CANE tool that could use that output to provide transparent integration with other CANE tools would import the standardized, formatted data from the common network information platform. The end result of the use of such a standardized platform for CANE tool data output and retrieval is the seamless integration of a variety of CANE tools spanning all phases of the network development life cycle.

The Final Frontier: Vertical Integration

Integration implies not only horizontal integration with software from other categories of the CANE family but also **vertical integration** with applications development platforms such as CASE (computer assisted software engineering) tools.

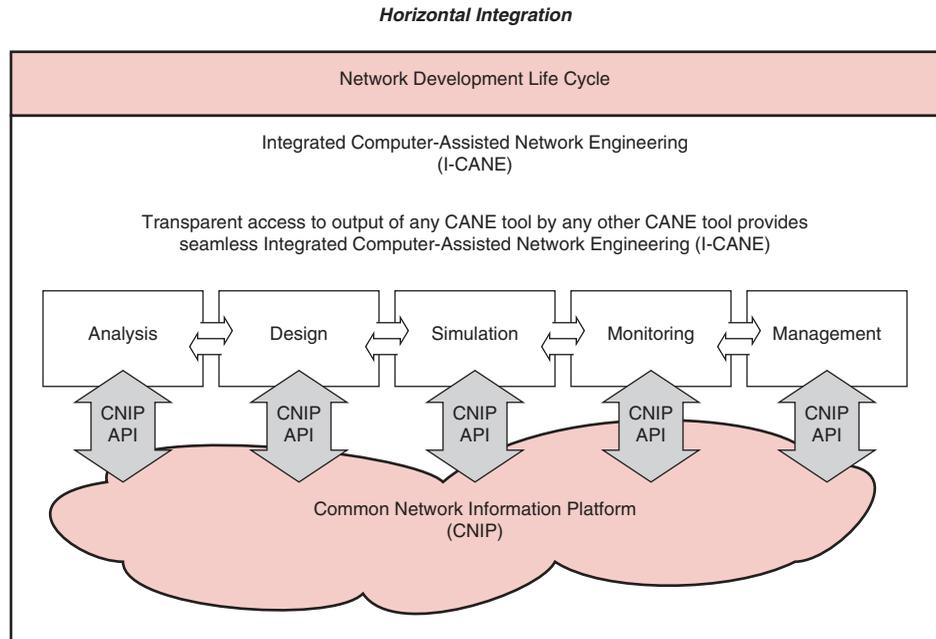


Figure 10-25 The Future of the Automated Network Development Life Cycle—Horizontal Integration

Integrated CASE (I-CASE) tools could generate code for a new corporate-wide application and could download key information concerning that new application to the CANE suite of software products to predict network impact of the new proposed application.

Proactive network management is the result when the network implications of the deployment of new network-intensive applications are known before the actual release of the software.

As can be seen in Figure 10-26, the actual gateway between the I-CASE and I-CANE tools may not be a simple API. Because of the sophistication of the interface between these two platforms, expert systems may be required to dynamically model the relationships between the objects underlying the CASE tools and those underlying the CANE tools.

Extending the vertical integration above the CASE tools and the strategic information systems that they produce, expert systems could again maintain the relationships between major software platforms. Applications layer objects used by the CASE tools could be dynamically linked via expert systems to the objects representing the business rules and processes that, in turn, support strategic business goals and objectives.

Thus, although current technology may not possess the capability, the business information system of the future may interface to the strategic business planning person who amends strategic business goals and objects via a graphical user interface and point-and-click manipulation of business process objects. The changes caused by this business process reengineering are immediately forwarded via an expert system interface to the strategic information systems design that supports

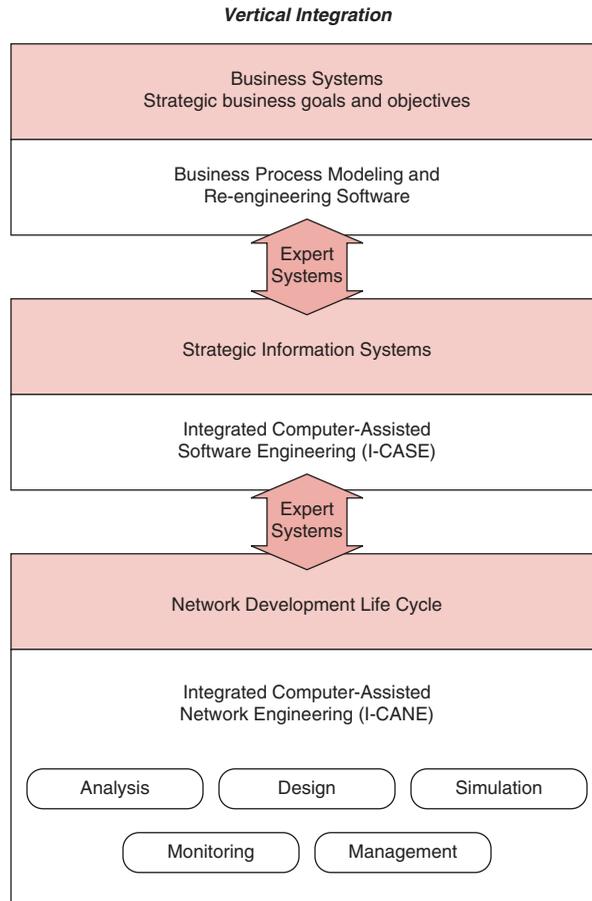


Figure 10-26 The Future of the Automated Network Development Life Cycle—Vertical Integration

these business processes. Changes to application programs would be automatically generated by integrated CASE tools.

Resultant changes in the applications programs produced by the CASE tools are immediately forwarded via expert systems to the integrated computer-assisted network engineering platform. Finally, network objects, circuits, and networking devices are amended as necessary due to the impact of the new applications programs. Network simulation programs are automatically run to assess network impact while network design optimization programs automatically reconfigure the network design to adjust most appropriately to the new network impacts. The amazing part of this whole process is that it was initiated originally by a change in strategic business objectives. The future of computer-assisted network engineering software represents one of the most exciting opportunities in data communications and networking while adhering to the overall top-down model philosophy of network design.

SUMMARY

As has been stated throughout the text, network design cannot be done in a vacuum. Effective network designs will only result from strict adherence to the top-down model by beginning with an analysis of business objectives rather than networking technology. Strategic information systems design must be conducted after business objectives and processes have been thoroughly examined. The importance of strategic information systems design lies not only in its delivery of business objectives but also in its role as a template for network design.

Information systems may be developed in-house or may be outsourced. In either case, it is essential to have a thorough and accurate RFP (request for proposal). Data traffic analysis is a multi-step process that assures that all potential sources of network traffic are identified and accu-

rately quantified. Circuit analysis and configuration alternatives match the proper WAN service to each location's data delivery needs, while network hardware analysis and configuration alternatives match the proper networking hardware with the location's input data and the installed WAN service.

Comprehensive budgets go beyond the typical proposal focus of acquisition costs to include categories for operations and anticipated network growth for a variety of cost centers and categories. Finally, although network design has been a manual process for many years, automated network design and simulation tools are beginning to become more popular as network scope and complexity make "back of the napkin" network design both impractical and unwise.

KEY TERMS

acquisition costs
baseline data
billing verification
business functional areas
business process reengineering
buy-in
CANE optimization routines
circuit analysis and configuration alternatives
CNIP
common network information platform
comprehensive systems & networking budget model
computer assisted network engineering
critical success factors
data traffic analysis
decision points
document flow analysis
evaluation criteria
feasibility study
flow analysis
horizontal integration
I-CANE

incremental change costs
IT project portfolio management
logical network design
make-or-buy decision
management abstract
mission-critical analysis
NDLC
network analysis & design methodology
network development life cycle
network engineering
network hardware analysis and configuration alternatives
operations costs
opportunities for improvement
payload type analysis
percent of fit goal
performance engineering
performance metrics
physical network design
pilot tests
proactive performance assurance process
process flow analysis
project charter product

protocol stack analysis
request for information
request for proposal
return on investment
return on opportunity
RFI
RFP
ROI
ROO
strategic information system design
TBO
TCO
three-pile approach
thresholds
time studies
total benefit of ownership
total cost of ownership
traffic volume analysis
transaction analysis
vertical integration
what-if analysis

REVIEW QUESTIONS

1. Explain how one can assure that IT projects are aligned with strategic business initiatives.
2. Explain how IT project portfolio management works and how it is able to adapt to different corporate business situations.
3. What is the difference between total cost of ownership and total benefit of ownership?
4. What is the difference between return on investment and return on opportunity?
5. Why does total cost of ownership calculation not lend itself easily to IT projects?
6. What is flow analysis and why is it important?
7. Explain how the NDLC interacts with strategic level business and IT infrastructure alignment.
8. Explain how the NDLC interacts with project specific activities such as RFP generation.
9. What are performance metrics and how can they help to assure IT/business alignment?
10. Where does the network development life cycle fit in the overall systems development life cycle?
11. How can one insure that a network design will meet strategic business requirements?
12. How can a company cost justify the expense of network analysis and design software?
13. What does optimization accomplish in network design software?
14. What are the two major characteristics on which networks are optimized?
15. Can these two optimization characteristics conflict with each other?
16. How is horizontal integration of CANE tools likely to be enabled?
17. How is vertical integration of CANE tools likely to be enabled?
18. What is so significant about the comprehensive systems and networking budget model?
19. What is meant by the term critical success factor? Discuss three.
20. What is the significance of process and product in the network analysis and design methodology?
21. What are the important elements of data traffic analysis?
22. Explain the relationship of data traffic analysis, circuit analysis, and network hardware analysis.
23. Explain the importance of evaluation criteria and percent of fit goals to the overall network design process.
24. What is the purpose of an RFP?
25. What are the major components of an RFP?
26. How can the RFP process be kept as objective and non-political as possible?
27. What types of information must be gathered about each corporate location?
28. How can a network analyst assure widespread support of new systems or network implementations?
29. What is cyclic about the network development life cycle?
30. How can computer-assisted network engineering software products exhibit the same cyclic nature?
31. Why are seasonal or occasional differences in transaction volumes or processes so important to network design?
32. What are some of the potential advantages and disadvantages of outsourcing network analysis and design functions?
33. How can so-called backroom politics affect network development and how can a network analyst minimize such effects?
34. What does corporate culture have to do with the method in which a network development project is carried out?
35. What does buy-in imply beyond simple agreement and why is it important to the network development life cycle?
36. How can responses to RFPs be objectively evaluated to determine those vendors worthy of further consideration?
37. What is the role of protocol analyzers in the network development life cycle and in the functionality of network optimization tools?
38. How do network analysts assure that they have a clear understanding of a business problem before proceeding to a network solution?
39. What is the importance of baseline data to the ability to articulate the eventual success or failure of a network development effort?
40. How can too much information be as detrimental as too little information for decision makers? What effect on network design might this have?
41. What is the danger in not starting the network development life cycle with an examination of business layer issues but merely networking business operations as they currently exist?
42. How can the amount of work invested in the development of an RFP be justified?
43. Why is the customer's proposed project schedule important to potential vendors?
44. What is the importance of the corporate location by location survey?
45. Although specific questions asked of vendors in an RFP may vary, what are the overall objectives in asking for this information?

46. How can a network analysis project leader assure that vendor demonstrations are objective and useful and don't revert to "dog and pony" shows?
47. What are some of the difficulties in transporting voice and data simultaneously?
48. What are some of the promising network technologies for transmission of video and data on both the LAN and WAN?
49. How can an I-P-O diagram be used to assist in the proper selection of network hardware devices?
50. Describe those items beyond acquisition costs which should be included in a network budget as well as the importance of those items.
51. What impact has object-oriented programming had on network design and simulation tools?
52. What is so proactive about proactive LAN management? What is the likely business impact of proactive LAN management?
53. Differentiate between ROI, TCO, and TBO in terms of methodology as well as appropriateness for network development projects.



⋮ **Case Study:** For a business case study and questions that relate to network development, go to www.wiley.com/college/goldman.