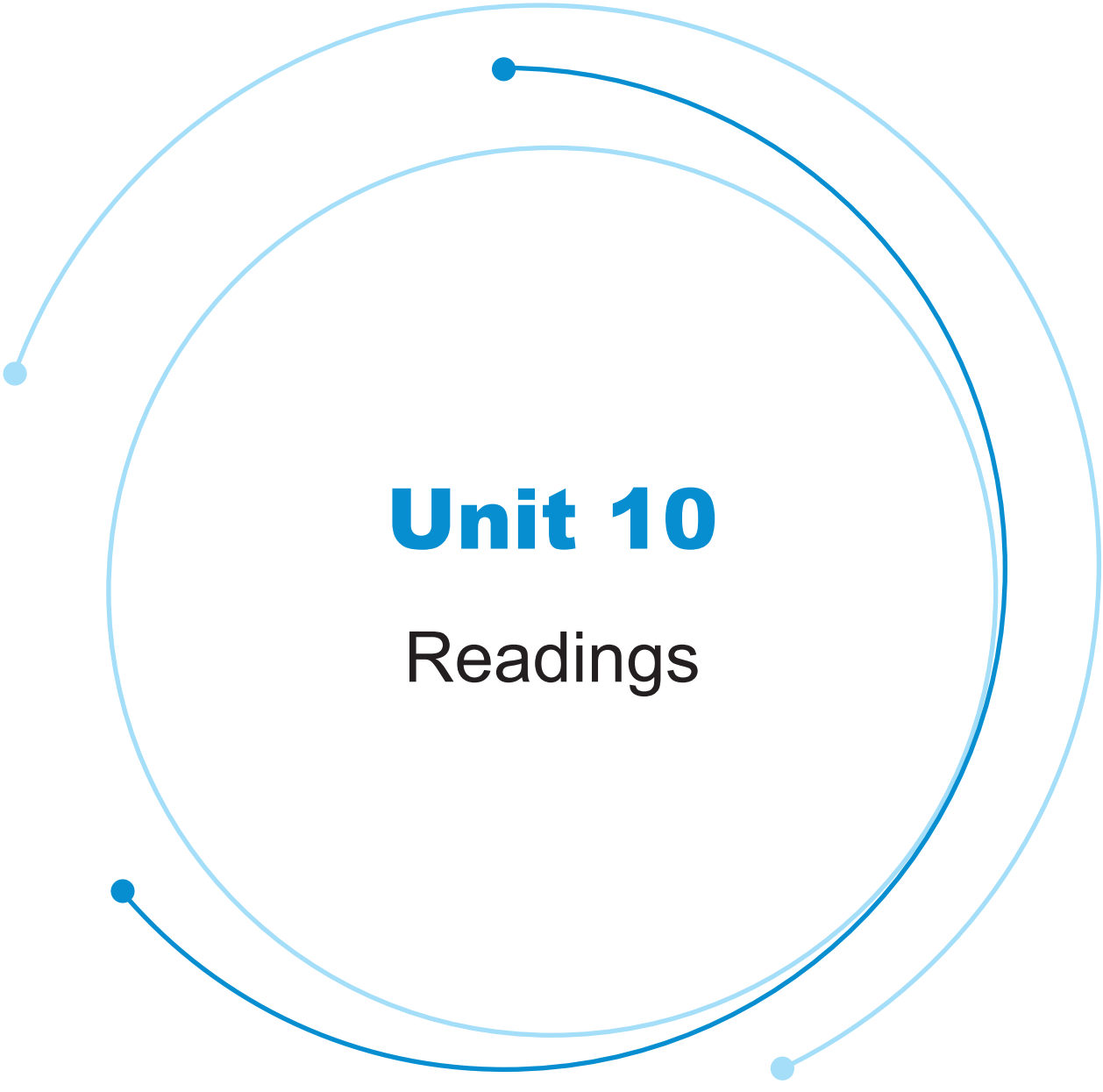
ELEC S212

Network Programming and Design



Unit 10

Readings

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Readings

Copyright acknowledgements

Readings 10.1–10.2.

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10.1

Dean, T (2002) 'Managing network design and implementation' in *Network+ Guide to Networks*, 2nd edn, Course Technology, 810–18.

many people, require significant capital outlay, or influence a company's profitability, project management is essential to ensure the project's success. This chapter will discuss not only project management, but also techniques for approaching typical network implementation projects.

Introduction to Project Management

Project Management is the practice of managing resources, staff, budget, timelines, and other variables so as to achieve a specific goal within given bounds. For example, if you were a Web site development consultant, you might use project management techniques to establish an online store for a national furniture retailer. The project might be constrained by time (for example, you might aim to establish the e-commerce site before November 1 so as to cater to holiday shoppers), money, or the number of developers who can help you with the project. In the networking field, you might employ the basic principles of project management in the process of replacing the CAT3 wiring in your organization's building with CAT5e wiring.

Every project begins with identifying a need (although, of course, identifying a need may not result in a project). As you will learn later in this chapter, you can conduct a feasibility study to determine whether a particular need warrants a full-fledged project. If the feasibility study confirms that a project is necessary, you must appoint a project manager and begin planning the project. As discussed in the following section, the project manager's first step is to conduct a needs assessment and establish the project goals. Only then can the project manager create a project plan.

The other elements of a full-scale project include participants, funding, a specific means of communication, definitive processes, contingency plans, and a testing and evaluation phase. The following sections describe these elements in more detail.

The Web offers many valuable resources for project managers. A good place to start is at the Project Management Institute's Web site for project managers at www.pmi.org.

The Project Plan

A **project plan** is the way in which details of a managed project (for example, the timeline and the significant tasks) are organized. Plans for small projects may take the form of a simple text or spreadsheet document (in fact, they may begin as notes scribbled on a piece of paper). For larger projects, however, you will typically take advantage of project management software (such as Microsoft Project, PlanView, or PrimaVera Project Planner). Project management software facilitates project planning by providing a framework for inputting tasks, timelines, resource assignments, completion dates, and so on. Such software is also highly customizable, so you can use only a small portion or all of its features, depending on the scope of your project and your project management skills. Figure 16-1 shows a list of tasks as they might appear in Microsoft Project.

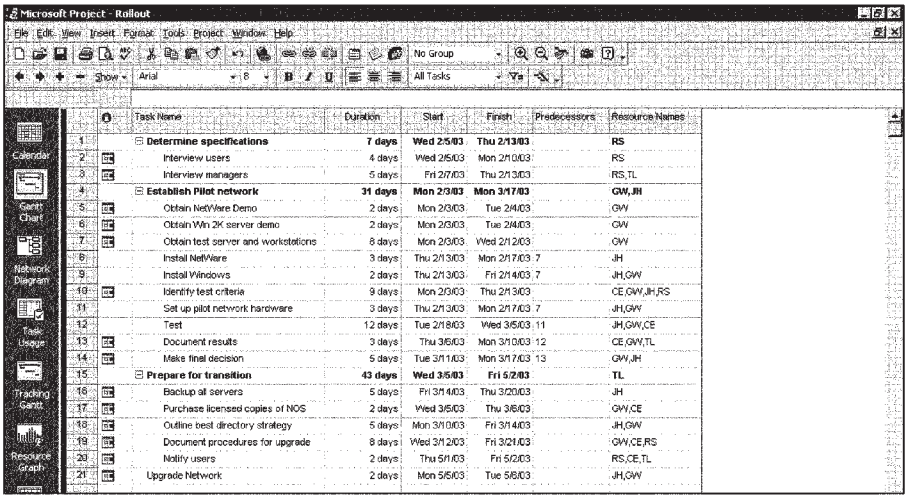

Figure 16-1 View of a project in Microsoft Project

No matter how large or small the project, its project plan will contain some common elements, as described below:

- *Task breakdown*—A project should be divided into specific tasks. Larger tasks are then broken into even smaller subtasks. For example, establishing an e-commerce Web site and server at an Internet service provider's data center represents a large task with numerous subtasks: obtaining racks for the equipment, ensuring backup and bandwidth capacity, obtaining software and hardware, installing equipment and software, configuring the hardware, testing the software, and so on.

You may find it tricky to separate a project into meaningful, discrete tasks that are specific enough to measure progress and guide participants, but not so narrow that they lose meaning. As you gain project planning experience, you will better be able to gauge how to best separate tasks into smaller but significant subtasks.

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- *Dependencies*—The project plan specifies which tasks depend on the completion of previous tasks before you can begin them. In some project management software, the tasks that must be completed before other tasks can begin are called **predecessors**. In the example of establishing an e-commerce server, you would have to determine which type of server you want to purchase before ordering the equipment racks. This ordering of tasks is necessary because racks come in different widths and depths. Thus the task of determining the type of server needed is a predecessor of the task of obtaining the racks. It's critical to examine potential dependencies in a project plan, because a dependency means that part of the project depends on another part. If you neglect to consider a dependency

at the beginning of a project, stopping to address it during the project may delay the schedule and impose unnecessary stress on team members, who must later rush to complete their tasks. Careful planning will reveal any dependencies that might affect the project's timeline and success.

- *Timeline*—The project plan should identify how long each task will take (with start and finish dates), which tasks take priority (due to dependencies), and how the timeline might change depending on resource availability or dependencies. Timelines are not always easy to predict. Seasoned professionals may be able to gauge how long a particular task might take based on their previous experience with similar tasks. Every project may entail conditions that affect a timeline differently, however. When creating a timeline, you should allow extra time for any especially significant tasks. For instance, in the e-commerce server example, the manufacturer might tell you that obtaining the equipment racks will take one week. If you plan for delivery in a week, and the installation of the Web site depends on this task, your entire project will be delayed if the racks don't arrive for two weeks. A **Gantt chart** is a popular method for depicting when projects begin and end along a horizontal timeline. Figure 16-2 illustrates a simple Gantt chart.

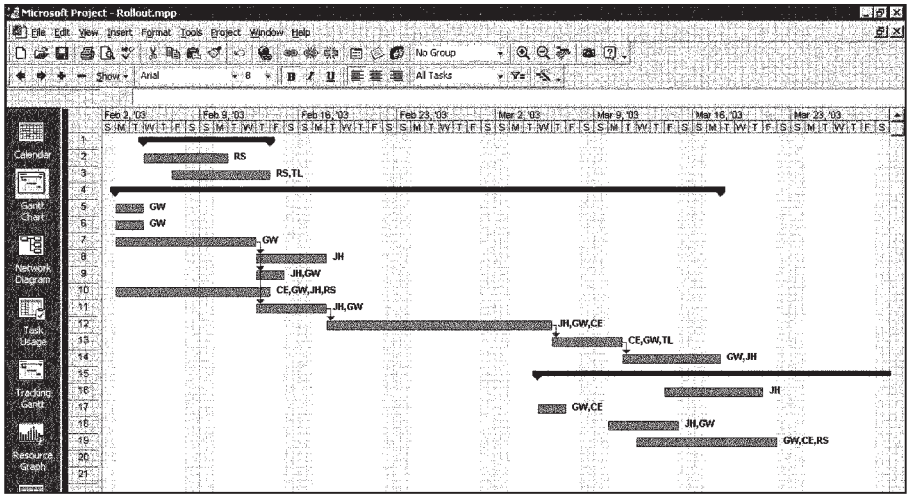

Figure 16-2 A simple Gantt chart

You may be asked to plan a project with seemingly impossible deadlines. One technique for making the project fit into a tight time frame is to work backward to create the timeline. In other words, begin at the project's predetermined endpoint and move toward the beginning of the project, allowing the normal time requirements for tasks. This method will highlight which tasks may delay the project and therefore need to be dropped or modified, at least temporarily.

- *Resources*—All projects require the staffing, materials, and money that are collectively known as **resources**. A project plan can specify all resources needed for each task or group of tasks. At the very least, it should identify who is responsible for tasks, whether it is a committee, consultant, manager, or technical person. This person is the **owner** of the task. The owner does not necessarily have to perform the work himself or herself, but nevertheless must ensure that it is completed on time and within budgetary guidelines.
- *Milestones*—Every project has significant accomplishments that mark specific steps in their progress. In project planning, a **milestone** is a reference point that marks the completion of a major task or group of tasks in the project and contributes to measuring the project's progress. For example, if you were in charge of the e-commerce server project, you might designate the completion of the software installation on your server as being a milestone. Milestones are particularly useful in large projects that have high visibility within the organization. They provide a quick indication of a project's relative success or failure.

In addition to these elements, project plans may provide information on task priority, the amount of flexibility in the timeline, task successors, links to other project plans, and so on. With most project planning software, you can add your own columns to the plan and insert any type of information you deem appropriate. For example, if you are managing a very large network design project, you might create a Web site with links to documentation for each phase of the project. In the project plan, you might include a column to list the URLs of the documents for each task or group of tasks.

During the course of a project, the project plan will likely undergo several changes. Some changes may result from unforeseen circumstances; others may reflect milestone evaluations and adjustments. Later in this section, you will learn more about these contingencies and how to plan for them.

Project Participants

As mentioned previously, each project depends on many resources. The human resources involved in a project may be employees from your department or other departments within the organization, outside consultants, vendor representatives, or employees from other organizations. Usually, human resources from various factions work together in teams. Although a single person may handle some project tasks (such as ordering a server,

updating a document, or configuring a router), larger tasks should be accomplished by teams. For example, as the project manager for a network redesign, you might assign the task of determining how to upgrade the backbone to a team consisting of a cabling vendor, a network technician, a facilities architect, and an IT manager. In an organization with limited staff members, some project participants may belong to more than one team.

As a project manager, you probably won't supervise everyone involved in the project. Therefore, you need managers who agree with the project's goals and will strive to help you achieve them. These authority figures are called project **sponsors**. Although sponsors rarely participate in project tasks and do not necessarily supervise the project manager, they can lobby for budget increases necessary to complete the project, appeal to a group of managers to extend a project's deadline, assist with negotiating vendor contracts, and so on.

A sponsor may be the person who originated the idea for the project. For example, suppose users in your organization complain about slow network response time, particularly when they try to pick up their e-mail. As a network administrator, you respond to these complaints by finding out the source of the poor network performance. You determine that the problem lies in the fact that the network uses routers and a 10-Mbps transmission rate. To solve the problem, you would like to upgrade the network to be fully switched and to run at 100-Mbps. You write a proposal for the change and bring it to the director of IT. She agrees with your research and your proposal, so she offers to become the project's sponsor. She will take your proposal to your company's executive board and attempt to obtain approval for the resources necessary to complete the project.

Another important group of project participants comprises the stakeholders. A **stakeholder** is any person who may be affected by the project, for better or for worse. In the example of upgrading a network to a fully switched, 100-Mbps environment, the stakeholders will include users (who will benefit from faster network access), executives (not only because they are network users, but also because they have responsibility for the budget), IT managers (who will ultimately determine the success or failure of the project), and project team members. Typically, the stakeholders are the people to whom the project teams must answer. At the beginning of a project, it is wise to communicate the project's goals, timelines, affects, and contingencies to project stakeholders. As you'll learn in the next section, it is also advisable to maintain regular communication with stakeholders about the project's progress.

Funding

Every project—whether it entails a simple hardware upgrade or an entire network redesign—requires funding. A project budget is usually set at the beginning of a project and approved by a hierarchy of managers whose staff participate in the project. Of course, a project's budget will depend on its breadth and complexity. As a project manager, you may have little control over the project's budget after it is established. For this reason, you should estimate your costs generously in the initial proposal for the project. It is always preferable to complete a project under budget than to continually appeal for more funding.

In some cases, the amount of funding available to your project can help to make other resources available. Naturally, if managers allocated $200,000 to your project rather than $20,000, you will have 10 times more money to spend on staffing, tools that might make your teams more efficient, or state-of-the-art hardware and software. Sometimes, however, no matter how much funding is available to your project, other constraints may block your progress. For example, your project of upgrading the company's customer service database may depend on the highly specialized knowledge of just two programmers who originally developed the system. Even a budget allocation of $2,000,000 for contractors or new staff wouldn't help you obtain qualified staff, because only these two programmers truly understand how the application works. In addition, the software they're creating might be constrained by functional limits on how many people can change the code at any given time. Thus your project is forced to rely on the efficiency of those two programmers.

Communications

Even if a project has sufficient funding, technical staff, and support from sponsors, it will falter if communication methods are not well defined and carefully followed. Communications are critical for several purposes:

- To ensure that a project's goals are understood by participants, stakeholders, and sponsors
- To keep a project's timeline and budget on track
- To encourage teamwork among participants
- To allow you to learn from previous mistakes
- To prevent fingerpointing if a task is not completed correctly or on time
- To avoid duplication of efforts
- To prepare stakeholders for the effects of the change

At the beginning of a project, the project manager should take responsibility for establishing the methods of communication. Suggested methods include weekly status meetings, daily status briefings for each team, weekly messages to stakeholders about the project's progress, monthly reports that compare a project's *anticipated* spending and timeline with its *actual* spending and timeline, distribution lists for each project team to share e-mail correspondence, and a Web page containing an archive of meeting minutes and other important documents pertaining to the project. Be creative—you might find other effective ways to communicate within your team. Whatever methods you choose, keep in mind that carefully fostered teamwork will contribute to the success of your project.

Processes

In almost everything you do, you follow a process: buying groceries, reading a book, building a deck. When you perform these tasks alone, you can do them whichever way you prefer. When a team of individuals must perform tasks together, however, agreeing on a process beforehand will help to ensure that the task is completed efficiently and that the team's efforts result in a desirable, high-quality outcome.

Process management consists of planning for and handling the steps needed to accomplish a goal in a systematic way. The processes you might manage during a project's implementation include change, support, training, transitioning, delegation, and problem resolution. If you've never managed processes before, it may be difficult to envision this endeavor without concrete examples. Consider how process management can help in the following scenarios:

- You and your colleagues decide to upgrade the network operating system on one of your file servers. You are responsible for ensuring that the change works correctly. Before performing the upgrade, you may want to define a change process. The change process could include notifying potentially affected users at least five business days before you make the modification, documenting exactly what the change will involve and who will make it, backing up the server prior to making the change, and providing a plan for reversing the operation should it cause problems on the server.
- A new network administrator is hired to shoulder some of the responsibilities previously assigned to an existing network administrator. The current network administrator plans to go on a two-week vacation on a remote island only seven days after the new network administrator starts. Before the new employee arrives, you may want to establish a training process. Part of this process could include asking the existing network administrator to identify recently completed tasks, outlining a training plan for the new employee, and identifying other employees who can act as resources for the new employee in different subject areas.
- You manage the 7 days a week, 24 hours a day support team for a corporate LAN. If serious problems arise during the night or on weekends, you may need to help with problem resolution. Having a problem management process in place will make your job and the jobs of the support analysts easier. Part of your problem management process may include notification of all affected customers if the problem hasn't been resolved within 30 minutes, maintenance of a list of second-level support contacts, instructions for how to record the problem in a call-tracking system, and procedures for contacting vendors required to troubleshoot hardware or software.

For any endeavor that requires the cooperation of several team members, process management is a wise investment of time. Creating a process will not be sufficient, however, unless everyone understands the process. You must ensure that the process is communicated to all

participants. Begin by proposing the need for a process at a meeting and ask for participants' input. After drafting the process, distribute it as a memo or post it on a Web page where everyone can find it. During the course of a project, urge colleagues to follow the agreed-upon processes.

Processes help you manage unusual or troublesome situations. In the next section, you will learn about another element of project management that can guide participants when things go seriously awry.

Contingency Planning

Even the most meticulously planned project may be derailed by unforeseen circumstances. For instance, a key team participant may quit, your budget may be unexpectedly cut, or a software package may not work as promised. Each of these conditions may threaten to delay your project's completion. To prepare for such circumstances, you must create a contingency plan at the beginning of the project. **Contingency planning** is the process of identifying steps that will minimize the risk of unforeseen events that endanger the quality or timeliness of the project's goals.

Although you cannot predict all possible pitfalls in a project, you should at least plan for the most likely hazards. To identify potential threats to the success of your project, you should analyze your organization's history. For instance, you may work for a company that is notorious for taking team participants who have committed to one project and switching them to new projects. In that case, you may want to increase the number of people working on the project initially, so that losing one or two participants will not detrimentally affect your project's success. Alternately, you may want to budget for subcontractors to step in when or if your organization's staff members become unavailable. In another organization, you may have experience with programmers who chronically underestimate the time needed to customize programs for your users. In this case, you should add time to the customization tasks to plan for the possibility that the programming will take longer than the programmers suggest.

In a networking project, taking some of the following measures in the beginning can prevent you from having to scramble during the project's implementation:

- Order more hardware components than you think you need.
- Ensure that your hardware and software vendors have extra components on hand and that they will respond to your requests.
- Document each piece of hardware and software that you order for the project. Also, keep a tally of supplies as they are received.
- Rely on a pilot network to test your project's goals (for example, to determine whether choosing switches over routers will improve your network's performance), in addition to testing the hardware and software components (for example, each switch that you purchase) that you will use.

- If the technology required to implement the project is new to project participants, ask a local consulting company with expertise in that technology to be available for questions in case you need help.

The amount of preparation you perform for each contingency should be commensurate with the potential effects of that possibility. For example, if you were planning a demonstration of your application to a very high-profile client who was considering purchasing the application for $5,000,000, you would want to plan a backup for everything that could possibly go wrong with your presentation. On the other hand, if you were planning a demonstration of the same program to your colleagues, you may not spend much time wondering what to do in case the splash screen containing your company logo doesn't appear.

Another way to help ensure your project's success is to perform regular testing and evaluation, as discussed in the following section.

Testing and Evaluation

Once you have reached a project milestone, you will want to verify that you are on the right path. One way of accomplishing this goal is through testing. For instance, if you were managing a project to upgrade a building's LAN from 10 Mbps to 100 Mbps, you might want to tackle one small segment of the network first. Before moving to the next segment, you should ensure that all workstation and switch or router configurations on the first segment work correctly. By confirming this fact, you can potentially prevent future down time or troubleshooting.

To successfully test your implementation, you must establish a testing plan that includes relevant methods and criteria. For example, your method of testing the network performance may be to use the Windows 2000 Server Network Monitor program from a server. For each performance test you perform, you will want to replicate this arrangement, so that you can compare your results across the various tests. In this case, the criteria you use to measure network performance may be the number of bytes that travel from one particular workstation to the server every five minutes.

Once you have devised a testing plan, emphasize to all project participants how vital it is to adhere to the plan. If participants ignore the testing plan for a backbone upgrade, for example, they might be tempted to quickly set up a workstation on a new network segment and assume that if they reach the network login prompt, the change is a success. Unfortunately, this approach may overlook protocol or transmission speed issues that can cause problems later. To provide an accurate assessment, a test plan should address at least the following questions:

- Was the change nominally successful? (For example, if the change comprised a backbone upgrade, can a client on the new backbone connect to the server?)
- Did the change fully accomplish its purpose? (For example, if the change comprised a backbone upgrade, did it result in a performance improvement?)
- If the change did not fully accomplish its purpose, did it partially accomplish its goal?

10.2 Edwards, J and Bramante, R (2009) *Networking Self-Teaching Guide*, Wiley, 514–18.

A few disadvantages of link aggregation include:

- Requires additional interfaces on each end[39]
- Higher potential of configuration errors
- May require device driver updates to ensure compatibility with link aggregation

POP QUIZ

What is forwarding delay?

LACP was introduced in 1999 as a standardized way to aggregate multiple gigabit links in a high-speed LAN. As many LANs already supported some proprietary form of aggregation — for instance, Multi-Link Trunking (MLT) for Nortel and Inter-Switch Link (ISL) trunking for Cisco — for lower-speed networks, it was already well known that these were proprietary and did not work with other vendors' equipment. LACP resolved this for the gigabit world, and things have been growing ever since. Link aggregation has been supported from switch-to-switch, router/server-to-router/server, and switch-to-router/server since it came out, but now many NICs support LACP, allowing aggregation to the end-user level. Although it isn't used everywhere and a lot of LANs still use proprietary standards, we predict that it won't be long for this to be the standard of choice. Of course, at the time of this writing, there are a few proprietary solutions that are under standards review, so who knows what tomorrow will bring?

12.5.3.5 Virtual LANs

Early on in this book, we determined that a LAN is a data network that serves a small geographical area. Most of us think of a group of nodes connected to one another as forming a LAN (in other words, a broadcast domain). Larger organizations have an organizational LAN that is made up of several broadcast domains, the extent of the LAN being the area it covers or a distance-limiting factor. With the LAN, the limits remain for as long as the node exists in the LAN. What we mean by this is that within a LAN, the logical topology is limited to the physical topology as well. Figure 12-22 shows an example of this. You can only adjust those limits by having additional nodes to collect the broadcast domains that may be located within the same area. In addition, a router is required to ensure that broadcast domains are separated, reducing the effectiveness of the router.

[39]You may have to buy more equipment, either now or in the future. Not only may you have to purchase more gear now to support this, this also means that you could be consuming empty slots on existing nodes. Although this is great for now, you may have to buy more in the future.

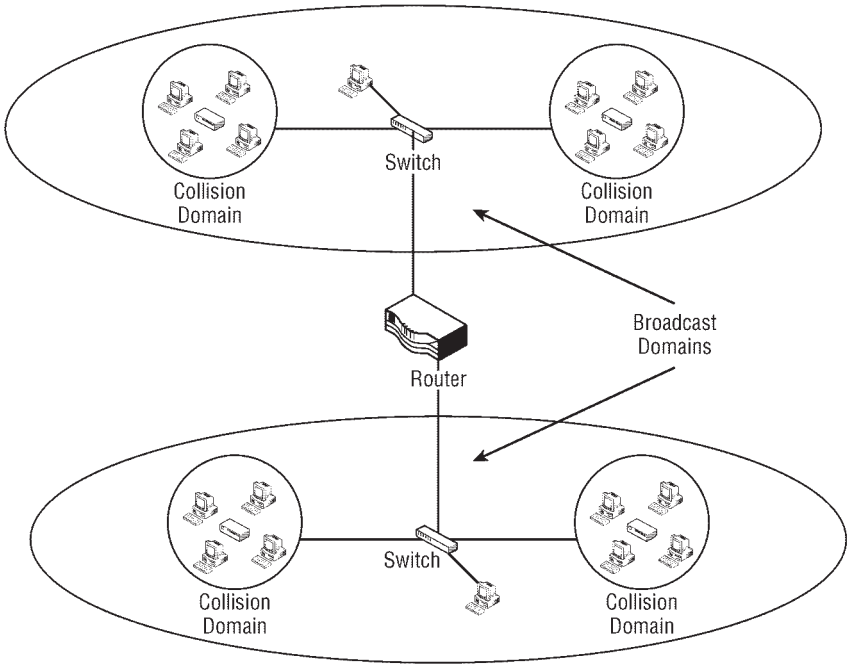

Figure 12-22 A traditional LAN

The virtual LAN (VLAN) was developed to give a LAN bridge the capability to separate these broadcast domains. This not only frees up the router to perform other important functions, but it also allows the network administrator to be flexible in domain configurations. Nodes no longer have to be in the same physical area to participate in a particular broadcast domain. Figure 12-23 shows an example of this. Notice that in each of the VLANs, there are members of each VLAN on each switch. This is a rough example, but the intention is to show that members of VLANs no longer have to be physically together to be in the same broadcast domain.

12.5.3.5.1 Benefits of VLANs

There are a lot of benefits to having VLANs configured in your LAN. Some of these include:

- Better performance. Only VLAN members receive multicasts.
- Members of a group no longer have to physically be located close to the group.
- Administration is easier. Changes to any work area can be done with simple configuration change.

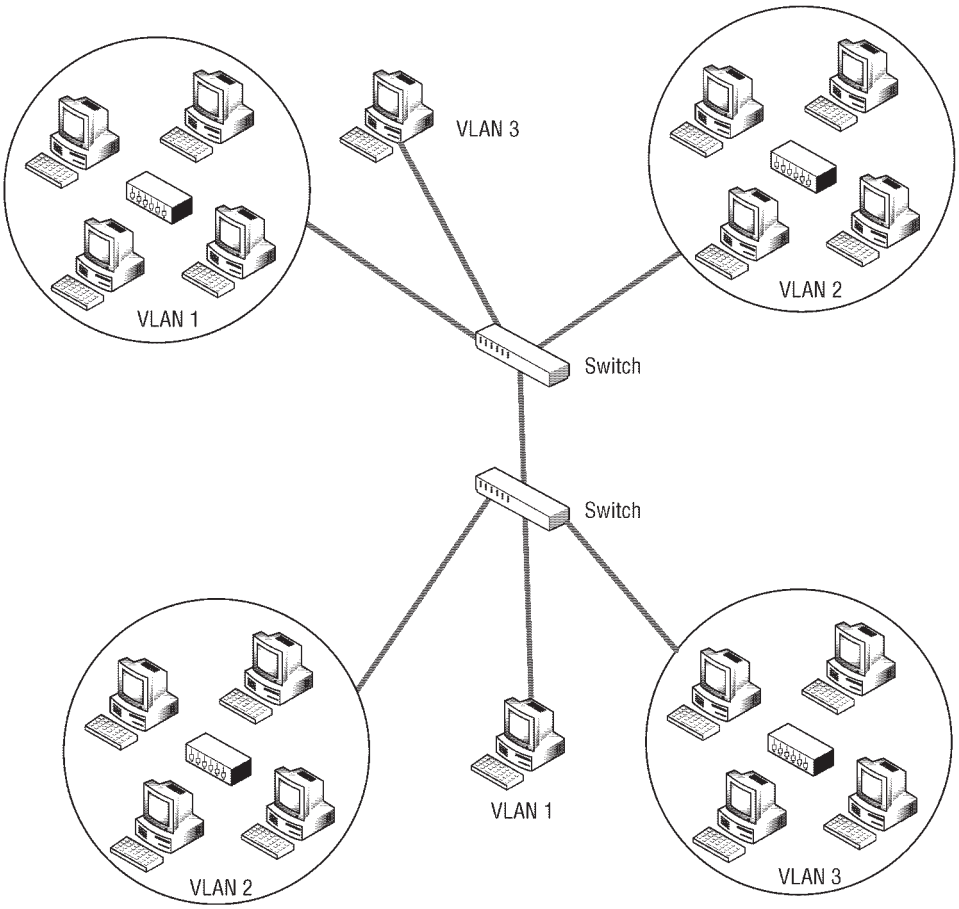

Figure 12-23 A VLAN

- Increased security. Only nodes within a VLAN have access to data.
- No need for a router in order to separate the broadcast domain.

RANDOM BONUS DEFINITION

individual port — A switch port that cannot form an aggregated link with any other port.

12.5.3.5.2 VLAN-Awareness

A node that participates in a VLAN, whether it is a user node or a LAN switch, is known as a *VLAN-aware node/switch*. This simply means that the node is aware of the VLAN rules and is participating in such an environment. VLAN-awareness is the capability to understand that there is an underlying function that allows the mapping of frames to the correct and appropriate

destination(s). VLAN-aware switches make forwarding decisions based on the destination address as well as the VLAN to which the frame belongs.

12.5.3.5.3 Tag! You're It!

To determine which VLAN a particular frame is a member of, the VLAN environment uses either implicit tagging or explicit tagging. When the switch receives a frame, it will "tag"[40] the frame with the VLAN identifier where the data came from. This process is known as *explicit tagging* (commonly referred to as *VLAN tagging*, or simply *tagging*). The other type, *implicit tagging*, is a method of mapping an untagged frame to its associated VLAN by inspecting the contents of the frame.

Information that is contained within the explicit tag can be based on MAC address, port, and any other combination of information, but will always contain the VLAN identifier. VLAN tags can be set by a VLAN-aware node, or they can be assigned to a frame when received on a VLAN-aware switch. When a VLAN-aware switch receives an untagged frame, it applies the VLAN mapping rules and forwards the frame with the tagged bit set.

The implicitly tagged frame is a frame that has no tagging at all. Forwarding decisions are made based on the source address, protocol type, network identifiers, etc.[41]

AN UNRELATED MOMENT OF PAUSE – WHAT IS IN THE WORD "TAG"?

In the preceding section, we discussed an implicit tag and an explicit tag. But what other uses are there for the word "tag"? One of the first things that I thought of was the kids' game tag, as in "Tag! You're it!" It wasn't so much me wanting to relive my childhood, but with five kids under my belt, I have spent many weekends playing tag in the backyard.

The next thought when I think of the word "tag" is my two boys, who outgrew tag long ago. Both of them went through a phase where they were constantly squirting Tag body spray on themselves. I thank goodness that the stampede of women you see on the commercials never came charging at the house.

You can call a small label a tag, although I think that "label" is perfectly fine. Tagging a wall means adding your personal graffiti, which some consider art (I have seen some impressive tagging). Your car has a couple of tags on it: a VIN tag, tax tag, license tag, and so on and so forth. There are tags in computer programming, tags on the shelves in the grocery store – as a matter of fact, I don't know that we could get through life without tags. Seriously, try getting through life without seeing that gas is at $4.00 a gallon. Okay, that's a tag we could all do without.

[40] A tag is a field inserted into a frame that provides an explicit indication of the VLAN association for that frame.

[41] And any such combination that is predetermined.

12.5.3.5.4 VLAN Types

Membership to a particular VLAN is based on the following criteria:

- **Port-based VLANs** — Port-based VLANs are determined by the ports that are members of a particular VLAN. This is a Layer 1 decision, as no Layer 2 or 3 data is used to make the membership determination.
- **MAC-based VLANs** — MAC-based VLANs are determined by the MAC address of the nodes that are members of the VLAN.
- **Protocol-based VLANs** — Protocol-based VLANs members are determined based on the protocol type in the header of the Layer 2 frame.
- **IP subnet–based VLANs** — IP subnet-based VLAN members are determined by the subnet address contained in the Layer 3 header. This does not mean that a Layer 3 VLAN can route. It cannot. This means there is a Layer 3 subnet address used for the VLAN membership rules.

POP QUIZ

What is implicit tagging?

12.5.4 Determining What Other Determinations Need to Be Determined

This section discusses a few things you should consider in designing a network. Some of the items are good practice talking points and the rest are provided as a vehicle for thought. Some of the determinations are based on decisions particular for your environment. Will you be using SNMP management? Is there a need for secure remote access? How much documentation is appropriate for your network? These are only a few questions that will be answered in this section.

If there is anything missing from this section that you feel is important, blame Rich![42]

12.5.4.1 Talking to a WAN

With any luck, your LAN won't require a connection to a WAN. Individual dialup sessions can be handled by the users on the network, if they require remote connectivity. This is ideal because the number of security issues that you could potentially have is reduced.[43] If this type of LAN works for you, go for it — it will be a gem to maintain in the long run.

[42]Just kidding! Jim can't help but give Rich a hard time.

[43]If you are not connected to a WAN, then a hacker has no way in, unless he is already in. The majority of security incidents in corporate LANs can be attributed more to physical (human) carelessness (some examples are losing laptops, leaving areas unsecure, not securing passwords, etc.) than to maliciousness.