Chapter 3

Testing and Lab Strategy Development

This chapter covers the following topics:

- Cost Analysis and Resource Planning
- Test Organization Financing Models
- Outsourced Testing
- Test Lab Facilities Design
- Test Lab Operations

Chapter 1, "A Business Case for Enterprise Network Testing," examined the significant role that an IT infrastructure plays in enabling revenue growth and driving cost efficiencies in a business. In the process of considering this role, we examined the monetary costs of IT service outages to a business, and found that they are often the result of network problems caused by unverified changes or unpredictable behavior during equipment or software failure. Chapter 2, "Testing Throughout the Network Lifecycle," went on to explain how adopting a structured test program can help to minimize these outages, and how testing fits into the overall Enterprise Architectural strategy of an organization.

All of this theory is useful, but applying it to a real business with a closely scrutinized budget for IT spending can be challenging. You need to know the costs associated with building, staffing, and operating a lab, understand best practices when building a lab facility, and know when it make sense to outsource certain test functions.

This chapter explores all of these issues. The chapter opens with a business cost analysis of test organization startup, followed by a discussion of various funding models. Best practices for test lab facility design are then presented, and the chapter concludes with a section on test lab operations.

Cost Analysis and Resource Planning

As with any business venture, the decision to undertake a test exercise has costs associated with its adoption and risks associated with its rejection as a course of action. Assuming that the risks of whether or not testing should be done in the first place are well understood, as discussed in previous chapters, this section provides some guidance with respect to the cost analysis of a proposed test environment.

Generally, business costs are examined in terms of capital expenditures (CAPEX) and operational expenditures (OPEX). CAPEX is typically defined as expenditures necessary to acquire assets with a useful life extending beyond the current tax year (hence the need to capitalize or depreciate the costs over a period of time). OPEX, on the other hand, can be defined simply as the ongoing costs of running a system or product.

A business entity's desire to use capital versus operational funds can be influenced by the current business and economic climate. These considerations may override other drivers pushing the business decision in a direction that is not otherwise indicated by the technical analysis.

Note that an initial "build versus buy" decision could also be made with respect to network testing. That is, the test effort can be either executed in-house or outsourced to a test services provider. This decision has a clear business impact: An outsourced approach would have minimal, if any, CAPEX costs and would be primarily accounted as an operating expense. The initial establishment of a test facility can be very costly, and careful assessment of the return on investment (ROI) needs to be made to determine the appropriate approach for any given venture.

Estimating CAPEX Necessary to Create a New Test Lab

The initial establishment of a medium- to large-sized test lab can be very costly and usually has significant CAPEX impact. Space needs to be established, and fixed assets need to be procured to support the test efforts. These components factor into the initial capital outlay to establish the lab, as well as ongoing capital expenditures to enhance the facility. The following sections examine these considerations in greater detail.

Environmental Considerations

The environmental requirements for test labs can vary significantly, ranging from a small amount of network gear located in a separated area to multithousand-square-foot facilities with electric consumption in the megawatt dimension.

In either case, a test lab should be given sufficient dedicated space to allow staff to perform their duties and provide the results needed, as dictated by the business requirements. Failure to provide sufficient lab resources to perform the expected level of work is simply wasteful and should not be attempted, although frequently the cost analysis provides an inclination to cut corners.

The following environmental factors should be taken into consideration when evaluating the startup of a new test facility:

- Physical space
- Power
- Climate control
- Access
- Other infrastructure

Physical Space

The test facility needs to be a distinct, separated area that is not subject to the vagaries of staff needs or production network issues. Dedicating the space (and other resources) is critical to establishing a properly run lab. The space considerations need to include

- Network equipment
- Equipment racks
- Test gear
- Supporting servers
- Tools storage
- Lab infrastructure space (for items such as cable plant and power distribution systems)
- Infrastructure storage (cables, screws, consumables)
- Human space for staff movement and physical work aspects (for example, card extraction, installation activities)

The actual lab space may simply be a closed room reserved for this purpose, a controlled area in a data center environment, or even dedicated test-specific building spaces. It is important that the lab space be a controlled-access area to prevent "unauthorized reallocation" of the gear contained therein. You do not want the lab gear to be cannibalized for production projects or to become a "spares depot." The lab may or may not have raised flooring, depending on the approach taken for cooling and cabling. Applying antistatic measures to the lab area is highly recommended. This may include static-free flooring, antistatic treatments, static-free workbenches, static grounding straps for staff, and so forth. Compliance with the antistatic measures from both a staff and physical environment perspective should be verified at regular intervals. In all likelihood, these policies are already defined for the production environment and need to be applied to the lab as well.

Tip Make sure to verify that you meet safety requirements for your new lab location. Many locations across the world have stringent environmental, health, and human safety regulations. Also, it is a good idea to verify that your company's insurance will cover your lab as it built.

Power

The power consumption of a test lab needs to be examined and carefully laid out. This exercise begins with an understanding of the gear to be deployed within the lab and its power requirements. For example, power needs may vary from simple 110-V/15-A AC feeds, to 3-phase 13-kW AC or even 48-V/60-A DC plants. You need to determine the amount of power needed for initial lab establishment, and apply further analysis to estimated future needs. Installing power upfront typically is easier than adding it later.

When planning for growth, consider locating the power source as close to the lab as possible. If it is not run through the lab itself, at least establish breaker panel space and central feed capacity in the lab. Also, consider conduit limitations in this planning exercise, as the cost of adding conduit capacity to the testing facility may eclipse the cost of the additional circuits, depending on how the conduit is run. It is better to include larger conduit diameters early on than to rerun them later.

Grounding also needs to be addressed—not only from an antistatic perspective, as discussed previously, but also with respect to power and signal grounding. Sources of noisy ground loops can be very difficult to pinpoint and can result in highly erratic behavior of electronic equipment. The criticality of the lab operation may also drive the need for an uninterruptible power supply (UPS) system capable of supporting the needs of the environment. These systems are usually specified in terms of the amount of power that can be drawn over a given period of time. An analysis of the critical lab components and expected outage tolerances will lead to a determination of the level of UPS required (if any). Very expensive and sophisticated electronic gear will be housed in this lab space, some of which does not take well to simply being powered off mid-operation.

The power distribution grid also needs to be considered. It may be sufficient in some smaller facilities to simply use power strips with sufficient capacity. Other situations may call for busbar-based power distribution systems, typically mounted overhead. Some environments may use a combination of both. Note that power strips are now available that can be programmatically controlled, resulting in benefits of reduced power consumption as well as the capability to remotely power cycle the test equipment.

Any power distribution proposal should be vetted by and installed by professionals to ensure that installation is to specification, complies with all local codes, and is safe to operate.

Climate Control

As with other considerations, the need for a controlled-climate space will be dictated by the amount and type of equipment in the lab as well as human needs. Most of today's small network gear, such as 1-rack-unit (1RU) appliances or other equipment that is not typically rack-mounted, has been designed to operate within the confines of an office space or equipment closet and can tolerate considerable temperature swings. Larger equipment usually has more stringent environmental demands, and these should be observed in consideration of the greater cost of this hardware as well. Most manufacturers provide heat output and temperature operating tolerance information in their specification sheets. It is typically sufficient to simply total the heat dissipation numbers for all the gear in the lab to arrive at an expected thermal footprint (include network gear, test tools, and so forth). If heat output numbers are not available for some equipment, simply use a worst-case estimate that all of the energy consumed by the unit is converted to heat. Buildings personnel will be able to assist with interpreting this thermal output in terms of the required cooling for the area.

In the calculation of a total thermal energy number, factor in human involvement. For instance, if the lab is to be manned by several people, and a significant amount of their daily time will be spent in the space, then cooling for their own heat generation should be considered. Also, to support a comfortable work environment, lab staff should be able to change the temperature as long as it's within the equipment's acceptable heat tolerance range.

Also consider the actual airflow produced by individual pieces of equipment with respect to other pieces of equipment. Simply calculating a total heat number in a large space will not be sufficient if, for instance, one device's exhaust heat blows directly into the intake of another device. You also must consider how the airflow will occur, rack to rack and device to device, and how cold air enters the facility and how excess heat might be vented.

Tip Consider redundant climate control and power management systems for large labs. Losing power may impact several testing projects at once, and having cooling problems could damage millions of dollars worth of equipment.

Heating and cooling are not the only considerations for climate control: Appropriate humidity levels also help to mitigate static issues. Other considerations are airborne particles and pollutants; electronic equipment should not be run in "dusty" areas.

You also need to examine lighting from a lab operations perspective, because this will be a lab environment, not a heads-down office space. Staff needs sufficient lighting to perform their tasks in the lab, and this may include both general overhead lighting and task-oriented lights such as flashlights. However, if the staff is not normally present in the lab itself, lighting may be controlled so that it is in use only when needed.

Access

As indicated previously, physical access to the lab space must be controlled. An operational lab is totally dependent on the availability of the equipment within it, and the repurposing of such gear is a frequent failure point for many labs. Additionally, there is typically a considerable equipment investment in the test lab, including test gear and small consumables such as transceivers, pluggable optics, memory, and so on. The availability of this equipment is critical to a test lab and needs to be controlled. The lab staff should be cognizant that multiple activities may be ongoing at any given time, and limiting access to the lab also reduces the likelihood of interruptions to a test exercise because, for example, someone tripped over a cable.

Access to the test facility needs to accommodate bringing equipment in and out of the environment. Consider the need for accessibility, from loading docks to elevators to lab entryways, doors, and ramps, when planning the lab facility. Depending on the size and weight of the equipment in the lab, you might need to consider weight distribution, especially in areas where raised flooring is used or in labs located in older structures whose subflooring may not be able to hold the weight of some larger equipment. Some gear weighs thousands of pounds, and having a lab on the second floor of a building will require some thought. There are several stories about companies reinforcing the floor on the second floor lab in their building to support the extra-heavy gear, only to be foiled by an elevator that isn't capable of bringing the gear up. This lack of forethought has forced more than one facilities manager to remove windows and hire a crane to lift pallets of equipment into an office building.

An additional access perspective relates to how the lab staff accesses the equipment locally or remotely. Frequently, console port access, through the use of IP terminal servers, is used to configure and manage the device in the test bed. Such access is relatively slow, however, and if possible, there should be an out-of-band (OOB) IP management network in place to facilitate the use of protocols such as Simple Network Management Protocol (SNMP), Telnet, and Secure Shell (SSH). Other tools may also be accessible via Remote Desktop Connect (for Windows appliances), Virtual Network Connect (for virtual hosting services), XWindows (for UNIX/Linux environments), or even HTTP/HTTPS connections for web-based management.

As previously noted, programmatically controlled power strips are also available. This accessibility allows staff members to access the equipment and perform their tasks remotely from locations outside the lab. In most corporations, many of the lab users are not physically near to the equipment, and they may possibly not even be direct members of the test organization with administrative rights to gain physical access. Such power control units allow for a wider range of staff to participate in the testing.

Remote, or out-of-band, access can help to make the testing more meaningful to a larger community of interest and potentially increase the use of the gear (with a correlating improvement in ROI). To provide the infrastructure to support this operation, you need to establish network connectivity into the lab environment. This connectivity needs to be carefully provisioned so as to prevent violations of corporate security policies, and also to avoid inadvertent lab traffic leaking into the production network. It is recommended that the lab network space be isolated as much as possible from the production network space, preferably through the use of firewalls, to prevent lab tests from injecting instabilities into the production environment.

Other Infrastructure

The infrastructure aspects relevant to a test facility are often underestimated. The following should be considered in your test lab design.

Cabling Test labs have a voracious appetite for cables, and typically most estimates of cable needs are far too low to meet demand. Imagine how embarrassing it would be to explain to your VP that a critical test could not be completed because of a cabling shortage. At a minimum, sufficient cable should be on hand to accommodate all the available ports of the equipment in the facility. This should include unshielded twisted-pair (UTP), fiber optic, and serial cabling as appropriate. Because of repeated reuse and general abuse, cabling in a lab does not last anywhere as long as it does in your production environment. Cables do break and fray with use, and consequently will appear as an ongoing cost; as such, cabling should be accounted for in the OPEX budget for the lab.

Cabinetry Virtually all lab facilities can benefit from the use of racks or cabinets to house the test equipment. Even a small test bed of six or so devices will quickly devolve into a "rat's nest" of cables and have gear subject to sliding and even falling during use. A cabinet can be acquired, complete with shelving, power strips, and cable management hardware, for approximately $1000 and is well worth the cost.

Network Connectivity As previously discussed, a "lab network" can support IP connectivity for staff members who are not physically in the lab facility itself. A well-planned lab infrastructure will have considerations for remote user connectivity in addition to local connectivity to "shared services" on which test operations rely, such as NTP, DNS, TFTP, and FTP. Lab devices (routers, switches, appliances, and servers) often have a separate "management port" that is dedicated to these purposes, and it is common practice to design an out-of-band "lab network" with a singular purpose of connecting the management ports.

Structured Cabling If the lab is large enough to warrant a structured cabling plant, investment in one might be appropriate. In such a system, the equipment racks have prewired patch-panel "cans" available, which are run directly to a central patching area similar to a telco main distribution frame (MDF), where patches, manual or automated, are used to interconnect equipment which sits in rack distribution frames (RDF). Figure 3-1 provides a simple example of a structured wiring system. In this example, the router port in cabinet 10.07 can be interconnected to the Ethernet switch in cabinet 11.08 without running a "temporary" cable overhead or on the floor.

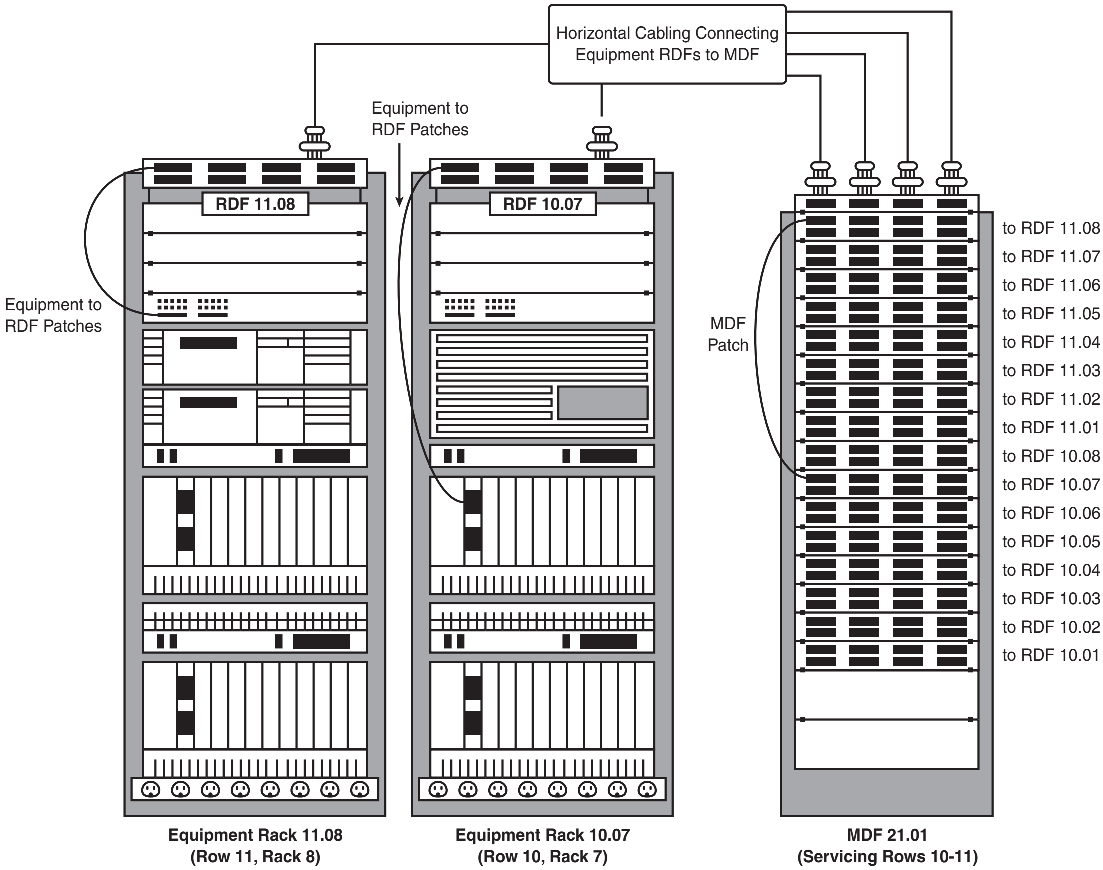

Figure 3-1 *Example Structured Wiring System*

Unit Under Test (UUT) Network Devices Any testing focused on network verification requires some level of simulated network infrastructure. To accomplish this, some amount of network gear is required to provide an environment representative of the production network. You should carefully review the production network environment and include the results as input to the test bed design exercise. Note that the test bed design effort is analogous to any design exercise in that it needs to consider all of the components used to provide the services supported in production. This necessitates the acquisition of sufficient equipment to be used as unit under test (UUT) network devices to conduct reasonable testing. Pricing for this equipment will vary greatly, depending upon the production network topology and the level of discounting your organization receives.

Test Tools Third-party tools are available specifically for testing needs. From an OSI model perspective, these include Layer 1 tools such as line simulators, line impairment insertion tools, and delay simulators. Layer 2 tools include repeaters, switches, and devices that can provide control and impairment mechanisms.

At Layer 3, there may be a requirement for tools that can drive traffic, emulate routers and networks, and offer “canned” test scripts (such as those described in RFC 2544). These tools may also provide Layer 4–7 simulation, or more specialized tools may be needed to address those requirements. This test gear is notoriously expensive and can easily run in excess of $250,000 for a modestly equipped system.

In certain cases, custom (often internally developed) tools that are not directly available from the tool vendors (perhaps due to market or copyright constraints) might be needed to support operations. These custom tools may include internally developed scripts coded in Tool Command Language (TCL), SNMP control scripts, and so forth. Note that, typically, internally developed tools do not impact CAPEX costs other than for the acquisition of the processing platforms upon which they reside. However, they may incur long-term OPEX costs if the engineering staff needs to perform ongoing maintenance, bug fixes, and new feature enhancements.

Antivirus Protection The use of antivirus software should not be neglected in the lab environment. While typically demanded in production user environments, the need for such protection is equally applicable to the lab with its stable of servers, test tools, and even general-use computers at risk. In some testing venues, there may even be intentional impairments being driven to cripple systems, and if a mistake causes the impairment to travel outside of the test area, the other devices should be protected as well as possible.

Monitoring Tools Ideally, the lab monitoring toolset should closely mimic your production environment. A wide variety of monitoring mechanisms are deployed in modern IP-network environments. Many are UNIX- or Linux-based tools, although Windows-based tools are becoming more commonplace. The decision to select a particular operating system platform depends on the availability of hardware to run the platform within the testing organization, internal support capabilities of staff, and the product availability itself. Most monitoring tools in IP-centric networks use the SNMP mechanisms (typically version 2c). Additionally, management tools may use Internet Control Message Protocol (ICMP), Extensible Markup Language (XML) scripts, and even CLI-based scripts using languages such as TCL, Expect, or Perl. Other approaches also exist, based upon ITU standards, but these have primarily been relegated to management of telco backbone facilities.

Tip For reference, the Stanford Linear Accelerator Center website has a large listing of both for-fee and freeware tools for network monitoring at www.slac.stanford.edu/xorg/nmtf/nmtf-tools.html.

Clearly, the costs of providing network monitoring platforms for the test facility can be very wide-ranging. A small lab environment may find that open source and simple CLI tools are sufficient to meet their needs. A larger facility may find that use of for-fee third-party tools is necessary to provide the information data points needed in a scalable manner.

Estimated OPEX to Operate a Test Lab

As previously described, OPEX costs are recurring expenses related to some business function. A test lab will also incur ongoing expenses in several areas, described next, as part of its operation.

Staffing

Staffing is generally the largest operational expense of a test lab. Staff costs include salaries and benefits, training costs, and ancillary costs associated with providing the tools and environment that enable personnel to perform their duties (such as leased computers). Staff costs for a lab may be somewhat mitigated by establishing a hierarchy of individuals based upon skill sets.

It can be beneficial for a test facility to incorporate a staffing structure that has some high-level, senior staff to lead the operation of the lab. These staff members would be involved in test planning and scoping, planning for lab growth, and providing support and a development path for junior staff. Frequently, test labs can gain valuable and cost-effective staff augmentation by bringing in college student interns during their co-op program phases at school. This approach benefits both the test facility, in that the staffing costs can be somewhat controlled, and the interns, providing an opportunity for them to learn from a real-world business environment. Many schools actively support such programs.

As the test facilities become larger, additional staffing may be necessary to accommodate internal tools development. This staff overhead usually applies only to the largest facilities, where such costs can be absorbed and having employees of several different skill levels can be productive. In large test facilities, a staffing structure as reflected in Table 3-1 would be appropriate.

There are more in-depth explanations of the job roles described in Table 3-1 in the "Test Lab Operations" section, later in this chapter.

Power

Power consumption for your lab's operations will be driven by the equipment in use and the environmental equipment needed to control the climate and lighting for the area. Minimizing these costs can be beneficial when lobbying for funds on an annual basis. As previously discussed, using automated tools for controlling power availability and even "lights-out" operation can help mitigate power consumption and, hence, associated costs. Keeping gear powered off when it is not being used is a great way to cut costs, and being able to power it on and off remotely, if you just need to check out a configuration or a command, makes it more likely that you will get great return on your investment.

Table 3-1 *An Example of a Test Lab Staffing Structure*

Title	Responsibility
Test Lab Manager	Overall responsibility for work efforts, lab operations, and staff
Project Manager	Manages the overall timelines and resources associated with all of the test projects
Lab Administrator	Oversees lab operations and ensures availability of equipment
Senior Test Engineer	Oversees project scoping and sizing, test plan development, execution of complex projects, staff guidance
Test Engineer	Executes majority of test activities
Part-Time Staffing	Provides staff augmentation, including test bed setup, inventory management, test execution assistance

Physical Facility

Depending on corporate policy, the costs of the actual lab space may be a chargeable item. If the facility is leased, the costs are clearly contracted, but many companies have also implemented cost-center approaches that implement departmental chargebacks based upon the space used. Fortunately, lab equipment usually can be highly compressed from a space consumption perspective, and if the lab itself is unmanned, those costs can be minimized.

Maintenance Obligations

Additional ongoing costs for the lab are the maintenance contracts relating to the equipment being used. Depending upon the criticality of the lab work, these agreements may be customized to control costs. With respect to larger test facilities, do not overlook the need for management tools to aid in the management of the lab and its ancillary components. You need to consider systems to manage tasks undertaken, scheduling of equipment, builds and teardowns, and inventory management. These systems will have some impact on OPEX, and these costs will appear as the overhead of keeping the databases' content current, customization of the environments, internal support needs, and ongoing software costs.

Other OPEX

You should also make budget allowances for small consumables associated with the lab operation, as previously discussed. Items such as small tools like screwdrivers, fasteners (screws, tie-wraps), and the like are needed in day-to-day operation. Budget should always be allocated on a recurring basis for replacement cables, as they tend to degenerate or get lost over time.

As the test environments become larger, the need for additional overhead management tools becomes apparent. A large facility needs an inventory system of some type to track the purchased gear for both operational and audit purposes. It can be difficult for the lab management to request funding for additional equipment without a clear, documentable understanding of the current lab inventory. In addition, the inventory system provides support data for any depreciation exercises that need to be executed.

A large lab with multiple staff members and several concurrent tests will also likely require an equipment management "checkout" tool. This will likely tie back into the inventory system and provide control over the use and availability of the lab gear. This can aid greatly in management of lab resources and prevent use conflicts by different projects. In addition, the utilization statistics from such a system can aid with determining which lab elements are under- or overprovisioned, providing a basis for lab growth planning and the support of funding requests. This type of system can also allow you to plan for and buy different maintenance levels for gear that is in high demand, as compared to gear that has low demand or for which spares usually are available. As gear stops being used, it may become worthwhile to take it off of maintenance altogether or trade some part of it in. Remember that some amount of "legacy" gear is always required for interoperability tests. However, once the legacy gear is no longer in use in your production environment, you are very unlikely to need it in your lab.

Test Organization Financing Models

There are some variations on funding approaches for a test lab. The choices presented in this section are generally applicable based upon the size and the related financial commitment of the facility in question. Funding is considered primarily from a cost perspective, with some perspective provided on ROI models.

Cost of Business

In a small network environment, it may be sufficient to absorb the costs of testing as simply the "cost of doing business." A minimalist test area may simply be a small amount of gear acquired concurrent with a network rollout, enabling network operations staff to reproduce problems, test various proposals, and augment training through experimentation in the test space. Generally, this approach is satisfactory only for the smallest organizations in which minimal funding is available.

Project-Based Funding

A widely used model for test facilities is the approach of funding as part of the costs of a specific project. For example, the rollout of a new Voice over IP (VoIP) suite of products may have a test lab cost built into the overall project costs. This model provides an easy justification path for equipment needed for the specific project. However, the total funding cost may become unclear over time, as follow-on projects are encountered and their costs become only incremental over the existing test environment. This may lead to audit questions as existing equipment becomes depreciated (against some other accounting line item) and skews project cost analysis.

Departmental Chargeback

Another approach to testing is to have a chargeback mechanism where the measured or perceived costs of test exercises can be charged back to the department benefiting from the work. As an example, finance traders might need higher-speed access to their data, necessitating some network change to accommodate this increased need. The testing of this enhancement can then be charged back to that department, because the traders are the primary beneficiaries of the change. This model also tends to suffer from the previously described issue wherein the costs of the needs of one department may be shouldered by another organization. In the preceding example, perhaps a management application also requires a higher speed of access to use a bandwidth-intensive application such as video conferencing, and it benefits from the finance traders' investment without having to pay for the testing at all.

Testing as a Business Function

Larger-scale test facilities may be able to demonstrate that there is sufficient scope of work to have a permanent, self-supporting test environment. An extreme example would be a professional services business that sells test services to third parties, where the test lab is an actual revenue generation tool. Without reaching that extreme, arguments can still be made for the definition of internal test services as an essential component of the operating costs of the business, in the same manner as with the operation of the production network. With this approach, a clear funding mechanism is established in which the testing efforts are forecasted (based upon business needs). They are then budgeted through an annual budget cycle or, minimally, on a per-project basis. Resources are then scheduled to meet those needs and results, and costs are tracked and reported as with any business effort.

Return on Investment

Return on investment (ROI), sometimes called rate of return (ROR), in its most simplistic sense, is the measure of the profitability of an investment. ROI is usually expressed as a percentage, given by the division of the revenue (or perceived revenue/cost avoidance) minus the actual costs of the item in question, by its actual costs, as shown in the following formula:

ROI = (revenue – cost)/cost

For example, if your lab brings in $800,000 in revenue, and your costs for the lab were $500,000, then your ROI is 60%, as shown in the following example:

ROI = ($800,000 – $500,000) / $500,000 = 60%

As a different example, we can calculate the ROI for a lab by assuming that it can save your enterprise one hour of downtime each year. Let's use $1,107,274 (the cost of one hour of downtime for a retail company taken from Table 1-1 in Chapter 1) as the savings/revenue for avoiding the downtime. Now assume we have spent $1,000,000 in lab costs. The ROI for the lab would be

ROI = (1,107,274 – 1,000,000) / 1,000,000 = 10.73%

In the case of a revenue-generating lab supporting a business of testing services, the processes to determine revenues/expenses and hence profitability (ROI) are reasonably clear and would follow general accounting principles. Where the test lab is not a direct revenue generator, the ROI for the facility can be difficult to quantify. In this case, it is necessary to consider both the hard and soft benefits of a testing facility. Some of these benefits were discussed in Chapter 1 and are summarized in Table 3-2.

Table 3-2 *Test Lab Return on Investment Considerations*

Test Lab Hard Benefits	**Test Lab Soft Benefits**
Network downtime avoidance	Personnel training
New technology and solution proof of concept	Industry certification preparation
Predeployment design verification	Engineer morale/retention
Accelerated application development	Showcase new technology

Outsourced Testing

An option for enterprises that want to avoid the costs associated with establishing a significant test facility is to use the services of a test services vendor. Many for-fee service organizations exist in the marketplace and may present a solution for the enterprise that does not have the expertise, tools, or time to execute on a test requirement.

The clear advantage to the enterprise, from a cost perspective, is that it will incur limited (if any) CAPEX costs—almost all costs associated with this type of approach will be accounted as OPEX. In addition, there will be a considerable reduction in staff workload, because the vendor will execute most of the test tasks. The enterprise will still need to provide test objectives and requirements, review results, and monitor the work efforts of the vendor. As well, the vendor presumably possesses the technical expertise to undertake the task in question, relieving the enterprise from the burden of developing the same. This includes not just the technical solution under evaluation, but also the tools and approach required to execute the testing.

Outside of cost, the primary consideration in using any external test vendor is the matter of trust. The enterprise must be certain that the service supplier can be trusted to perform the tasks on time, within budget, and in confidence. Note that outsourcing a test exercise does not totally devolve the burden of this work from the enterprise. The enterprise using the contracted services must ensure that the vendor is meeting its needs, that these requirements are well understood, and that the results are in line with expectations. This approach should be viewed as a partnership with the contractor, where the benefits and responsibilities are mutually recognized.

Selecting the right organization to outsource testing activities to for a particular project can often be challenging. Evaluation of potential candidates requires the same process as would be used to select a managed service provider or professional services firm to provide design functions. A request for references of similar test engagements, skill levels, and certifications of test engineers, and representative samples of project plans, test plans, and test results documentation, is required to make an informed decision. Remember that the enterprise engineer that coordinates the contract, rather than the test vendor, will ultimately be held responsible for the failure of a networking project that was improperly tested or inadequately documented.

Test Lab Facilities Design

The exercise of designing a lab facility is very similar to the efforts involved in designing the production network. The primary objective in the lab design, from a topological perspective, is to enable the test area to mimic the production network environment to the largest extent possible, within given budgetary constraints. Over and above that, the physical aspects of the lab facility, explored in the previous cost discussions, also need attention from a design perspective.

Functional Lab Design: Selecting the Hardware and Software

The corporate test lab should mirror the standard computing and networking environment in use within the enterprise. Ideally, a lab designer should be familiar with not only the architectural and operational aspects of this environment, but also the scope and charter of the test organization that will operate the lab. For example, a lab designer should not invest excessively in server or storage equipment if the test organization's charter is limited to testing the network infrastructure. When possible, the lab designer should enlist the support of the executive lab sponsors, in addition to the production design architects and operations engineers, who can provide invaluable input to the test facility's development. Most enterprises will not be engaged in abstract "black box" performance or feature testing. An enterprise's interest in testing is to assess the operation of the item for use in the production environment. As such, the results of any lab testing will be relevant only if the environment is tailored to replicate the production network as much as possible. The lab designer should consider the following when selecting hardware and software for the lab:

- Type and quantity of network nodes needed (actual equipment as well as those that can be simulated with test tools)
- Simulation tools (capabilities and availability)
- WAN and LAN physical specifications
- End systems (hosts and servers) needed to verify operations
- IT software applications (commercial and custom)

Physical Design

The amount of funding receivedfor a lab project will determine the level of sophistication that a team will be able to add into the physical design. Whereas the right level of funding will allow an organization to build an impressive showcase for emerging technology, inadequate funding will result in a lab that more closely resembles an equipment storage room—hot, cramped, dimly lit, with haphazardly strewn cabling that completely obscures the presence of equipment.

The implications of a poor lab design extend beyond that of aesthetics. Operation of the lab facility will be greatly impacted by the physical aspects of the environment. Good physical design will improve productivity and enhance the work environment. The following considerations should be addressed when gathering requirements for a lab's physical design:

- **Square footage:** Be sure to consider rack space, workbenches, intrarack shelving, cable management systems, and storage within the work area and outside of it. Many of the larger lab facilities are constructed as separate "computer rooms" inside a data center so that they can benefit from the power distribution, HVAC, and corporate network access. At a minimum, a lab facility should be controlled in terms of physical access and HVAC capabilities. A smaller lab's requirements could be met with a 15- by 15-foot space with a 10-foot ceiling to accommodate the equipment racks and cable management system. Space-saving measures such as master Keyboard, Video and Mouse (KVM) switches that use one monitor, mouse, and keyboard to control several machines can be used to minimize clutter in these smaller facilities.
- **Power availability and layout:** Consider total power, differing modalities (AC/DC/voltage/connector types), the total number of connection points, your power strip requirements, and the distribution method (overhead or under the floors are most popular). The size and amount of equipment will drive much of your power

requirement. Do not forget to take into account cooling, lighting, and UPS when planning. UPS may also require special physical space considerations.

- **Air conditioning and airflow:** Assess the total cooling load, determine the distribution (under floor, open room/rack-specific methods), review the placement of hot/cold aisles, and ensure that interequipment airflows are minimized (in other words, try to minimize the amount of hot air you are blowing from one piece of gear onto another).
- **Cabling:** Examine cabling solutions for intrarack and interrack connectivity, as well as interconnects to servers, test tools, and external feeds (such as Internet, production, or video feeds). A large facility may choose to use a structured cabling approach, with racks prewired to rack distribution frames (RDF) and RDFs prewired back to a centralized patching area commonly called a main distribution frame (MDF), as previously shown in Figure 3-1. Also assess the need for appropriate cable troughs and conduits.
- **Special and free-standing gear:** Determine whether there is a need to support large hardware platforms, such as a Cisco CRS-1 or storage and mainframe systems, which can require their own floor space and special power connections. Ascertain the need for test tools (such as third-party test equipment) and various infrastructure services platforms (such as FTP, TFTP, NTP, DNS, and certificate servers) and address the relevant power and accessibility requirements for them. You must factor these special items into the physical and topological planning previously discussed.
- **Equipment storage:** Establish a separated, lockable area for storage of valuable unused gear. Assess the need for non-ESD card racks and their relevant sizes, cable storage, shelving, and drawers for consumables (such as SFPs, attenuators, splitters, and connectors). Ensure that the working lab space has sufficient storage to meet the immediate needs of your staff, including cable hangers, small hand tools, power tools, and cable construction tools.

Figure 3-2 shows an example layout of a large lab facility. This example follows the recommendations made for computer room design in ANSI/TIA-942, “Telecommunications Infrastructure Standard for Data Centers.”

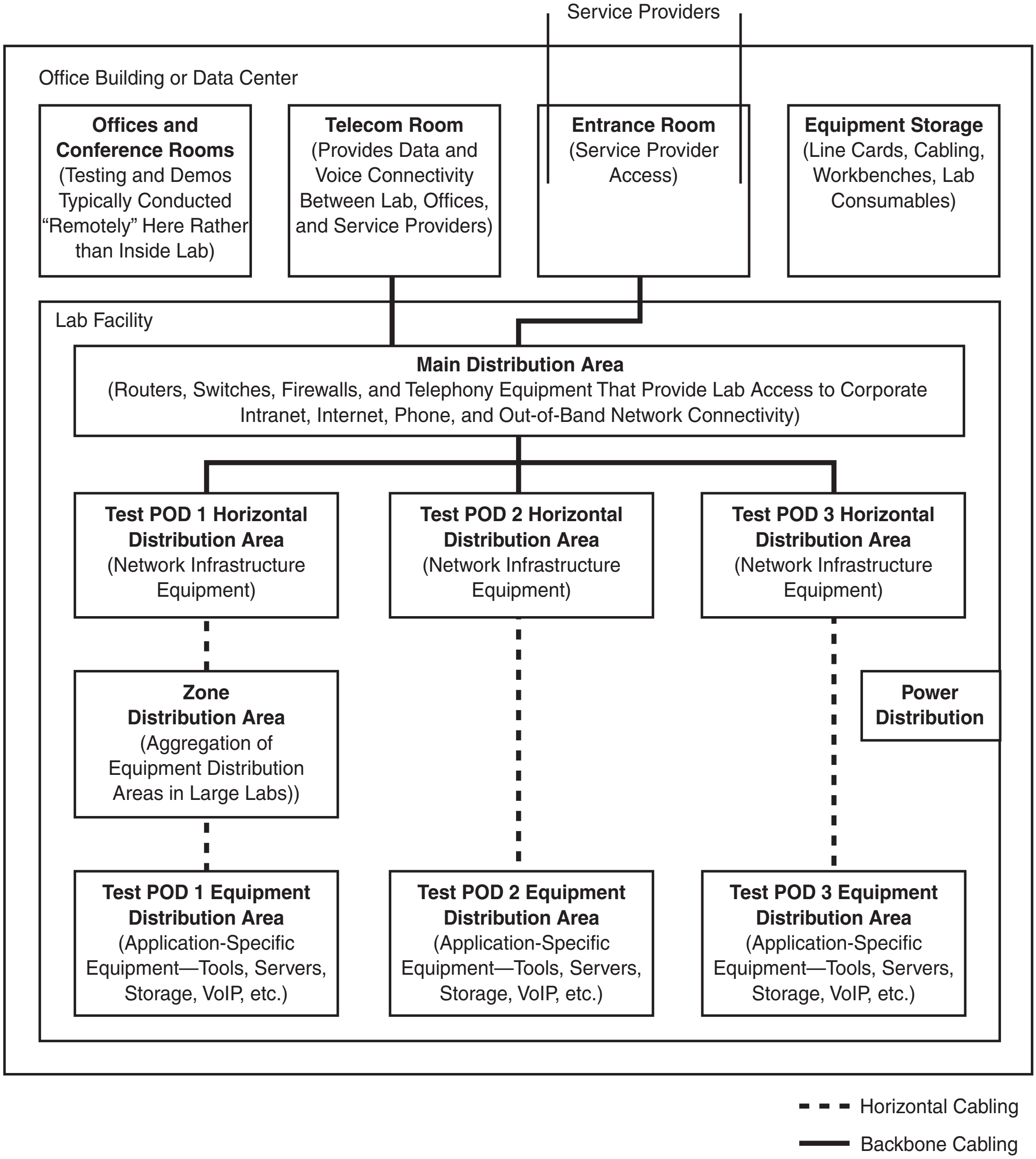

Figure 3-2 *Example Large Test Lab Layout Based on Standard Computer Room Design*

> **Note** This standard specifies the minimum requirements for telecommunications infrastructure of data centers and computer rooms, including single-tenant enterprise data

centers and multitenant Internet hosting data centers. The topology proposed in this document is intended to be applicable to any size data center.

Equipment Cabinet Floor Plan Layout

The physical space that the equipment cabinets will occupy will depend on several factors:

- Type of equipment
- Amount of equipment (initial and future growth)
- Cabinet size
- Aisle spacing
- Amount and location of freestanding equipment
- Room dimensions and obstructions

Estimating the type and amount of equipment needed in a test lab can sometimes be a challenge, particularly when you are trying to forecast future needs. The types of equipment needed vary from lab to lab, based on the particular network architecture and focus of the design elements to be tested. In many cases, the CAPEX budget will determine what is available for initial installation, leaving the staff with the task of estimating what will be needed in the future. This future estimation should ideally be based on a 5- to 10-year expected growth forecast, unless there are other considerations that will cause the facility to be used for a shorter duration (such as the project-based funding model, covered earlier).

Calculating the number of cabinets needed for the facility is a fairly simple exercise, once the type and quantity of equipment is known. Most vendors follow standard rack unit (RU) height design with their products. While an organization might be tempted to fully populate its cabinets with equipment when developing the provisioning plan, this should be avoided if possible. It is common practice in many labs not to populate the upper third, or sometimes even the upper half, of lab cabinets (depending on the devices installed in the cabinet), due to the inability to efficiently cool the upper half of a rack. In some cases, there is also a structural component, which means that if all racks are completely filled, the subfloor may not be able to handle the weight. In considering the cooling implications for the cabinets, take a conservative approach when planning how many cabinets will be necessary to house the equipment; we recommend no more than 75 percent cabinet subscription.

After the number of required cabinets is known, determine the physical footprint of the equipment cabinets themselves. Taking into consideration the exceptional depth of today's equipment (for example, the Cisco Carrier Routing System or many blade server implementations), and the cable management and power delivery systems that will occupy the rear of the cabinet, a deeper cabinet will serve better than a shallower one. A conservative approach would entail planning for cabinets up to 48 inches deep and 32 inches wide. Planning for such extrawide cabinets will help facilitate cable management within the enclosure, particularly if you plan to employ a closed cabinet design with front and rear doors for physical security or environmental purposes. Having plenty of space inside your cabinets for effective cable management also facilitates the effective cooling of your gear and the testing work you will be performing. Having cables hanging in front or behind your test gear can make pulling out or replacing line cards, power supplies, and servers (something you do fairly often during testing) an onerous task.

The final decision to be made before developing an equipment cabinet floor plan regards aisle spacing around the perimeter and in between cabinet rows. In many cases, site-specific safety codes ultimately dictate this, but in general, allocate at least four feet of aisle space around the perimeter of the cabinet rows. This should be adequate for people to pass unobstructed, even with equipment pallets in tow. Interrow aisle spacing will depend on the cabinet orientations, in particular whether a hot-aisle/cold-aisle strategy is employed.

Note In its simplest form, the hot-aisle/cold-aisle design involves lining up server and other equipment racks in alternating rows with cold air intakes facing one way and hot air exhausts facing the other. The rows composed of rack fronts are called cold aisles. Typically, cold aisles face air conditioner output ducts. The rows the heated exhausts pour into are called hot aisles. Typically, hot aisles face air conditioner return ducts.

Because all cooling architectures (except for fully enclosed rack-based cooling, as required by some blade server implementations) benefit dramatically from hot-aisle/cold-aisle layout, this method is a recommended design strategy for any floor layout.

Note The use of the hot-aisle/cold-aisle rack layout method is well known and the principles are described in other books and whitepapers, such as *Thermal Guidelines for Data Processing Environments, Second Edition* (2009), published by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), and the 2002 whitepaper from the Uptime Institute titled "Alternating Cold and Hot Aisles Provides More Reliable Cooling for Server Farms."

Aisle spacing between cabinet rows is determined when you establish the aisle pitch for the cabinet locations. Aisle pitch is the distance from the center of one cold aisle to the center of the next cold aisle, either to the left or right, and is based on floor tile size. Data centers often use a seven-tile aisle pitch. This measurement allows two 2- by 2-foot floor tiles in the cold aisle, 3 feet in the hot aisle, and a 42-inch allowance for the depth of the cabinet or rack. For larger cabinets or cabinets with high-power servers, there may be a need to use an eight-tile pitch to facilitate airflow.

The sample floor plan in Figure 3-3 is an example of the number of large equipment cabinets one could expect to fit into a relatively small (600 square foot) test lab.

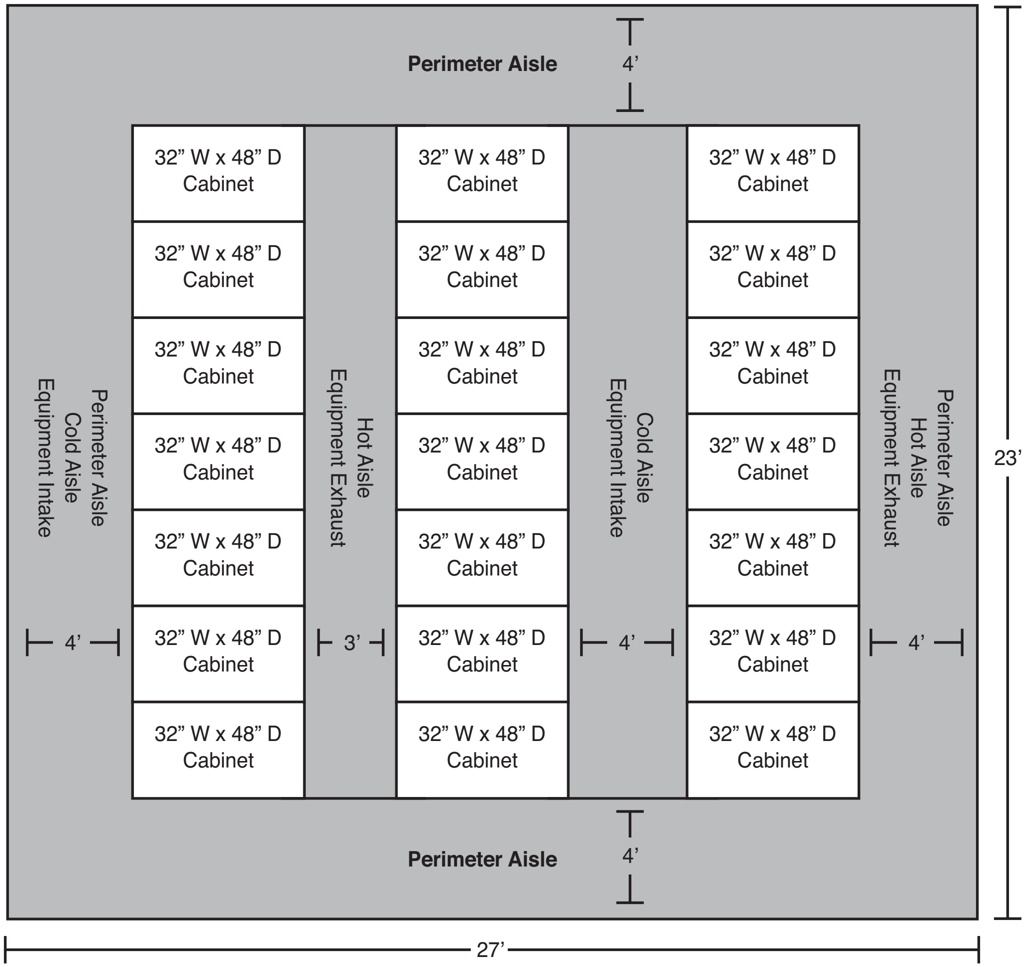

Figure 3-3 *Equipment Cabinet Floor Plan Layout for a 600-Square-Foot Facility*

Armed with these design considerations, you are now ready to design your lab facility. This exercise may be as simple as a meeting over coffee and drawing some diagrams on paper, or complex enough to require several weeks and multiple individuals' focused efforts. In either case, taking the time to understand the objectives and requirements of the test lab, and the commitment that the enterprise is willing to make to it, will help to clarify expectations and drive the building of a superior testing facility to a successful conclusion.

Test Lab Operations

Many differing operational models exist for running a test lab, and are usually outgrowths of the culture of the enterprise itself. The following provides an example of a model for operating a test lab and may be applicable to a medium-sized to large corporate structure.

Test Organization Charter

A formal test organization typically has a documented charter, which defines the operational guidelines for the group. Such a document helps others to understand the lab's capabilities and business focus, aids in organizing the relationships and engagement approach with other corporate entities, and guides the lab staff in their direction and operation. Having a formal charter helps alleviate the requests for your team to test the latest desktop image if you are a team focused on network testing; and more importantly, it should minimize the times you will hear "I did not know your team did that."

Examples of the types of statements that may appear in the charter include the following:

- **Mission statement:** A formal, short, written statement of the purpose of a company or organization. A mission statement for a test lab group may look something like the following:

  "To provide testing services relative to corporate initiatives, with a focus on improvements to network stability, and easing of integration of new services."

- **Statement of focus:** A short, written statement of the types of testing activities that the organization would primarily address. Some test organizations, for example, would focus solely on network infrastructure testing, while others may expand this focus to network services (telephony, video, servers) as well. A statement of focus for a test lab group may look something like the following:

  "To address any and all production-related testing as it may pertain to new product introduction, protocol enhancements, services improvements/changes, and scalability in the network, voice, and video infrastructure."

- **Responsibility directive:** A short, written statement that describes the purpose of the test lab, as it relates to the architectural process. A responsibility directive for a test lab group may look something like the following:

  "All network change plans must include test verification by the test facility team prior to adoption in production."

- **Engagement statement:** A short, written statement that describes how the test lab organization should be engaged. An engagement statement for a test lab group may look something like this:

  "Engage the test team at the earliest opportunity in project planning. Contact us via testteam.ourcompany.com or e-mail testgurus@ourcompany.com."

The test team should establish a website or something similar (wikis have become very popular) to describe its charter, capabilities, and engagement process in greater detail for use by the rest of the organization.

Team Roles and Responsibilities

When building a testing organization, you will likely be required to define the roles and responsibilities, as well as create job descriptions for the staff you will be employing. As mentioned earlier in this chapter, most test teams of any significant size have the following:

- **Test lab manager:** This individual provides a leadership presence to guide the team's direction, productize its services, control budgets, manage staff, and address other management issues as they may surface.
- **Project manager:** If appropriate, the team may also include a project manager who manages individual project flows, tracks schedules, and acts as an engagement "controller" to ensure that the team is not overloaded with concurrent work to the point that it becomes unsuccessful.
- **Lab administrator:** A lab of significant size will also benefit from the establishment of a lab administrator who focuses on lab operational requirements, ensures availability of equipment and sundries, helps manage resource allocations and budget, and generally ensures smooth operation of the test facility. In all likelihood, the lab administrator will manage the maintenance arrangements and undertake the repair and replacement of defective gear as needed.
- **Senior test engineers:** The technical members of the group will likely include one or more senior members who guide the group technologically, scope initial work efforts, and undertake highly complex test efforts. Senior test engineers are an escalation point for the rest of the testing staff in all of their efforts. They often are the liaisons between senior network architecture staff, operations engineers, and other project stakeholders, and the rest of the engineers on the testing team.
- **Test engineers:** These engineers conduct the bulk of the testing work and write most of the test result documents. These team members work with the senior test engineers in executing any work as appropriate. The test team can also be an excellent training ground for operations staff, who may be rotated through the testing facility, and for design engineers and architects, to sharpen their understanding of specific technologies as needed.
- **Part-time staff:** As previously discussed, the test team may also include some members who are university co-op students. These staff members gain the opportunity to learn technology and become exposed to business operations and may end up becoming excellent pretrained recruits for the company upon their graduation. They are often responsible for maintaining the lab inventory, setting up the test beds, and providing assistance with any test execution as needed.

Management Systems

As a testing facility comes online and gear starts arriving, you will find that keeping track of everything can be challenging. Because it is easier to get your management systems online at the same time (or before) your lab infrastructure gear and equipment arrives, you should consider investing in some of the following systems as part of your startup costs.

Equipment Inventory System

As discussed in the "Estimated OPEX to Operate a Test Lab" section earlier in this chapter, in consideration of the significant costs of operating a test lab, an inventory management system is a clear requirement. All gear should be inventoried upon receipt prior to being placed into operation in the lab. The system should be detailed enough to manage product identification (part number, name, serial number, and internal asset tag). As the lab grows, such a system can become invaluable in many of the aspects of the facility's operation, including equipment availability and scheduling, defect management (repair and return), and data for budget and purchasing decisions.

Equipment Scheduling/Lab Checkout Tool

A lab checkout tool can greatly aid in the operation of a lab with multiple users and multiple concurrent tests. Such a system can help prevent overscheduling of equipment for tests and aid the test engineer in finding the equipment needed for a particular work effort. It should provide for both short- and long-term (indefinite) checkout scheduling. A well-designed checkout system closely integrates with the inventory management system to tie the gear in use with appropriate asset management information. The close operation of these tools also greatly aids in budget planning cycles for both equipment and staffing, because they can be employed to report on utilization of the lab resources.

A larger test facility may wish to introduce another layer of management to help keep track of resources from a project management perspective. This tool can support management of project acceptance, costing (if chargebacks are applicable or simply to demonstrate value), and scheduling of equipment and staff, help management of the individual projects in detail, and provide a closure and reporting mechanism.

Team Website

As discussed earlier, the test team should deploy a website or wiki to present a visible focal point to the rest of the organization and to showcase team efforts. This site should also provide a tool that allows users to request a test engagement from the testing team. Such an instrument should have an easy-to-use interface that provides sufficient information to begin the engagement exercise without being so onerous as to hamper client usage.

At a minimum, the GUI should present fields for the following:

- Requestor name
- Organization and contact information
- Requested engagement dates
- A brief description of test needs and business drivers
- An option for inclusion of more detailed information such as "bill of materials" data and topology descriptions or diagrams if available

The system should automatically notify appropriate team members of the request (at least the manager and project manager) and provide an expected response interval to the user.

There should also be a secured area where documentation such as test plans, network information, test logs, and test reports can be maintained for the consumption of the test team only. As the test team works various exercises, the methodologies, scripts developed, and ancillary information that is learned should be captured and saved in this repository. This data can prove invaluable in efforts to streamline new engagements and help train future staff in lab operations.

Other Operational Considerations

The need for security in the lab facility cannot be overstated. All lab facilities need to be established in a secure manner, with access limited to authorized staff members. The physical security requirement exists both to protect the valuable equipment and to avoid the cost of test cycle interruptions. In this same context, fire prevention and control considerations should lead to the provisioning of smoke detection equipment, manual fire control devices, and, possibly, automated systems. The requirements for these safety devices are likely already addressed by corporate building policies. In addition, the ready availability of first-aid kits is highly recommended along with staff training with respect to its usage.

Summary

This chapter focused on the business and organizational requirements involved in building and running a successful testing organization. The chapter covered the costs and planning associated with starting the test facility, and the physical considerations that should go into it. You also learned about the staffing requirements and other OPEX costs of a typical testing organization. In addition, the chapter explored outsourcing your organization's testing, and some of the pros and cons that come with that approach. Also, you learned what designing a typical network test lab infrastructure would include. Finally, the chapter covered test lab operations and a testing group charter. The next chapter explains how to craft the test approach and how to get ready to conduct your enterprise network testing.