Selecting the right tool depends on who will use it and why. Discover several features to look for when you choose your next network design tool.

Arnold W. Bragg

Which Network Design Tool Is Right for You?

We've all seen advertisements for commercial network design tools. They usually show colorful workstation and server icons suspended like insects in a spider web of switches and routers, all neatly superimposed on a map of Northern California. But network design is more than dragging, dropping, and connecting icons to build a graphical network infrastructure.

Network design is challenging, requiring designers to balance user performance expectations with network-resource costs, capacities, capabilities, and use levels. Network operators want to keep resource utilization high and costs low. But then the resulting design might produce unacceptable service levels when congested links and undersized routers cause too much delay or too many dropped packets. You need a design that will efficiently use your network resources and effectively serve your users. And you want a network design tool that can produce the design you want.

Networks are a complicated mix of applications, protocols, device and link technologies, traffic flows, and routing algorithms. There may be tens of thousands of feasible configurations, each with different performance attributes and costs. Can network design tools help you find the combination that is right for your organization? Yes, but it's important to use the right one for the job.

Inside

Other Network-Related Tools

WHAT IS A NETWORK DESIGN TOOL?

Network design tools help IT professionals sift through conflicting features, trade-offs, and thousands of reasonable design alternatives. Is the designer building a new network or maintaining and troubleshooting an existing one? Will proposed changes in the network handle the anticipated traffic demand without violating service-level agreements? Does the design require wireless or satellite links? Is the tool suitable for presentations to customers, and can it provide fast answers to their what-if questions? Is the designer testing an experimental protocol or a novel routing algorithm?

Tools analyze (visually, mathematically, or by simulation) what is happening in the network and predict future behavior. Nearly every general-purpose network design tool works the same way. The designer either uses a drag-and-drop graphical editor to create or modify a network topology or imports the topology directly from a network management tool like HP OpenView. Most tools have extensive libraries of device and link models, so building an Ethernet local area network (LAN) or IP-routed backbone network is straightforward.

Next, the designer specifies (or confirms) the attributes of each device, link, or application—bit rate, traffic load, device throughput (in bits or packets per second), transaction rate, routing protocol, and so on—and simulates the network's operation. Simulation runtimes vary from several minutes to several days, depending on the required level of accuracy and detail in the results. Most tools can display results graphically at the end of the simulation run, and many use animation or dynamic utilization bars during the course of the simulation to highlight bottlenecks and traffic flows. Nearly every tool can identify and

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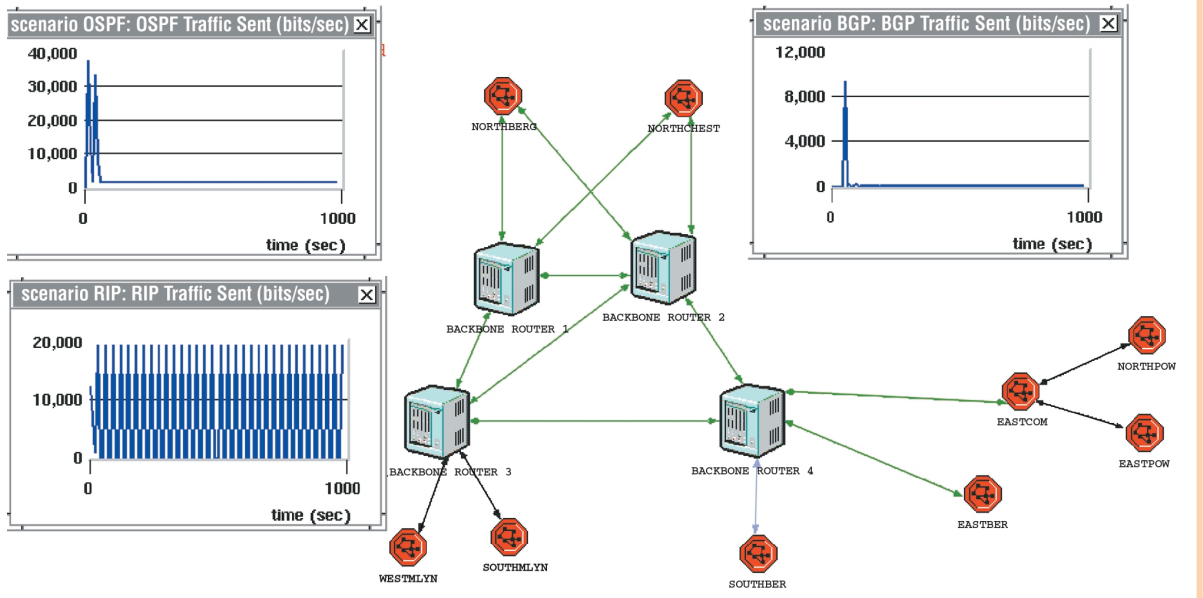
Figure 1. Opnet Technologies' IT DecisionGuru portrays a network of interconnected backbone IP routers.



summarize network congestion, load, lost packets, failure and error conditions, and response times.

Network design tools also let you evaluate different scenarios. For example, suppose you need to evaluate the traffic load introduced by three different routing protocols on a portion of an existing wide area network (WAN). Figure 1 shows how one tool portrays the network as a set of interconnected backbone IP routers, each directing traffic to and from one or more abstract subnetworks. In this example, the border gateway protocol (BGP) generates slightly less routing traffic than the open-shortest-path-first (OSPF) protocol, and both generate far less routing traffic than the routing information protocol (RIP). Configuring the three scenarios in this example may be as simple as selecting a different value for the routing protocol attribute from a single pull-down menu.

Quantitative network design tools produce more accurate and defensible results than qualitative methods or rules of thumb. A network operator may have expected BGP and OSPF to generate less routing traffic than RIP but couldn't predict the relative performance of OSPF and BGP for this specific topology. Network design tools are also valuable for predicting performance problems rather than merely reacting to them when they arise.

Simulation is not the only solution. Several tools rely partly or solely on mathematical analysis and queuing theory. Analytical tools provide solutions more quickly than simulation but don't always achieve the required accuracy.

WHO USES NETWORK DESIGN TOOLS?

The ideal network design tool can mean different things to different people. But whether you're a network designer, network manager or engineer, sales or marketing manager, or member of the R&D staff, you probably want intuitive graphical interfaces that resemble computer-aided design tools. Distances are important in LANs and WANs, so the tool must recognize and compensate for user-defined scales. You want several levels of operational abstraction, so you can model a LAN as 37 distinct packet-generating devices at one extreme, and as a cloud raining 10,000 packets per second at the other. You also want to test whether your proposed design or change can handle the workload with acceptable performance.

However, depending on your situation, concepts of the ideal network design tool can vary greatly.

Sales and field-services staff

You sell network hardware or provide network services and want to show customers reasonably accurate representations of how a product, service, or technology will improve their network and support their business case. You want an intuitive tool that runs on a laptop computer and that you can master in just a few days. You need fast execution speed (tens of seconds per scenario rather than tens of minutes) and extensive presentation features (such as traffic animation, graphical indications of service-level performance, reports, diagrams, charts, and graphs).

Network managers and engineers

You operate the networks, troubleshoot and solve performance problems, and ensure compliance with service-level agreements. You try to gauge how proposed changes will affect cost, performance, capacity, and availability before the changes go through. Changes typically include introducing new routing protocols, adding new devices and links, supporting new applications such as those for enterprise resource planning (ERP) or e-mail, upgrading servers, and changing service-level agreements. If the existing network is large, you must import topology and traffic data from other tools. The set of alternatives is usually enormous, so you need to evaluate scenarios in tens of minutes rather than hours.

Network designers

You specify and build new networks or overhaul existing ones. You try to reduce design time and improve design accuracy. You want your designs to meet performance requirements without overbuilding. And you want to be able to identify potential bottlenecks and overloads. Designers need an extensive library of link technologies, devices, architectures, and protocols to build or upgrade the network, and you need tools to accurately predict its performance.

Researchers

To reduce development costs and risks, you test the effects of new or modified protocols, devices, architectures, component designs, and traffic models in the lab or on the workbench. You need complete control of simulated behavior at the programming language level, and you want the language to provide a rich set of special-purpose modeling functions. You typically simulate discrete events (packets transiting a router, protocol retransmissions, and so on), and mimicking actual behavior can take billions of events. You prefer accuracy over speed.

WHAT GENERAL-PURPOSE TOOLS DO

Many network design problems are relatively easy to solve. Nearly every general-purpose tool will

- model LAN, frame relay, IP, and asynchronous transfer mode (ATM) segments and traffic using stock library models;
- predict link and device throughput and utilization;
- show which links and devices are over- and underused;
- show how (un)balanced loads affect links and devices;
- show the effects of link or device failures;
- show how changes in topology, device upgrades, or expansion will affect performance;
- identify the applications or protocols contributing most to network congestion and delay;
- confirm that service-level agreements can or cannot be met;
- predict the response times of applications before deploying them;
- predict where bottlenecks and application response time delays will appear first;
- predict how many users an application can handle; and
- present results via animated utilization bars, online graphical statistics and counters, diagrams, reports, charts, and graphs.

Not-so-easy problems

General-purpose tools only partially solve some problems. Here are some of the more common ones.

Determine the best performance-cost ratio. Let's say you want to decide which devices, LAN or WAN technologies, or routing protocols give the best performance at the lowest cost. Exploring alternatives is easy, but the user must specify the scenarios and evaluate the costs and results, usually one by one. Some tools generate a bill of materials for the network devices, but few general-purpose tools factor in communications costs. Estimating costs is challenging because telecommunications tariffs vary widely by location and type of service—for example, leased lines versus frame relay.

One of the most challenging decisions is determining how much accuracy to sacrifice for speed.

Provide accurate solutions in seconds. You must trade off execution speed and accuracy. Speed comes from high levels of abstraction, as when a tool models a large LAN as a cloud generating an aggregate traffic flow. To test a new component or protocol, you need to simulate every packet passing through it. To figure out whether you can add five workstations to that overburdened LAN on the fourth floor, using aggregate flows makes sense. There is some middle ground, though. Some tools let you simulate part of the network in detail while modeling traffic in the background or in other parts of the network as aggregate flows. One of the most challenging decisions is determining how much accuracy to sacrifice for speed.

Realistically model an existing network. Realistically modeling a large network can be difficult if each device, link, and traffic load must be manually configured.

Most tools can import a network topology from a network management suite like HP OpenView, or discover and import the topology with a tool based on the simple network management protocol (SNMP). Some tools import traffic data or profiles from a network sniffer—a device that monitors and characterizes the traffic passing over a communications link. Others have rapid configuration wizards to quickly build large networks. A few have databases with tens of thousands of voice, video, and data devices that you can drag into your design window.

Capturing traffic behavior is usually more important than modeling devices in minute detail. If you need to import topologies or traffic profiles, make sure the tool can do this.

Stress test the network. Stress testing means ratcheting utilization levels up over 90 percent. Simulating every packet flowing through a congested network leads to very long simulations. But watch out for analytical tools that blithely report link utilization above an impossible 100 percent or tools that do not accurately reflect how protocols like TCP respond to packet loss at high loads. Select a tool that can distinguish between the load offered to the network and the load actually carried by the network.

Balance power and ease of use. Powerful tools have steep learning curves. Power comes from the ability to precisely configure or customize device and protocol behavior. Some tools offer both full-featured designer versions and less-expensive runtime versions. The latter usually have configurable attributes (such as link speed).

Some tools offer both full-featured designer versions and less-expensive runtime versions.

Confirm that devices are connected correctly. Most tools ensure that devices and links are correctly matched, and some give a warning if, for example, a router is not compatible with the optical link it's connected to. But few tools confirm that LANs are within their maximum lengths and that the network correctly compensates for delays over long-distance WANs. For example, if a tool tells you there is zero propagation delay on that Boston-to-Seattle link, you have a problem.

Provide statistically useful output. Most tools simply compute average delay and utilization, but you'll want to know how high utilization was between 2 and 4 p.m., and how much traffic exceeded the maximum delay promised by the service-level agreement. If you need to plot time series, histograms, or confidence intervals, make sure the tool you're considering can do the job.

Tough problems

Some problems are quite difficult to solve. Here's a short list.

Optimize network design or performance. Network design tools do not claim to provide optimal solutions. Optimization is very difficult, and objectives often conflict. Users and network operators have different sets of requirements and constraints.

Automate the what-ifs. Most designs have more options than a tool could evaluate in a lifetime. The usual approach is to identify a few feasible alternatives and test them. During the evaluation, other alternatives may emerge. In theory, tools could automate this process. In practice, they usually do not. Is it better to mathematically evaluate a few hundred designs with moderate accuracy or to simulate a dozen with great precision? It depends. Sometimes coarse estimates provide insight and reduce the number of scenarios you need to simulate.

Simulate models with thousands or tens of thousands of devices. This problem is common when importing topologies from network management systems. Discrete-event simulators may run out of computing resources when evaluating very large networks. Consider using a tool with an analytical engine. Analytical tools use steady-state queuing theory formulas and mathematical modeling techniques to produce quick solutions. They don't capture nuances of protocol behaviors, but most provide good first-order approximations. Analytical tools may be the only reasonable approach for very large networks.

Model mobile or wireless components. Mobile and wireless networks have a unique set of problems that most general-purpose tools do not address. Uneven terrain, satellite trajectories, 3D dynamic positioning, and fading signals require special-purpose tools. Some vendors offer these as separate add-on modules. Don't buy them unless you need them.

Simulate every nuance of link and network protocols. One of the most difficult problems in selecting a tool is deciding what level of detail you require. Some tools cost five to 100 times more than others, so this is an important decision. Decide whether you need to model behavior at the programming language level. If so, make sure the tool has a rich set of functions and procedures, and that you can modify its stock models. If your goal is to simulate some variant of TCP, you can save lots of effort by starting with the stock TCP model and customizing it.

A SAMPLING OF GENERAL-PURPOSE TOOLS

If you need a general-purpose network design tool, consider these first. Most have earned at least one editor's-choice or best-in-class award. They all have a graphical toolkit for building or importing network topologies and traffic flows. They all predict or portray a network's behavior or performance in some way. And they all have an extensive set of reports, diagrams, charts, and animated displays. Each tool supports all the common link and transport protocols, LAN and WAN architectures, routing protocols, and devices. Most support some level of customization through simulation attributes.

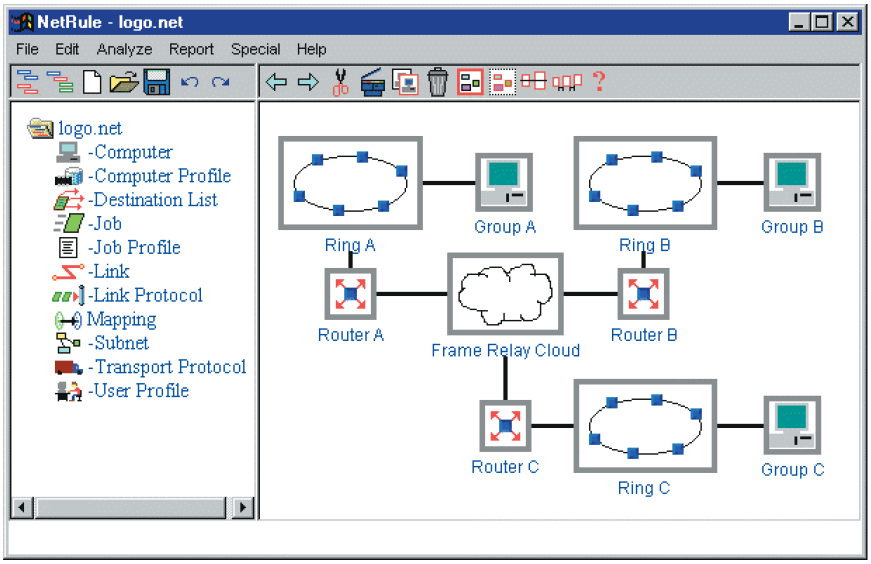
Analytical Engines' NetRule and NetRule Viewer

Analytical Engines advertises NetRule (http://www.netrule.com) as an analytical tool for planning network changes. The company has clearly positioned NetRule as a mid-level tool "optimized for practical use on real networks and less suited for research and development of new protocols or component designs" as stated in the product descrip-

tion. The company intends this tool for use by network engineers involved in network planning. Figure 2 shows the components available to build a WAN in NetRule.

NetRule is written in Java and runs on the thirty or so platforms that have Java virtual machines. It also uses analytical methods instead of discrete-event simulation, so you can usually evaluate its models in tens of seconds. NetRule's developers believe that simulation is too complex, too slow, and too expensive for practical network planning. The analytical engine uses steady-state queuing theory formulas, mathematical modeling, search algorithms, component-level simulation, and rule-based inference tools. Advertisements claim evaluation times rarely exceed 10 seconds, even for large networks. NetRule can model and stress test very large networks (1,000 to 10,000 nodes) because runtimes don't depend on the number of packets transiting the network.

Figure 2. Modeling a wide area network with NetRule.



NetRule also has a viewer for read-only access to network modeling results. Users can replay analyses but cannot alter them.

Compuware's Comnet III, EcoPredictor, and EcoProfiler

Compuware (http://www.compuware.com) acquired several excellent tools from CACI International in 1999. Two of them are mature products with large installed bases. Comnet III is a high-end design and discrete-event simulation tool. Designers can create hierarchical network models using a drag-and-drop tool palette, or they can import topology and traffic data from several network management tools. Tightly integrated with other Compuware tools, Comnet III has an extensive library of devices and protocols. It also has optional add-on modules for circuit-switched traffic (voice, video, satellite), distributed applications, and mobile or wireless networks.

EcoPredictor is a mid-level analytical performance-prediction and capacity-planning tool, advertised as "fast, scalable, easy-to-use, and ... designed for day-to-day use." The tool's most interesting features are reports and alarms that identify a network's top contributors to congestion. It also locates bottlenecks and excess capacity. EcoPredictor can import data from several third-party management and monitoring tools and, if a user requires more precision, export topologies directly to Comnet III.

EcoProfiler is a specialized tool for assessing the effects of new ERP applications on network performance, as well as the opposite problem of assessing how adding users or network upgrades affects existing ERP performance. Some ERP applications have rather stringent resource requirements, so you can use tools like EcoProfiler to assess an application's performance before deploying it.

NetCracker's Designer and NetCracker Professional

NetCracker Technology (http://www.netcracker.com) has two network design products: NetCracker Designer and NetCracker Professional. Designer is a low-cost, low-end tool for designing, verifying, documenting, and visually analyzing networks via animation. It can import topologies from Visio and OpenView, and automatically confirm device connectivity and compatibility. NetCracker Designer supports the most common network and routing protocols and media. Its most interesting feature is a database of more than 25,000 network devices. Each device has several dozen attributes (supported media, protocols, port configurations, latency, bandwidth, price, and so on). NetCracker Designer can use the network topology and device database to generate a bill of materials. Database updates are available by subscription.

NetCracker Designer simulates static traffic flows by animation but does not simulate or analyze performance. NetCracker Professional reads Designer files, simulates

Figure 3. Modeling a circuit-switched network with NetCracker Professional.

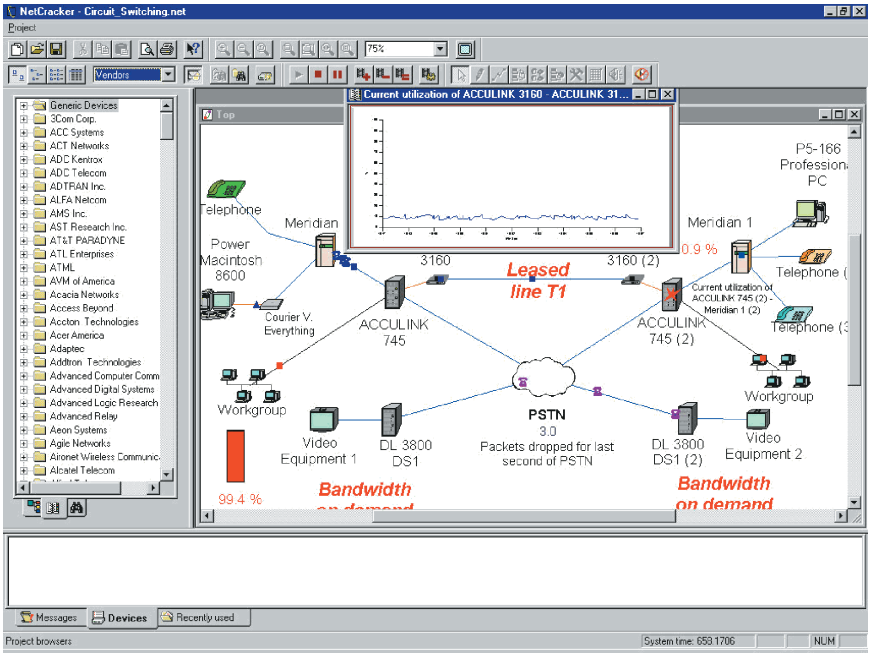
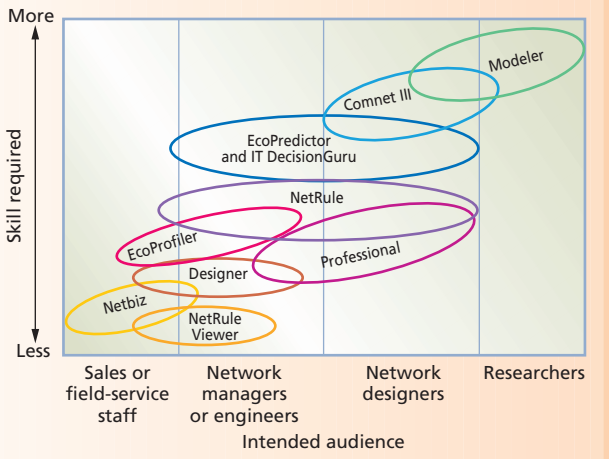


Figure 4. Intended audience and required skill for 10 general-purpose network design tools.



behavior and performance, and generates reports, diagrams, charts, and online dynamic graphs, as shown in Figure 3. Animations are impressive, with graphical bars showing utilization, packet loss, load, and other performance attributes. You can specify traffic loads in several ways, including by application type.

Opnet Technologies' Modeler, IT DecisionGuru, and Netbiz

Opnet Technologies (http://www.opnet.com) also has a family of mature tools and a large installed base. Modeler is a more expensive, high-end product used mostly by network R&D engineers. It can very precisely model protocols, devices, and behaviors using a finite-state-machine paradigm, C/C++ language features, and about 400 special-purpose modeling functions. Modeler has optional add-on modules for radio and satellite modeling, multivendor import, and service-level prediction. Originally a discrete-event simulator, Modeler now supports hybrid simulations, which combine discrete-event simulation and analytical modeling. It can also run a simulation in parallel over several CPUs. Both hybrid and parallel simulations can significantly reduce simulation runtimes.

IT DecisionGuru is a mid-level analytical tool for network architects, managers, and planners (see Figure 1). Advertisements say that it's easy to use and that you can become proficient with it in just one day. IT DecisionGuru shares Modeler's vast protocol and device library. Opnet Technologies developed it jointly with HP (which may explain its impressive capabilities for profiling applications and importing and digesting packet trace information). IT DecisionGuru can also predict and display the impact of changes on service-level agreements.

Netbiz is for sales, professional services, and field services staff. It provides a rules-based environment for network design that you can customize to your organization. It has excellent presentation and configuration features and boasts a minimal learning time. It targets companies selling networking services or equipment.

Figure 4 is a subjective summary of the intended audience and skill requirements for these general-purpose design tools.

OTHER TOOLS

Several network performance tools, application and

Other Network-Related Tools

Network performance tools

- Mimic (Gambit Communications, http://www.gambitcomm.com): SNMP (simple network management protocol)-based enterprise management tools for network management developers and users.
- Chariot, Pegasus (Ganymede Software, http://www.ganymede.com): A tool intended for managing, testing, monitoring, and troubleshooting network performance.
- NetClarity (LANQuest, http://www.lanquest.com): Network performance management and diagnostic tools for load balancing, capacity planning, and service-level management.
- NetMaker (Make Systems, http://www.makesystems.com): Network planning, network engineering, and traffic analysis.
- Link Analyst (Network Instruments, http://www.networkinstruments.com): Graphical network mapping, route analysis, quality-of-service management, troubleshooting, and up-time monitoring.
- NetSpec (University of Kansas, http://www.ittc.ukans.edu/netspec): Traffic generation tools for network experimentation, passive measurement, and performance testing.

Application and business performance tools

- Total Control (Lightspeed Systems, http://www.lightspeedsystems.com): Traffic load, quality of service, firewall, and server monitoring and control.
- VitalSuite 7 (Lucent Technologies, http://www.ins.com): Network application and business performance data, custom reports, and views.
- S3 (NextPoint Networks, http://www.nextpoint.com): Managing networks, e-commerce, IP services, and applications designed to support the business objectives of the enterprise.
- Application Expert (Optimal Networks, http://www.optimal.com): Visualizing, reporting, and tuning e-commerce, ERP, and Web-based applications over wide area networks.
- WebLoad (RadView Software, http://www.radview.com): Simulating and confirming real-world traffic to test Web applications' performance and scalability requirements.

Special-purpose tools

- SystemView (Elanix, http://www.elanix.com): Designing and simulating analog, wireless, cellular, and other communications systems and networks.
- Odyssey (Logica, http://www.logica.com/offerings/): Design tools for radio-based networks.
- Visio 2000 (Microsoft, http://www.microsoft.com/office/visio): Network drawing and diagramming tool.
- Simulink (The MathWorks, http://www.mathworks.com): Digital signal processing and control system component design.
- Telsoft (Telsoft International, http://www.telsoft.com): Extracting and presenting real-time network activity, traffic, and routing data; primarily for telecommunications networks.
- VPI Suite (Virtual Photonics, http://www.virtualphotonics.com): Bandwidth design tools for physical layer components, and access and transport networks.
- NetSuite (Visionael, http://www.netsuite.com): Discovering, validating, and designing complex networks.
- VisSim (Visual Solutions, http://www.vissim.com): Modeling and simulating analog, digital, and mixed-mode components and systems.
- NPAT—Network Planning and Analysis Tool (WANDL—Wide Area Network Design Laboratory, http://www.wandl.com): High-end tools for network design, capacity planning, failure analysis, and network management; includes a sophisticated database of tariffs.

business performance tools, and special-purpose tools have network design features. See the "Other Network-Related Tools" sidebar for more information.

DEFINING YOUR NEEDS

Do you need a special-purpose tool, or will a general-purpose one suffice? If you design and test components for optical networks, then that six-figure, one-of-a-kind optical network design tool you saw at the trade show might just be what you need. As noted, some performance monitoring tools have network design features, so you may already own a low-end network design tool. If you just want to draw network topologies, stick with Visio.

How much are you willing to spend? How fast must the tool evaluate scenarios? How much time can you invest to master the tool? If you think you need a general-purpose network design tool, what type of user are you?

Table 1. Consider which features best support you, based on the type of user you are.

	Type of user				
Feature	Sales or field-services staffer	Network manager or engineer	Network designer	Researcher	Prevalence
Represent resource capacity and bandwidth	x	x	x	x	Common
Measure, estimate, and report utilization; network congestion; load; delay; lost packets; response time; device latency; or availability	x	x	x	x	Common
Identify bottlenecks	x	x	x	x	Common
Support exploration of alternatives	x	x	x	x	Common
Perform sensitivity analysis		x	x	x	Uncommon
Specify traffic and server workloads	x	x	x	x	Common
Distribute load across complex topology		x	x	x	Uncommon
Handle high-load and other stress tests		x	x	x	Uncommon
Model failure and error conditions		x	x	x	Common
Predict when and where the network will develop performance problems	x	x	x	x	Common
Predict which device, link, or subnetwork will reach capacity first	x	x	x	x	Common
Identify applications and protocols causing congestion	x	x	x	x	Common
Ensure service-level conformance	x	x	x		Uncommon
Identify nodes and links close to exceeding user-defined thresholds	x	x	x		Uncommon
Identify underutilized resources	x	x	x		Uncommon
Predict how many users an application can support	x	x	x		Uncommon

Features

In the table, I list various features to help you decide what kind of network design tool you need. (For a far more extensive table, see http://computer.org/itpro/it2000/pdf/f5023x1.pdf on the *IT Pro* Web site.) Depending on what you do, you can use this table to select features you consider important or at least something you should be aware of. The table also indicates how prevalent these features are.

Reconsider your execution speed requirements. Execution speeds span four orders of magnitude, from tens of seconds to days. If you really need to simulate every packet, tune a routing protocol, or tweak TCP, then you absolutely need a discrete-event simulator. To configure a network design while the customer waits, or to simulate a very large network, you probably need an analytical tool or a tool streamlined for field use. Ask the vendor about hybrid solution methods and about techniques that simulate abstract traffic flows rather than individual packets. If you purchase a mid-level or high-end product, invest in two to five days of training to learn techniques for optimizing execution speed. Discrete-event simulators can deliver very precise results in tens of minutes if the user can specify (and the tool can handle) less-critical background details at higher levels of abstraction.

Price

Once you've settled on the feature set, reconsider your budget. Prices for general-purpose tools vary from several hundred to more than fifty thousand dollars. Most vendors have several levels of products:

- high-end tools for developers;
- runtime and "lite" versions for the sales and field services staff; and
- add-on modules for specific applications like wireless networks.

Vendors can give you good advice if you talk to them. A good fit is mutually beneficial. Don't buy a five-figure tool if a four-figure tool is sufficient, and don't settle for a four-figure tool if you really need that five-figure tool.

Network design tool vendors often change company or product names. Companies are bought and sold. The tool you evaluated in 1998 might not be the tool you get today. Ask for a demo version. Check the pedigree. And don't buy add-on modules until you need them; you may decide you don't.

As for future trends, hybrid engines make sense. Expect more vendors to support a mix of discrete-event and analytical solution methods, with tuning knobs to make the speed/accuracy trade-offs easier. Also expect some network and application performance tools with network design features to move into the mainstream, particularly at the low end. Expect vendors to offer more add-on options, because integrated add-on modules keep network design tools affordable. Finally, techniques from artificial intelligence and operations research might go far in automating the what-ifs. Watch for better ways to gain insight about bottlenecks and congestion points, and evaluate competing design scenarios. ■

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IT Pro

Features to Consider in a Network Design Tool

The following table lists various features to help you decide what kind of network design tool you need (see A.W. Bragg, "Which Network Design Tool Is Right for You?" in the Sept./Oct. 2000 issue of *IT Professional*). Depending on what you do, you can use this table to select features that you consider important or at least something you should be aware of. The table also indicates how prevalent these various features are.

Consider which features best support you, based on the type of user you are.

	Type of user				
Feature	**Sales or field-services staffer**	**Network manager or engineer**	**Network designer**	**Researcher**	**Prevalence**
User interface					
Intuitive CAD-like graphical interface	x	x	x	x	Common
Drag-and-drop tool palette for building or modifying models	x	x	x	x	Common
Network topology overlays map, grid, descriptive background	x	x	x		Common
Standard and custom maps, grids, backgrounds	x	x	x		Common
Model behavior accurately reflects map distances and grid scales		x	x	x	Uncommon
Modeling paradigm					
Hierarchical representation (at network, subnetwork, and device levels) with ability to drill down	x	x	x	x	Common
Standard object-oriented constructs (such as those for inheritance and specialization)		x	x	x	Common
Multiple levels of detail and/or abstraction	x	x	x	x	Common
Model individual devices and links	x	x	x	x	Common
Create custom device and link models		x	x	x	Common
Library of models for links, media, devices, architectures, protocols, applications, packet types, and so on	x	x	x	x	Common
Database of voice, video, and data devices, including attributes and prices	x	x	x		Uncommon
Represent subnetworks in terms of aggregate behavior	x	x	x	x	Common
Accurately model large networks (1,000 to 10,000 elements)		x	x		Rare
Confirm connectivity based on device and media attributes	x	x	x		Uncommon
Network topology					
Create topology via tool palette	x	x	x	x	Common
Create topology via rapid configuration tool		x	x	x	Uncommon
Discover and import topology from network management tools (such as HP OpenView)		x	x	x	Common
Discover, map, and import topology via SNMP-based tools		x	x	x	Common
Import user-specified subset topology (such as those for LANs, WANs, or access networks)		x	x	x	Uncommon
Import topology from external file or drawing/presentation tool (such as Visio)	x	x			Uncommon

Feature	Type of user				Prevalence
	Sales or field-services staffer	Network manager or engineer	Network designer	Researcher	
Types of networks supported					
Support wireline (including point-to-point, multipoint, broadcast, switched, and routed) networks	x	x	x	x	Common
Support optical networks, including those based on optical layer protocols			x	x	Rare
Support wireless (fixed- and mobile-node, satellite, radio, cellular, or microwave) networks	x	x	x	x	Common
Mobile nodes' positions change as simulation progresses		x	x	x	Uncommon
Wireless models reflect terrain, fading, multipath effects		x	x	x	Rare
Traffic models, traces, or profiles					
Generate traffic via common models (such as constant and variable bit rate, or bursty traffic)	x	x	x	x	Common
Generate traffic by application (voice, e-mail, or Web browsing) characteristics	x	x	x	x	Common
Create custom flows based on user-defined traffic profiles	x	x	x	x	Common
Import packet traces from network monitors and sniffers		x	x	x	Uncommon
Import traffic profiles from monitors and sniffers		x	x	x	Uncommon
Import traffic traces or profiles from text files		x	x	x	Uncommon
Define load via traffic matrix that represents flows between end systems		x	x	x	Common
Specify background traffic as a baseline load on network	x	x	x	x	Uncommon
Model traffic as aggregate flow from LAN or WAN clouds	x	x	x	x	Common
Solution methods					
Integration of design tool with simulation or analytical tool	x	x	x	x	Common
Analytical solution methods (such as queuing theory or mathematical modeling)	x	x	x		Uncommon
Discrete-event simulation		x	x	x	Common
Hybrid analytical and simulation methods		x	x	x	Uncommon
Parallel simulations over multiple CPUs				x	Rare
Ability to vary simulation granularity (from simulating every packet to aggregates and flows)		x	x	x	Common
Vary speed of solution method		x	x		Rare
Simulation output					
Real-time graphical indications of performance (such as for delay, throughput, packet loss, link use, load)	x	x	x	x	Common
Display traffic flows via real-time animation	x	x	x	x	Common
Graphical output (diagrams, charts, or graphs)	x	x	x	x	Common
Reports	x	x	x	x	Common
Export results to spreadsheets, files, or other tools		x	x	x	Common
Generate bill of materials and estimate material costs	x	x	x		Rare
Estimate tariffs for communications links	x	x	x		Rare
Presentation tools for nontechnical audience	x				Uncommon

Feature	Type of user: Sales or field-services staffer	Network manager or engineer	Network designer	Researcher	Prevalence
Analysis tools					
Customized plots (such as time series or histograms)		x	x	x	Common
Probability functions, parametric curves, confidence intervals		x	x	x	Common
Compute descriptive statistics (such as mean, variance, minimum, maximum, or quantiles)	x	x	x	x	Common
Analyze output via filters (for example, moving average)		x	x	x	Uncommon
Overlay plots, charts, or graphs		x	x	x	Uncommon
Level of customization					
Support user-defined protocols and devices		x	x	x	Common
Simulate any required behavior at the programming language level				x	Rare
Language-level functions for special-purpose modeling features				x	Rare
Source code provided for models		x	x	x	Uncommon
Integrated debugging tool				x	Rare
Ability to import existing code into simulation				x	Rare
Ability to export simulation code				x	Rare
Functions the tool must perform					
Represent resource capacity and bandwidth	x	x	x	x	Common
Measure, estimate, and report utilization; network congestion; load; delay; lost packets; response time; device latency; or availability	x	x	x	x	Common
Identify bottlenecks	x	x	x	x	Common
Support exploration of alternatives	x	x	x	x	Common
Perform sensitivity analysis		x	x	x	Uncommon
Specify traffic and server workloads	x	x	x	x	Common
Distribute load across complex topology		x	x	x	Uncommon
Handle high-load and other stress tests		x	x	x	Uncommon
Model failure and error conditions		x	x	x	Common
Predict when and where the network will develop performance problems	x	x	x	x	Common
Predict which device, link, or subnetwork will reach capacity first	x	x	x	x	Common
Identify applications and protocols causing congestion	x	x	x	x	Common
Ensure service-level conformance	x	x	x		Uncommon
Identify nodes and links close to exceeding user-defined thresholds	x	x	x		Uncommon
Identify underutilized resources	x	x	x		Uncommon
Predict how many users an application can support	x	x	x		Uncommon
Other factors					
Computing requirements (hardware and operating system)	x	x	x	x	Not applicable
Ease of use, short learning curve	x	x	x		Not applicable
Training, technical support, and documentation	x	x	x	x	Common
Availability of less-expensive runtime version or viewer	x	x			Uncommon

Feature	Type of user				Prevalence
	Sales or field-services staffer	Network manager or engineer	Network designer	Researcher	
Availability and cost of special-purpose add-on modules and features			x	x	Common
Annual maintenance fees			x	x	Common
Tiered versions (for the sales or field-services staff, and network managers and engineers)	x	x			Common
Degree of integration with vendor's other products	x	x	x	x	Common