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Network Testing Tools

All of today's exciting network initiatives such as Voice over IP, Gigabit Ethernet, and multimedia streaming rely on the underlying cabling and connectivity. Network testing tools are the best way to diagnose and troubleshoot your network's foundation directly.

Many professions are clearly identified by the tools of their trade. They are inseparable—the astronomer with his telescope, the botanist with her microscope, and the carpenter with his wood tools. For the IT professional, network testing tools should have the same important distinction. Network testing tools bring light to the workings of a network and its underlying cabling. They provide visibility, information, and insight into the cabling and the network, and bring some sanity to an IT group conducting both day-to-day network chores as well as troubleshooting difficult problems. These tools are not surprisingly used in most smooth-running networks managed proactively by effective IT professionals who understand the importance of using the right tool for the job. By understanding the applications and differences among the somewhat dizzying number of testing tools available, an IT department can choose the right tools for the right people in its group.

Here, we will focus on cable and network testing tools used in small and large corporate networks by IT professionals such as front-line network technicians, network managers, systems integrators, and independent consultants. For most companies, these tools will focus on unshielded twisted pair (UTP) cabling, Ethernet, and the TCP/IP protocol. We will define, describe, and discuss cable verification tools, network ping tools, network discovery and monitoring tools, and protocol analyzers.

It's amazing when you think of all the information silently traveling through the cables that make up a company network. Financial information, important e-mails, sales proposals, presentations, and other important information flows over the cabling as bits of information. All this vital company information not only relies on the network but also the cabling beneath. However, some companies don't know what is happening on the cable and in the network and instead just hope the network functions and wonder what happened when it does not. Hoping and wondering are bad for business. A network that performs poorly can often be traced to an IT department with insufficient training, a scattered approach, or a lack of appropriate tools to detect and fix network and cabling problems.

Let's imagine two different networks. The first network is constantly going up and down and no one seems to know why. There is vagueness and uncertainty when something does not work—could it be the application? Maybe it's the servers, or it might be the cabling. The problems are never defined enough to solve them, and the company stumbles forward with its sick network. The IT group constantly chases problems but rarely provides a permanent fix.

The second network is almost always running, grows to accommodate new users, and handles new



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applications gracefully. When problems arise, they are diagnosed using the right tools, and fixed quickly. The IT group has time to spend helping with interesting, special projects and everyone in the company uses the network and systems effectively as a vital resource for the business.

Who wouldn't choose the second network? Network testing tools can help you move in that direction. These solutions save time—both for the end users relying on the network and for the IT group managing the network—and they reduce the frustration and cost that comes from the uncertainty that arises from misdiagnosed or undiagnosed problems. They are a key component in turning network management from a guessing game to a game of certainty. With all of the new network-centric changes afoot such as Gigabit Ethernet, Voice over IP, and wireless connectivity, it's important to have a solid, working foundation. After all, you don't want a \$10 patch cable destroying productivity.

● The Right Tool

There are many products classified as network testing tools (ranging in price from under \$100 to over \$30,000), and at first glance, it may be difficult to discern among the different products. To keep all the products straight, we'll introduce five categories of products that describe most of the tools available:

- Cable verification tools
- Network ping tools
- Network discovery and monitoring tools
- Cable certification tools
- Protocol analyzers

In the first three categories, most (if not all) of the tools will be handheld devices. In the last two categories, there are a few form factors, including handheld devices, rack-mountable appliances, and software that

must be loaded on a notebook or other computer. We'll describe each of these product categories below and discuss some of the common features found in each category. Of course, some products will not fit easily into one of these categories. Some are highly specialized and some will solve a broad range of problems spanning the features typically found in each category.

Cable Verification Tools

Cable verification tools are used on a daily basis by front-line network technicians for in-wall cabling and patch cables. They are most commonly used before connecting a PC to a new wall plate, or when installing a new patch cable. Cable verification tools can display wire mapping, detect cable faults, show link status, and in some cases, provide the cable length. These tools use simple DC voltage applied to the cable to determine cable faults and wire mapping, and use a technology called time domain reflectometry (TDR) to determine cable length. They are very inexpensive, priced between \$100 and \$300.

Wire maps compare the pin-outs on the RJ-45 connector on one end of the cable to the pin-outs on the other end. Typically you're looking for a straight-through cable for hub/switch-to-PC connections, but crossover cables (with some pairs reversed) are needed when connecting one switch to another switch. Wire maps require that a remote device (typically included) be placed on the other end of the cable to serve as a termination point.

There are various types of cable faults:

- Opens: wire cut or not terminated correctly
- Shorts: two wires touching, usually at termination point
- Splits: a wire is mistakenly paired with a wire from a different twist pair
- Crosses: two pairs are crossed when crimping
- Reversals: the wires within a pair are crossed

As mentioned, crosses sometimes don't represent a fault, so you might want a crossover cable for a hub-to-hub connection.

These kinds of faults are quite common—they even occur in patch cables purchased from reputable companies, and certainly can occur if the cable has been bent or crushed in any way.

Most cable verification tools have the ability to send a link pulse to a hub on the other side so that the two sides of a cable can be determined and labeled. A hub indicator light will turn off and then blink, making it easy to identify. Finally, some of the higher-end devices use TDR technology to determine the length of the cable. Sometimes long cables (close to or over the 100 meter maximum for Ethernet on UTP) can create intermittent network problems.

These tools won't tell you if a particular cable will work for Ethernet, Fast Ethernet, or Gigabit Ethernet. That requires a cable certification tool that tests the cable at the frequencies used by these technologies and determines if the cable exhibits acceptable signal/noise characteristics such as signal loss and cross-talk. However, if the cable has previously been certified, you have purchased a well-labeled patch cable signifying its rating, or if you've determined a cable installation's suitability through historical performance, then verifying the cable can be sufficient when changes are made.



Network Ping Tools

Network ping tools are essentially cable verification tools with one important difference that can really help when connecting a PC to the network: they allow you to ping important network devices such as the gateway router and servers. This ensures not only that the cable behind the wall plate is working, but that the actual TCP/IP network layer is working as well. By using a ping test, you can rest assured that the cabling works, the cable is connected to a hub or switch on the other side, and that network connectivity extends out to the pinged devices.

If subsequently the PC can't see the network, you'll know the problem lies with the PC, probably with TCP/IP or other network settings. This kind of problem isolation saves a lot of time and eliminates guesswork. If you only use a cable verification tool to check the connection, there is a chance of a bad or misconfigured hub or switch.



The only downside to network ping tools is higher cost. The new LinkRunner from Fluke Networks, for example, has an introductory price of about \$500. It's worth the extra cost, however, for companies that make many additions and changes to their network.

Network Discovery and Monitoring Tools

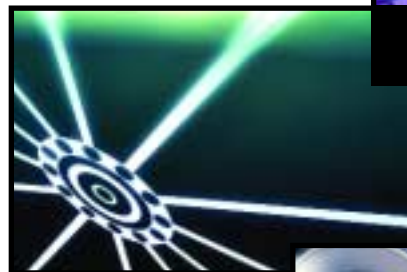
Whereas cable verification tools and network ping tools are typically used for one connection at a time, sometimes a network administrator will need a macro view of the network. Network discovery and monitoring tools provide a detailed look into the network through discovery of routers, servers, desktops, and other kinds of network devices. The tools will also display overall network utilization and break down traffic on a connection-by-connection basis. They interrogate hubs and switches to learn which ports are used, and in some cases, create a visual map of the network. Most have reporting facilities to document the network information.

These tools are ideal both for discovering and documenting network components and troubleshooting network problems when they arise. Many are available as portable handheld devices that can be moved from one network to another; others come as rack-mountable appliances intended to monitor a single network continuously and alert you to any problems. These tools are priced from about \$3,000.

Cable Certification Tools

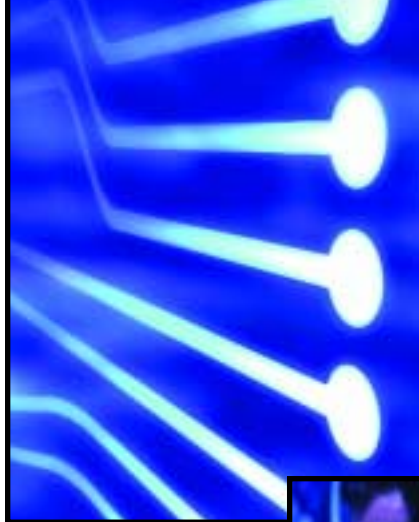
Cable certification tools are typically for the professional cable installer, but some larger companies with many installed cable may

choose to purchase their own tools and certify their own cabling. The tools typically cost thousands of dollars, and are really only practical for large companies that need to certify many floors or buildings. That said, cable certification should be an absolute requirement for new cable



installs, but it often goes undone. Certification is the only way to determine if your cabling is ready for Fast Ethernet and Gigabit Ethernet.

These tools come in a variety of flavors that test cabling according to the cable certification standards set by the Telecommunications Industry Association (www.tiaonline.org). For example, some older devices test up to 10MHz, the signal frequency for standard Ethernet. For Fast Ethernet, the devices must signal at frequencies up 100MHz (called Level II devices), and perform the tests set by the Fast Ethernet standards. Gigabit Ethernet tests are best performed at higher frequencies (Level III devices). Many of the devices use 350MHz signals to test for certification. Although Gigabit Ethernet only uses 100MHz, it uses all 4 pairs of cable, and Gigabit certification runs tests using all 4 pairs.



These tools typically will store the results, and allow the cable installer to print those results. Ask for these reports when installing new cable or certifying old cable.

Protocol Analyzers

Protocol analyzers capture and dissect the individual packets that travel across the network. They often uncover problems on the network that other tools cannot, such as mismatched passwords, Windows master browser issues, viruses, and application-level problems. These tools are used by software engineers when designing client-server or browser-server software applications. For network engineers with the right training, a protocol analyzer can reveal a lot about the network. On the other hand, for those without experience or expertise, a protocol analyzer can be overwhelming and unhelpful.



In the good old days, protocol analyzers were one of the few options for network administrators. Unfortunately, they were difficult to use for



diagnosing and solving common network problems, and in many cases, they were overkill for the task at hand. Still, protocol analyzers have their place for problems in the upper transport, session, and application layers.

Table 1 provides a summary of the five tool categories, and Table 2 compares the categories.

Table 1: Network Testing Tool Categories

Category	Target User	Common Features	Common Usage Scenarios
Cable verification	Network technician	Length, wire maps, cable faults, link pulse, tone generator	Verify patch cables and in-wall cable runs
Cable certification	Cable installer	High-frequency certification tests; storage for hundreds of test results	Certify new cable installations, certify existing cabling for new high-speed network
Network ping	Network technician	Same as cable verification plus TCP/IP pings	Assist in network moves, adds, changes
Network discovery and monitoring	Network manager, Network help desk, Network control center	Network device discovery, network utilization, connection utilization, reporting facilities, historical reports	Discover and document networks, ongoing network monitoring, network troubleshooting
Protocol analyzers	Network engineer, software engineer	Protocol decode for all common applications, packet generation	Troubleshoot application-level problems, view detailed network usage including detailed application parameters, rogue applications, and network viruses

Table 2: Comparing the Tool Categories

Feature	Cable Verification	Cable Certification	Network Ping	Network Discovery & Monitoring	Protocol Analysis
Cable length	Yes	Yes	Yes		
Link confirmation	Yes		Yes		
Hub/switch speed indicator	Yes		Yes		
Cable faults	Yes	Yes	Yes		
Wire mapping	Yes	Yes	Yes		
Identify hub port	Yes		Yes		
Cable certification		Yes			
Cable certification reports		Yes			
Fiber testing		Optional			
Network ping			Yes	Yes	
Discover all devices on network				Yes	
Trace route				Yes	
Network utilization				Yes	
Individual connection utilization				Yes	Yes
Web interface				Yes	Yes
Reporting				Yes	Yes
View detailed application information inside packets					Yes

● Common Scenarios

Network testing tools are part of an overall customer service strategy and helpful in providing a higher level of service to a company and its employees. There are many ways that companies can use these tools. For example, when an add, move, or change is made, a front-line network technician can check the cable, ensure there is a live connection to the network, and if using a network ping tool, ping key network devices to ensure a working network connection. Below, we'll describe a number of common scenarios where network testing tools can help.

Network testing tools allow IT professionals to do their work effectively and reproducibly. Without these tools, the following tasks are difficult or impossible.

1: Testing a plethora of patch cables

Who: Network technician, network administrator

Scenario description: Patch cables are purchased from different sources and stored in the network closet. You discover that one of the batches has an unacceptable number of bad cables, but you can't identify all of the bad cables visually. Also, from experience, you know that previously working patch cables can be damaged by rough handling.

Common problems: Poor connector crimps leading to shorts and opens, distinguishing crossover cables from straight-through cable, cable faults introduced when janitor pulls cable violently from wall plate, cable bent under furniture.

Solution: Use a cable verification tool to test all patch cables. Cables that fail verification test can be discarded or cut and new RJ-45 connectors applied.

Ideal tool: Cable verification tool

2: Mapping your existing cable infrastructure

Who: Network administrator

Scenario description: Your wiring closet is a mess. Cables are not labeled and it takes you a long time to match a wiring closet

cable to its corresponding wall plate out on the floor. You want to replace some old hubs with new switches, but don't even know which patch cables need to be reattached.

Common problems: Cabling does not have identification labels, identification labels are incorrect.

Solution: Use a cable verification tool with hub link pulse feature, walkie-talkies, and a label maker or markers. Send a link pulse through into each wall plate and note the corresponding hub port (it will typically shut off and then blink). Add matching labels to each side of the connection.

Ideal tools: Cable verification tool

3: Testing new or existing cabling in preparation for Gigabit or Fast Ethernet

Who: Cable installer, certified cable tester

Scenario description: You want to ensure that the in-wall cabling runs have been installed correctly and terminated appropriately. The old adage says that 90 percent of cabling problems are in the installation, not with the cable itself. While Fast Ethernet and Ethernet only use two cable pairs, Gigabit Ethernet over copper requires all four pairs, so a recertification is appropriate. Gigabit Ethernet can run over most Category 5 installations.

Common problems: Excessive unwrapping at cable ends, cabled stapled to inside walls, lower-grade cable such as Category 4 used for installation, splices made in some cables, incorrect termination for all four pairs.

Solution: This is a job for a certified cable installer. There are no shortcuts. Use a high-end cable certification tool capable of sending a range of low and high-frequency signals through the cabling and checking for characteristics such as near-end cross-talk (NEXT), far-end cross-talk (FEXT), and signal loss.

Ideal tools: Cable certification tool

4: Testing new user connections

Who: Front-line network technician responsible for end-user support

Scenario description: In a medium or large network—whether it's a corporation, government department, or even a school—nothing stays the same. Employees, consultants, temporary workers, and students are always coming and going, and must be connected to and disconnected from the network. Individuals or entire groups move to new desks and offices or between floors. These people must be connected to ports with working cabling and a live connection to the network.

Common problems: Bad patch cable between wall plate and computer, patch panel not connected to hub/switch in wiring closet, bad patch cable between patch panel and hub/switch, computer using incorrect TCP/IP or other network settings, Ethernet speed mismatch with auto-negotiation turned off, Ethernet duplex mismatch (half/full), router down, network technician wastes time changing computer setting when the problem is a bad patch cable.

Solution: Use a network ping device to check both for good cables and a live network connection. Ping key network devices such as the gateway router and servers. Don't forget to verify the patch cable as well. A cable verification tool can check the cable run and the patch cable, but can't confirm connectivity to key devices. If the tool can ping key devices but the computer cannot, check the computer's TCP/IP settings.

Ideal tools: Network ping tool

5: Getting your hands around a new network

Who: New network administrator, systems integrator, network consultant

Scenario description: You are responsible for maintaining or fixing a network previously unknown to you. Unfortunately,



there is insufficient or a complete lack of documentation. You need to create documentation for the cabling, network devices, PCs, and servers—and uncover any problem areas. You need to get this done today.

Common problems: No documentation, no onsite expert, insufficient information.

Solution: Hook up a network discovery and monitoring tool to uncover network routers, servers, and PCs. You can print the information or import it to another software tool such as Microsoft Excel or Visio. It's also a good idea to test all cabling at this time—it will save time later. Use a network ping tool on all end points to ensure good cabling and a live network connection. If necessary, label any unidentified ports.

Ideal tools: Network discovery and monitoring tool, network ping tool

6. Fixing a slow network

Who: Network administrator

Scenario description: The network always seems slow, is slow at certain times of the day, or is intermittently slow.

Common problems: Network backups slowing down network, one or more people playing network games, one or more people downloading large files, bad NIC jabbering, broadcast storms.

Solution: Analyze network utilization during both good and bad network conditions. Drill down to individual desktops or servers using a high amount of network bandwidth. Check for cause of high network usage—valid use of network such as network backup, unauthorized use of network such as network game, or jabbering network adapter. Depending on the problem, reschedule the problem application if possible, stop the use of unauthorized games or downloads, or replace the offending network adapter. If necessary, use a protocol analyzer to uncover specific application usage.

Ideal tools: Network discovery and monitoring tool, protocol analyzer

7. Diagnosing application problems

Who: Network engineer

Scenario description: An employee has network connectivity but can't connect to an e-mail server or print to a new printer.

Common problems: Employee using unsupported mail protocol such as IMAP, or has incorrect driver for new printer.

Solution: Use a protocol analyzer to view all packets flowing between the client and server. Check that there are no missing steps, and if necessary, that the information in each packet is correct at the byte level. The use of these tools requires a network engineer knowledgeable with the expected behavior of the suspect protocols.

Ideal Tools: Protocol analyzer

● A Sampling of Tools

Here is a sampling of some of the network testing tools available from CDW, representing some of the most popular products in each of our five categories.

Product	Category	Capabilities	CDW Part #
Agilent WireScope 350	Cable certification	Copper Gigabit certification; Pro version tests multimode fiber also	327559
Agilent FrameScope 350	Network discovery & monitoring	Network and Internet server performance; network reporting	353991, 354890
Belkin Cable Tester	Cable verification	Cable continuity and pin configuration	119335
Black Box Veri-Net+ Tester	Cable verification	Link, speed, and link pulse	312992
CompuCable Enhanced Network Tester	Cable verification	Tone generator; tests for cable opens, shorts, and crosses	240795
Fluke Networks MicroScanner Pro	Cable verification	LCD display, TDR length determination, UTP or coax	374613
Fluke Networks DSP-4300 Digital Cable Analyzer	Cable certification	Level III tester for Cat 5, Cat 5e and Cat 6 certification; cable test management software	338193
Paladin LAN ProNavigator	Cable verification	Pass/Fail mode, tests for cable opens, shorts, and crosses; works with BNC coax	213663
Fluke Networks LinkRunner Network Multimeter	Network ping	Cable verification plus ping up to 5 devices	392822
Fluke Networks NetTool Inline Network Tester	Network discovery & monitoring	Inline testing between a desktop computer and network	235713
Fluke Networks OneTouch Series II Network Assistant ITS2100	Network discovery & monitoring	Network utilization, network device connectivity, network documentation	229384
Fluke Networks OptiView Integrated Network Analyzer	Network discovery & monitoring; protocol analyzer	Handheld high-resolution color screen; stylus input; high-performance protocol analysis	319710

Note: For current product prices, contact your CDW Account Manager.

Beyond the Tools

The right tools are only one part of an effective network testing tool solution. In fact, we feel there are three important aspects to a good solution:

- Proper training
- Documented processes
- The right tools

Although many of the tools are easy to use, network troubleshooting still requires proper training. This training can be formal or gained by experience on the job with an experienced network guru. It's important to understand the terminology, technology, and tool usage.

Checklists and documentation go a long way towards ensuring a high-quality network. If best practices for troubleshooting problems are documented, there is consistency across the IT group. This breeds confidence, because the job is done right, and done the same way each time.

Finally, the right tools are crucial to maintaining, diagnosing, and fixing network problems. Otherwise, the cabling and network connectivity and the cause of the problem remain invisible and difficult to diagnose. With the right tools, network maintenance and troubleshooting becomes challenging and fun, as problems are solved systematically. Properly used network testing



tools can help gain respect for the IT group, since it will help them provide better service to employees. Also, users will feel more confident in seeing professional equipment being used to diagnose and fix problems.

Network testing tools are a critical part of a healthy network. Once you've chosen the right tool and have the training and processes to go with it, that tool will quickly pay for itself. No IT professional should be caught without them.

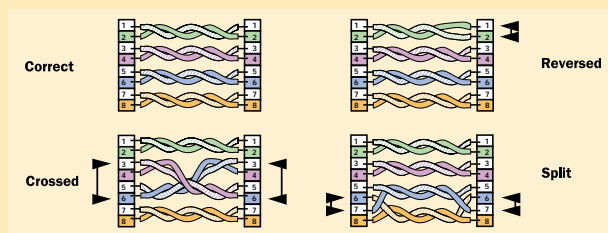
PRACTICAL INFORMATION ON UTP CABLING

UTP cabling can be a confusing subject, so let's go through some helpful background and practical information on UTP cabling. First of all, what's the deal with the cable specifications—Cat 3, Cat 5, Cat 5e, Cat 6, and so forth? Are these types of cable or cable specifications? The answer is both. Rolls of cable and patch cables are labeled with these designations, and the cable itself has the capability to meet the specifications, but the cable installation determines the final grading. The cable specifications as set forth by the Telecommunications Industry Association (TIA) and each Category grade must meet its own set of performance characteristics. The TIA produces and publishes specifications for cabling, and published its 568A document which discusses unshielded twisted pair cabling in 1991. The Category 5 and Category 5e specifications are outlined in the 568A document which has been updated periodically since 1991. They both describe using up to 100MHz frequencies, but the Category 5e specification is stricter on performance characteristics (for example, near-end cross-talk, or NEXT, has to be 3 dB higher). The specifications for these cabling types determine the maximum or minimum acceptable values for such things as NEXT, signal attenuation, delay, and so forth.

Cat 3 cabling, for example, was used in the first star-based 10Mbps Ethernet networks, and is still commonly used for telephone connections. However, it lacks the ability to transmit data faster than 10MHz, as larger frequencies introduce a lot of noise and cross-talk. So the Cat 5 and 5e standards were drafted and accepted to allow faster data transfer rates up to 100MHz and 350MHz, respectively.

When looking at cable, there are really two kinds of problems that can occur—those that are easy to find and those that are more difficult to find. UTP cable consists of four pairs of wires contained in a plenum sheath or other insulator. Shown below, the easy problems can be found by simple cable verification tools and include the following types of problems:

- **Opens** (one or more of the wires have been broken)
- **Shorts** (two wires touch, often when crimping)
- **Crossed pairs** (at least two pairs crossed when crimping)
- **Reversed pairs** (two wires in a pair reversed when crimping)
- **Split pairs** (wires from two pairs mismatched)



Common wiring problems

However, your wiring may not have any apparent faults, but still may not meet the specifications required for a Fast Ethernet or Gigabit Ethernet installation. These kinds of problems include excessive cross-talk, large signal attenuation, excessive propagation delay, or low signal/noise ratios. These problems can stem from low-quality cable, but most often occur due to poor installation. For example, if an installer untwists the cable too much when punching the cable to the patch panel, a lot of cross-talk will result. These kinds of problems can only be found with more expensive cable certification equipment that sends high-frequency signals across the cable and measures the signal attenuation, cross-talk, and delay.



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Network Testing Tools

- Tools explained: cable verification, network ping, network discovery and monitoring, and protocol analyzers
- How to choose the right tool for the job
- How to use testing tools to solve common network problems



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