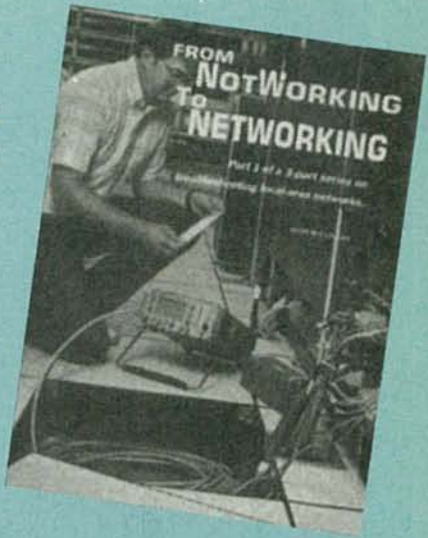
FROM NotWorking To NETWORKING



Learn about basic and advanced equipment for troubleshooting LAN's.

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THIS IS PART 2 OF A THREE-PART SEries on troubleshooting local-area networks (LAN's). In Part 1 we presented technical background on network technologies including cable types, topologies, signal schemes, and access protocols. This time we introduce the tools and test equipment necessary to service LAN's quickly and effectively. Next time we'll put our knowledge to work in diagnosing and solving easy and difficult network problems.

Experts say that cable faults cause more than 70% of all network failures. Cable faults may sound simple in theory but, in practice, diagnosing and locating them can bring strong men to tears. However, common sense, good test equipment, and intelligent substitution techniques can take you a long way toward rapid, inexpensive repair.

Common sense helps you localize the problem to avoid wasting time performing irrelevant tests. Good test instruments are your eyes and ears into the LAN; equipment can be as simple as a $20 digital multimeter (DMM) or as complex as a time-domain reflectometer (TDR) costing thousands of dollars. (A TDR uses radar-like techniques to measure the distance to a cable fault. Typically a test instrument transmits a signal and measures the time it takes for its reflection to return to the source.)

Gone are the days of mindlessly swapping computers, boards, and cables. Instead we use intelligent swapping to localize a problem, and then use appropriate test equipment to find the suspect part. Next we install a substitute, and if the LAN comes to life, that part remains. Otherwise, we will repeat the process until the fault disappears and the LAN comes on-line.

Some training firms claim that only a screwdriver is required to service a LAN. We won't go that far—but with the techniques discussed here, we'll come close.

Hand tools

Common hand tools are useful in servicing LAN's. Table 1 describes the basic requirements; you'll probably add other, more specialized tools to the list as time goes on.

One quick and easy way to get the tools you need is to buy a Jensen tool kit. For example, the reasonably priced JTK-5 tool kit contains all the essentials for servicing Ethernet LAN's. Also check with Jensen for tools and tool kits suitable for twisted-pair and Token Ring LAN's.

Probably the most common problem in LAN service is connectors. Sooner or later, you'll have to replace a bad one. The best way to learn the proper techniques is to work with someone already skilled in the art. Failing that, there are other resources. Try a local electronic parts distributor for manufacturer's literature on connector installation. Or locate a copy of the *Radio Amateur's Handbook*, published by the American Radio Relay League. The Construction Practices chapter of that handbook describes the proper way to install BNC-type coaxial connectors. You might also contact AMP and other manufacturers to request assembly information on their crimp-on coax and RJ-xx series connectors. The sidebar lists several sources of information.

The DMM

No service technician in his right mind would be caught dead without a DMM; it is literally indispensable. You can use it to service LAN's, and also to check building AC-line power and repair electronic equipment of all types. DMM's are available with a dazzling variety of features. If you are shopping for a DMM, choose a 3½-digit unit, like the one shown in Fig. 1, that is easy to use, has the features you really need, and has a low price. Minimum LAN-specific requirements for a DMM include a 0 to 200 ohms range, a continuity beeper, a 0

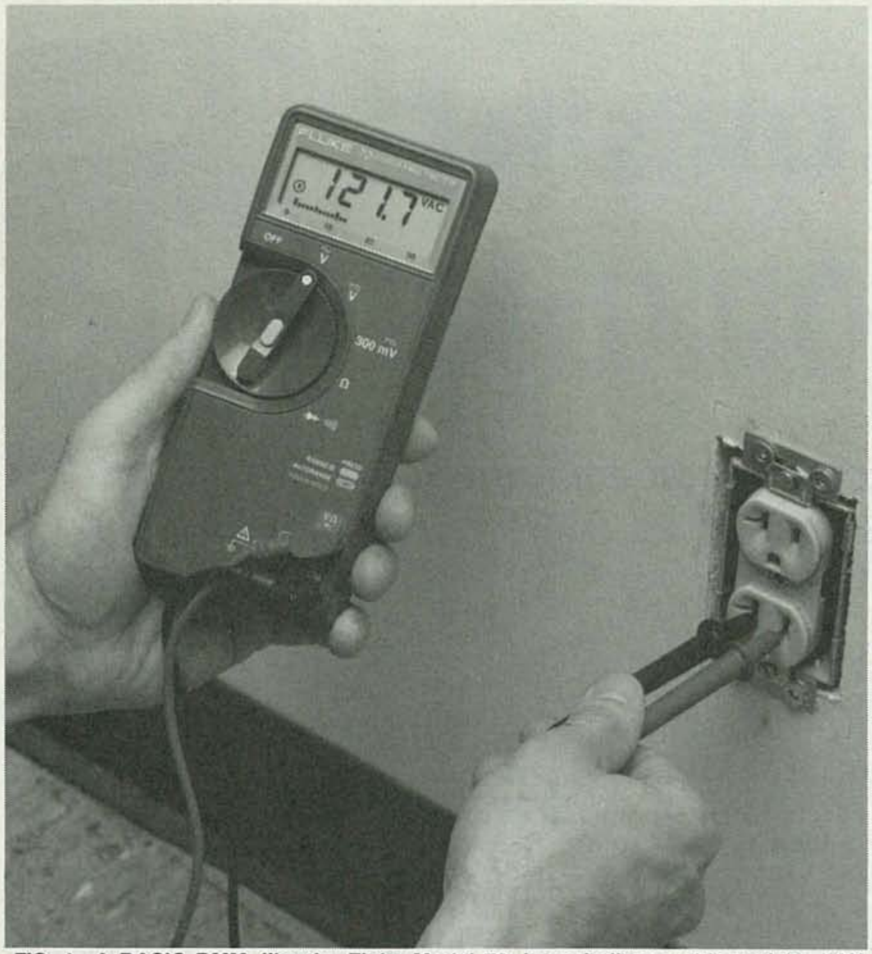

FIG. 1—A BASIC DMM, like the Fluke Model 70, is an indispensable tool for LAN troubleshooting.

to 20-volts DC range, and a 0 to 200-volts AC range. Most DMM's sold today meet those minimum specifications.

Let's discuss briefly how you can use a DMM for LAN servicing. Resistance and continuity are probably the most used functions in LAN servicing. Use the ohms function to measure the resistance of cables and terminator resistors, and to locate shorts or opens in cables and connectors. A low-end range of 0 to 200 ohms is important because coaxial cables typically measure less than 5.0 ohms end-to-end, and twisted pair less than 20.0 ohms. To make this type of measurement, first power down the network to avoid affecting LAN operation. Disconnect questionable cables before making measurements.

High-resistance cables can have partially severed wires or bad connectors. Test all terminators (connector bodies containing 50-, 91-, or 100-ohm resistors) to ensure proper resistance. Use the continuity function to locate shorts and opens in cables and connectors. Audible beeps are especially useful when working in dark or tight places like plenums (dropped ceilings).

The DC function is useful as well. Ethernet LAN's carry 5-volt power and data to the transceivers attached to the backbone cable. Use the DMM to verify that power is present at the transceiver if it does not have a Power Good indicator. You can also use the DC volts function to verify voltages in emergency lights and uninterruptable power supplies (UPS's).

Last but not least, use the AC volts function to measure AC power outlets and noise levels on the LAN cables. It is not uncommon for power problems to cause trouble on a LAN, particularly when the file server or hub computer is affected. Then the whole network may crash. Just check the outlet voltage with a DMM, and if it is outside the 105 to 125-volt AC operating range of most computers, call an electrician!

Noise problems can be a big headache, especially on LAN's with unshielded twisted-pair (UTP) cable. Noise causes random data errors and, in serious cases, can crash the network. Measure noise with a DMM by connecting it to one end of the cable, making sure the other and is terminated properly. The DMM reading for a good UTP cable can be in the range of 5 millivolts or less. A high reading can uncover unusual faults such as a coil of excess cable or cable routed too close to EMI sources such as fluorescent lighting fixtures. In fact, the author once determined that a 50-foot coil of excess UTP left on top of a light fixture by an installer was causing intermittent problems on a newly installed LAN. The problem drove everyone crazy for months! Using a DMM as a noise meter has limited utility because DMM's measure voltage in the kHz range, not in the 4 to 16-MHz range typical of most networks protocols.

Worse, DMM's don't measure impulse noise, which is especially disruptive to LAN operation. For that type of measurement, we must go to more specialized equipment such as that described in the following sections.

Microtest cable scanner

Microtest was the first company to provide specialized, all-in-one LAN test equipment such as the Microtest Cable Scanner. This handheld instrument contains everything you need to troubleshoot LAN cables, including ohmmeter, noise meter, time domain reflectometer (TDR), Ethernet activity monitor, and cable tracer. Best of all, the Cable Scanner is reasonably priced and readily available. Figure 2 shows the Cable Scanner and several other similar models.

Although optimized for Ethernet LAN's, the Cable Scanner also tests unshielded twisted

FIG. 2—MICROTEST'S HANDHELD LAN TESTERS combine most-needed features in easy-to-use, hand-held packages. Clockwise from upper left are the Cable Scanner, the Ring Scanner, the Pair Scanner, and the Quick Scanner.

pair (UTP), shielded twisted pair (STP), Token Ring, and RS-232 cables with simple adapters. In addition, Microtest offers specialized scanners specifically for testing unique features of other cable.

Key features of the Cable Scanner include resistance and continuity functions, a basic noise meter, and a TDR. The noise meter is a simple AC voltmeter that reads millivolt noise in the 1-kHz range; it has no capability for measuring impulse noise. Due to the shielding nature of coaxial cable, noise problems are less common in Ethernet systems—but they do happen. The Cable Scanner is adept at sensing 60-Hz power-line noise that often appears in problematic coaxial cable systems.

The TDR function can locate shorts and opens in LAN cables. Operating it is as simple as pushing a button. The device then injects pulses into the cable where they travel until they strike a fault, and subsequently bounce back to the instrument. The Cable Scanner measures the travel time, calculates distance to the fault, and then displays the distance. All you have to do is inspect the cable at that distance and repair the fault.

Remember that for a TDR to work properly, all equipment must be turned off. Otherwise, data on the line could cause false distance readings—not to mention what it would do to on-line computers! You should also know that all TDR's have a blind spot, or dead zone, from where the instrument connects to some distance down the cable. The Cable Scanner cannot detect faults occurring within the first 25 feet of cable. If you suspect a fault in that section, inspect the cable manually, or make another measurement from the other end of the cable.

The Cable Scanner's Ethernet activity monitor is useful for spotting bad transceivers and other cases of network overload. Recall from Part 1 of this series that Ethernet works on a first-come, first-served basis, somewhat like an old-fashioned telephone party line. Whoever speaks first gets the line. Should something go wrong—for example, a transceiver that "jabbers" or talks all the time—traffic could soar to 100% usage. That, in turn, would prevent other computers on the network from exchanging data because their collision sense multiple access (CSMA) circuitry would force them to wait continually. The result is that LAN operation would come to a grinding halt.

The activity monitor counts the number of data packets (messages) sent between computers on the network over a set time period (for example, one second or one minute). Then it calculates percent usage. You then look up that value on a chart to determine whether there are problems. If so, you must troubleshoot to locate the cause of the fault.

The Cable Scanner also has an optional cable tracer that allows you to trace a specific cable as it runs through the building alongside others. This is a handy feature because LAN cables look alike, making it easy to waste time tracing the wrong cable. To operate the cable tracer, you must also purchase a cigarette-pack-size receiver. In operation, the Cable Scanner sends a special signal over the cable under test. Then you hold the receiver next to each cable in turn; the one that produces a warble tone is the one you want.

Microtest also sells more specialized instruments for testing other kinds of cables. For UTP/STP cables there is the Pair Scanner, which addresses major twisted-pair concerns including impulse noise and signal loss through the cable. The Pair Scanner also has switching capabilities for selecting different transmit/receive pairs, as well as a hub computer test function. For Token Ring cabling there is the Ring Scanner, which isolates faulty multistation access units (MAU's), determines whether the ring maintains continuity, and monitors network traffic. Interestingly, it can simulate network faults, so you can perform "fire drills" on a good LAN and get a feel for symptoms before they occur. All Microtest products provide a serial output for logging data or printing hard copy reports.

Paladin Patch Check

Growing popularity of UTP-based LAN's has created a market for special test tools. One good example is a simple, low-cost cable tester from Paladin Corporation called Patch Check. Patch Check, shown in Fig. 3, identifies the most common faults in UTP systems, namely bad connectors, shorts, and opens.

Patch Check tests the full range of UTP systems, from single- to four-pair cables terminated in RJ-11 or RJ-45 connectors. Operation is simply a matter of snapping both ends of the cable into the unit, pushing the Test button, and watching the indicators. Bad connections or opens appear as one or more unilluminated LED's; shorts appear as multiple simultaneously lit indicators. Paladin also offers a remote indicator for situations where you can't get at both ends of the cable.

Patch Check can save lots of time. For example, in resolving one problem described in Part 3 of this series, the author checked a cable with Patch Check in ten seconds, vs. five minutes on a DMM!

FIG. 3—PALADIN'S PATCH CHECK provides instant go/no-go testing of RJ-11 and RJ-45 telephone-style connectors, used for shielded and unshielded twisted-pair wiring.

Tektronix 1502C TDR

Of all the equipment discussed in these articles, the Tektronix 1502C TDR is oldest and best established. For finding tough problems it can't be beat. It can identify badly crimped connectors, crushed coaxial cables, wiring chewed by rodents, and more. It is sensitive enough to locate problems to within inches on the cable. The 1502C is a state-of-the-art version of a line of analog TDR's that goes back several decades.

The 1502C looks much like a benchtop oscilloscope, as shown in Fig. 4. However, instead of the usual cathode ray tube (CRT), the 1502C has a liquid crystal display (LCD) to reduce power consumption and weight. A removable reticle fits over the display, which shows cable impedance vs. distance. The operating controls are simple, and there are less of them than on an oscilloscope. An excellent operator's manual helps new or infrequent users operate the device.

Key features of the 1502C include a negative-going output pulse, which shuts down live Ethernet transceivers, and a *zoom* feature that allows you to examine tiny faults which show up as impedance spikes on the display. Zoom helps you find problems like rusty connectors or bad crimps. In Part III we will show how we found an unauthorized cable tap using these features.

One important feature is the propagation-rate control. It's important because it determines the distance accuracy of the TDR. As you might recall from physics class, electrons travel at the speed of light in a vacuum. But in the real world of copper cabling, signals travel much slower. The speed reduction is due to insulation quality and conductor diameter. The propagation-rate control calibrates the equipment to compensate for the slower conduction in the cable, thereby providing correct distance indications.

RESOURCES

Following are addresses of manufacturers whose products were discussed in this article. Contact them for current pricing and more information.

- **Paladin Corporation, 3543 Old Conejo Rd., Newbury Park, CA 92123, (800) 272-8665.**
- **Jensen Tools, Inc., 7815 S. 46th Street, Phoenix, AZ, 85044, (602) 968-6231.**
- **MicroTest, Inc., 3519 E. Shea Blvd. Suite 134, Phoenix, AZ 85028, (800) 526-9675.**
- ***Radio Amateur's Handbook*, American Radio Relay League, Newington, CT 06111.**
- **Tektronix, Inc., Redmond Division, 625 S. E. Salmon Dr., Redmond, OR 97756, (800) 833-9200.**
- **AMP, Inc., P.O. Box 3608, Harrisburg, PA 17105, (717) 561-6168.**

Typically you set the propagation rate by consulting a chart published by the cable manufacturer or LAN equipment vendor. Values are usually expressed as a percentage of the speed of light, c. The higher the percentage, the faster the signals travel through the cable. Typical Ethernet backbone cable has a propagation rate of 0.76c. Some sources refer to propagation rate as the numer-

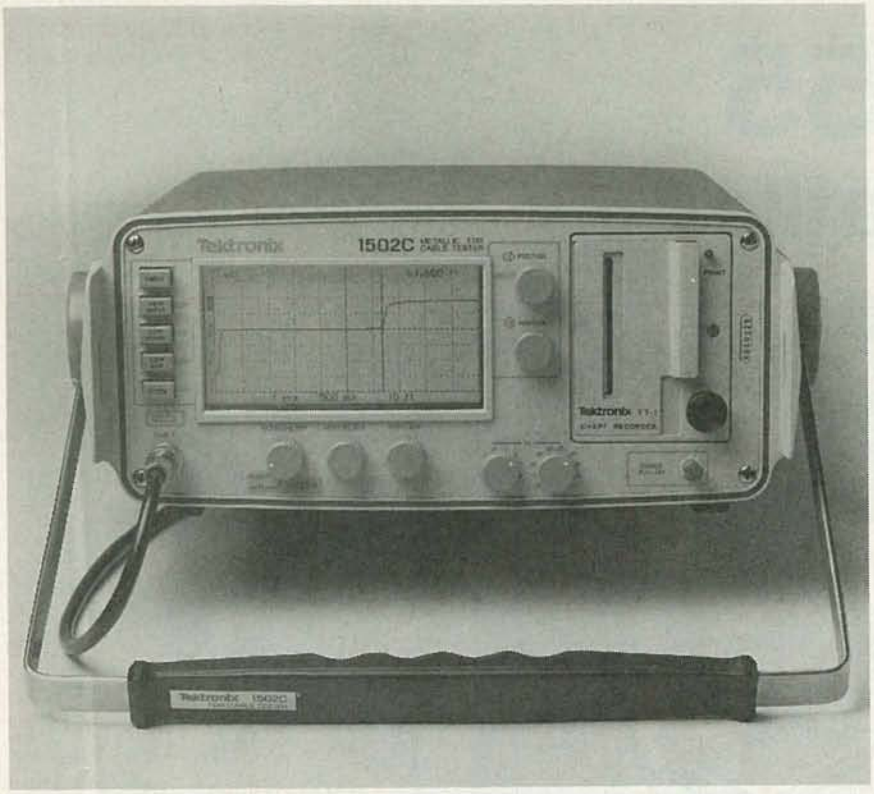

FIG. 4—TEKTRONIX' 1502C TIME DOMAIN REFLECTOMETER provides analog display of distance versus impedance. A knowledgeable technician can interpret the display to locate subtle LAN cable faults.

ical value of propagation (NVP) or velocity factor (VF). The terms all mean the same thing. Regardless of name, it is important to set the propagation rate control of your TDR if you want it to display meaningful, accurate readings.

Operating the 1502C is straightforward. You begin by powering down the LAN equipment on the questionable cable segment and removing any terminator resistors. (Terminators can trick a TDR into displaying fantastic cable lengths.) Then connect the TDR to the cable through an impedance adapter, install the correct display reticle, and apply power. Then adjust the controls, and you'll receive a visual indication of cable quality.

Tektronix makes several other TDR's. The 1503C analog TDR accommodates cables as long as 50,000 feet, and has an Ethernet option. The 1503C looks like a good choice for cable TV or aircraft carrier applications. Tektronix also makes the TMA-802, a moderately priced digital TDR and Ethernet activity monitor.

Analog vs. digital

In this article, we have described two types of TDR's: digital (Microtest) and analog (Tektronix). Each type of TDR has its own advantages and disadvantages; both instruments are widely used in LAN servicing.

The major differences between the two are in information display and sensitivity to minor faults. Push a button on a digital TDR, and you'll read something like *Short 40 Ft* on the display. Digital TDR's are great for novice users because they make it easy to understand results. Their drawback, however, is that they report only major faults, missing minor ones that often cause the most frustrating problems.

Turn on an analog TDR and you'll see a oscilloscope-style wavy line over a black reticle calibrated in impedance vs. distance. Clearly the analog TDR is intended for more experienced users who can disregard the dead zone, interpret impedance changes, and read distance from the reticle. Analog TDR's also have an amazing sensitivity to rusty contacts in connectors, water-logged cables, and other faults that can go undetected with less-sensitive instruments.

Network certification

Another issue is network certification, which is becoming increasingly important as corporations continue the downsizing trend. Downsizing involves using networks of PC's to perform mission-critical applications formerly run on mainframes. *Mission-critical* means that the health and competitiveness of the company depend critically on the computer systems that support the company. Without a reliable network, workers can't do their jobs, so goods and services are delivered to customers late. If customer dissatisfaction increases, the company suffers, and so do jobs. Clearly, we all have a vested interest in keeping our LAN networks running reliably.

In the past, LAN cables were often pulled by electrical or telephone wiring contractors who might not have had proper tools and expertise. As a result, Ethernet cables may exceed recommended lengths, excess UTP cable may be left coiled in plenums over fluorescent fixtures, and so on. Those problems decrease LAN performance and, even worse, can serve to reduce reliability.

In response, major LAN vendors have devised performance tests to help ensure that LAN's meet standards for noise level, cable length, attenuation, and other factors that affect performance and robustness.

Without thinking out the problem the fanciest TDR in the world will be useless. Develop your ability to identify a problem and logically work your way through possible causes until it is solved.

Be sure to join us in Part III when we will roll up our sleeves and troubleshoot actual LAN's with the equipment and tools described here. **R-E**