Ethernet Over Standard Category 5 Cable

Functional Testing & eE Certification

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The WideBand Gigabit Networking Alliance was created in 1997. In the last few years its members reported that they were experiencing two major problems with Ethernet equipment. (1) Some 10/100BASE-T NICs and switches seemed to have difficulty in transmitting data over some of the existing Category 5 cabling installations, and (2) Some 1000BASE-T equipment seemed to have difficulty transmitting data over some Category 5e cabling installations.

The WGNA commissioned this study to evaluate the extensiveness of these problems. A study of the literature and the market was first conducted to establish if these problems had been observed elsewhere. A testing program was then established focusing on these problems to determine how significant they were and to determine if there was a solution available.

Problem: The Physical Layer

Ethernet is the most common network in use today. About 90% of all Local Area Networks (LANs) today use Ethernet equipment. This equipment comes in three basic speeds: 10 Mbps (802.3), 100 Mbps (Fast Ethernet 802.3u), and 1000 Mbps (Gigabit Ethernet 802.3z/802.3ab). A fourth network speed of 10 Gigabit/sec (802.3ae) is currently being developed.

Even though the cost of high-speed networking equipment has dropped significantly, the deployment of the technologies has not kept pace with expanding networking needs. One thing hampering the migration to 1000BASE-T is performance problems associated with the physical layer. The physical layer defines the electrical, mechanical, and functional specifications for establishing the physical links between systems. It is made up of the cable, connectors, the physical links on the devices, and the encoding/decoding circuitry of the network devices (hubs, switches, routers and NICs).

The physical layer is very important to the integrity of the system. Pete Lockhart, Vice President of Technology at Anixter and standards pioneer in the data cable industry, quotes a study commissioned by LeCroy, a high-end test and measurements equipment manufacturer.

> "Failures at the physical layer accounts for an average loss of $250,000 per year per 100 users." The study also said "losses are measured in user productivity, network manager effort, and business downtime." [1]

Various research studies have concluded that between 50% and 90% of the problems in the LAN are due to physical layer (layer 1) problems. According to Robert Grubbs, Anixter's President and Chief Executive Officer, networks with data corruption can operate significantly below the specified bandwidth.

> "A system can be running at 100 megabits per second, but if the data is corrupted along the way and the server has to attempt to send it repeatedly until it gets through, the true speed might be closer to 60 megabits per second." [2]

As networks become faster and more complex they become more susceptible to distortion of signals from physical layer problems. As network speeds progress from 10 Mbps to 100 Mbps and even Gigabit speeds, they must operate with greater precision with less room for deviation.

> "The mounting costs of physical failure in networks have focused network managers' attention on the three leading causes of such outages: faulty cabling and or connectors; failures in hubs, network interface cards (NICs) and other active devices; and disruptive levels of electromagnetic or radio frequency interference (EMI/RFI). Each of these three problems are exacerbated by higher network speeds and more complex configurations such as larger server farms. Furthermore, in combination they can be devastating." [3]

Many networks today have older wiring installed. In addition, many newer installations were based on the 'low bid' mentality and as a result have very low quality wire installed. This has a significant impact on the ability to upgrade these networks.

> "Some manufactures produce cable and connectors, which (according to the industry) are barely compliant, and if they are not installed with the greatest of care may fail the channel tests. Secondly, many of these components are not interoperable with other company's components creating problems for the installers in the field when choosing suppliers." [4]

> "Many users now have 10/100 NICs in their PCs but are only communicating at 10 Mb/s to the hub/switch. When the switch is upgraded to 100 Mb/s, e.g. 100BaseTX, all the attached terminals will try to auto negotiate up to the higher speed. If the cabling is not up to this requirement then this exercise will fail and the PCs will fall back to 10 Mb/s." [5]

> It is now accepted throughout the industry that "only certified category 5 installations are capable of running at 100-Mb speed reliably." … "Upgrading to Category 5e wiring is a necessity for implementing a high speed, fully monitored, and centrally managed 10/100/1000 MBPS network. The entire picture must be considered, you can put in the best switches, servers, security, and monitoring, but if the infrastructure won't support it, what good is the system?" [6]

> "Our recent tests of gigabit switches from Alteon, Intel, and Lucent Technologies, conducted at the Advanced Network Computing Lab of the University of Hawaii, discovered a number of problems with the new standard. Cat 5 cabling proved marginal for gigabit speeds. Category 5 enhanced (Cat 5e) is the recommended specification because of its superior ability to protect traffic from signal degradation. Many existing business connections will need to be reterminated and, in some cases, new cabling installed to support the new gigabit switches." [7]

This leaves many network installations in great difficulty. MIS departments find that in order to meet expanded networking needs new cabling must be pulled. The cost for pulling high-quality network cable and/or fiber can exceed all the rest of the costs of the network upgrade. In many cases, this cost has prevented the intended network upgrade from taking place.

As network managers consider moving to Gigabit Ethernet, the cabling inadequacies of most facilities become quite apparent. Even with all the training and education available about various cabling standards, just a small percentage of networks in the US today have Category 5e or better cabling installed. The numbers are worse in Europe and almost non-existent in many third world countries.

Today, the typical network administrator is convinced that before any possible upgrade to Gigabit Ethernet can take place, a significant investment must take place in the cabling portion of the physical layer.

When testing 100BASE-T systems, it has been found that there are numerous examples of improper operation even when using Category 5 or better cables. “There have been numerous reports, during the latter half of 1999, about Cat5e and ‘draft’ Cat6 systems being installed and tested OK. Yet when presented with real network traffic, they have failed to pass data sensibly at all – even though the link lights on the network interface cards (NICs) are ‘on’, on both the PC and the hub or switch. The practical solution in many cases has been to switch the 100 Mbit/s NICs from Full Duplex to Half Duplex – effectively halving the theoretical maximum bandwidth to 50 Mbit/s and in fact taking the practical bandwidth much lower.” [8] Even the idea that bandwidth might be compromised due to problems on the physical layer is disturbing.

As demands on the network increased over the years, it became clear that network speeds needed to exceed the capabilities of 100BASE-T. At that time the goal was to develop a Gigabit Ethernet technology capable of deployment over the existing base of installed Category 5 cable. This goal made a lot of sense due to the amount of Category 5 cable already deployed. As the development of the standard progressed and testing results from early implementations of Gigabit Ethernet were reviewed, the standards committee decided that a superior grade of cable would be required for 100 meter segments at gigabit data rates. A special grade of cable has been specified for Gigabit Ethernet called Category 5 enhanced (Category 5e).

> “Although Gigabit Ethernet was designed to run on 100MHz cable, problems may arise with older Cat 5 systems. The more stringent Cat 5E standards take into consideration that Gigabit Ethernet uses a four pair transmission method, but this was not part of the test parameters with Cat 5. If you are trying to run Gigabit Ethernet over standard Cat 5 cabling, then the whole system should be tested to confirm that it meets the new Cat 5E standard.” [9]

> “To guarantee proper operation of 1000Base-T, installed category 5 cabling must be re-certified with a tester conforming to the Level IIE requirements also specified in TSB-95. Addendum 5 to TIA-568-A (ANSI/TIA-568-A-5) specifies enhanced category 5e cabling. Category 5e cabling is specified to 100 MHz with added headroom on the cabling parameters important for 1000Base-T operation.” [4]

> “If you take the gigabit route, are you sure your Cat 5 can run gigabit without unacceptably high bit error rates? I’d advise getting that cable tester out” [10]

If network cabling is inadequate it can cause networking switches and NICs to slow the transmission rate down to a lower speed for error-free operation. One such case was reported as follows: A MIS reported “I have a Catalyst 4006 with a 6 port Gigabit switching module slotted in (amongst others). Having [been] advised that I could buy a 1000Base-T GBIC and slot it into the module to get Gigabit to one of my servers, I tried the advice and found I can only get 100Mb out of the GBIC.” [11] The answer to the MIS came back as “An important matter is that you must have a CAT5 enhanced or CAT6 or CAT7 cable in order to run GE over copper.” [12]

In a report by Krone, a highly respected firm that specializes in structured cabling, their engineers found that as the physical layer starts to have difficulties, data is lost. Ethernet networks were impacted significantly due to their automatic retransmission of bad packets. For example, the effective bandwidth of the network is reduced to 20% of the rated speed with only 1% of the packets being bad. This is due to the time delays associated with the automatic retransmission of bad packets. They reported the following reduction in network speeds with various percentages of retransmissions. [8]

% of Retransmissions	Data Rate
0%	100 Mbps
1%	20 Mbps
2%	4 Mbps
3%	800 Kbps
4%	160 Kbps
5%	32 Kbps

> "In separate tests, Krone labs discovered that, in sending 1 million bits through a Cat5 system with only 6 ohm variations, some 365,000 (or 36.5%) were actually being sent again. Of these 365,000 retransmissions a further 36.5% had to be sent again and so on. At the end of the day Ethernet got the data through perfectly, but it had to send and receive 1.6 million bits to get 1 million correct bits. That meant that the network throughput was reduced by nearly 40%. Krone engineers claim to have seen far worse on site. 'Field experience has shown that some low end systems are operating at as little as 4% of supposed capacity, that's only 4 Megabits from a supposedly 100 Megabit system!' Krone's UK Technical Services Manager, Karl Tryner claims." [8]

Even with the improved cabling, some users are having difficulty with the data integrity of Gigabit Ethernet at the 100-meter cable length. *Network Computing*, a leading trade journal, tested various brands of Gigabit Ethernet equipment using Category 5e cable:

> "Given that our test bed was well in excess of IEEE 802.3ab gigabit-over-copper specs for quality of copper cabling, and was within the gigabit-over-copper distance and interconnect specifications, we were a little concerned that we saw any corruption, regardless of the vendor." [13]

> "Of course, the errors and difficulties we saw were only present in the most extreme cases. We encountered no errors when running gigabit over copper at distances of 50 or 100 feet. It was only when we pushed the spec to the limit that we began to see strange phenomena cropping up on our network. Specifically, when we used a 98-meter run, we saw intermittent errors that were nonexistent at shorter distances. … And our tests were run on Category 5E, whereas the 1000BASE-T specification calls only for Category 5 wiring, which is more commonly used. Why should you have to sacrifice any reliability to the physical layer?" [13]

> "The results scream a word of caution to shops considering gigabit over copper: This technology is really pushing the limits of conventional copper wiring, and a less-than-perfect network may generate significantly higher error counts than our tests revealed." [13]

Physical Layer Considerations

To ensure reliable transmission over a network, industry standards specify performance requirements for the network's physical layer. The requirements encompass multiple measurements including DC voltage measurements, immunity to interference, bit error rate, network analysis, frequency domain measurements, and time domain measurements.

Cables and Connectors

According to Pete Lockhart, today's higher performance networks require demanding attention to details, with no variances.

> "Back in the days of 10 Base T, you could run data on wet string or barbed wire. But as you go up the food chain and run data over some really fast speeds, all the connectors and cable assemblies have to be absolutely dead perfect; you can't get away with any variances. … The industry has to be reinvented." [14]

As specified in IEEE 802.3ab, 1000BASE-T can operate over Category 5 cables installed according to the specifications of ANSI/TIA/EIA-568A. There should be no need to replace existing Category 5 cabling to use 1000BASE-T. When the IEEE committee started to actually test components, it was found that the equipment didn't work properly in many cases. IEEE found that by specifying additional restrictions on the cable, the tested equipment worked at greater distances. However, these additional specifications eliminate many of the cables that Gigabit Ethernet was initially designed to operate on.

The Category 5e cable specifications were made after the Gigabit Ethernet committee's recommendation and included the additional tests for return loss and far end cross talk. Even so, systems that utilize 5e cable may still not work properly with Gigabit Ethernet, as shown in actual tests. [13] It is interesting that, to solve the problem, the committee advocated modifying cabling specifications instead of requiring manufacturers to get their physical layer to work with existing cable. This decision seemed to benefit both the cable companies (new cable sales) and the networking component developers (quicker to market products). This decision, however, significantly impacted the bottom line cost to the customers having to upgrade their cable plant.

Although Category 5e cable is not considerably more expensive than conventional Category 5 cable, the cost of installing the new cable is a substantial barrier towards the integration of the new Gigabit technology at many installations. At the minimum, the network cabling has to be tested to determine if it is compliant to the new Category 5e specifications.

Even if data integrity problems could be resolved, many are hesitant to pull new cable because of the cost to do so. The industry has a very substantial installed base of conventional Category 5 cabling. For Gigabit Ethernet to "catch on", methods must be developed to utilize this existing resource.

Networking Components

> "Many problems are rooted in manufacturers' apparently minor deviations from standard specifications, says Diane Myers, senior analyst at In-Stat, a Scottsdale, Ariz., market research and consulting firm. 'You get a lot of problems in the chips because it is very hard to integrate mixed-signal, 10/100 products at the physical level,' she explains. 'Some manufacturers deviate from the standard to integrate the functions of 10 and 100 Mbps'." [3]

> "Vendors interpreted Ethernet specifications differently...Even cards that function perfectly well at 10 Mbps can cause massive problems at 100 Mbps due to variations in implementation of the Ethernet standards." [3]

Many standards compliant devices work better with some components than others. It has been found that equipment manufacturers need to test their equipment to "real-world" network conditions.

> "Manufacturers of Ethernet switches face a test quandary. If you test just for conformance to standards, you risk shipping products that fail in real applications. Standards such as IEEE 802.31 provide a baseline for switch testing, but standards fail for the very reason they were adopted—they represent the least-common denominator. Testing to a predictable standard is not the same as testing for performance on a network. … To find defects in Ethernet switches, you should test the device not just to standards but also to real-world network conditions." [15]

Improving the Physical Layer at the Component

The networking industry has reported that some networking equipment has difficulty establishing a low error connection using either long-length or low-performance cables in both 100BASE-T and Gigabit Ethernet networks. The traditional approach has been to force the consumer to upgrade or modify the wiring so that the non-performing equipment can work.

An approach being taken by some manufactures to solve the problem is to develop methods of improving the signal encoding/decoding at the physical layer of Fast Ethernet and Gigabit Ethernet equipment so that it can be deployed over a wider range of existing wiring.

> "The solution to these problems is not to replace the existing CAT5 wiring with CAT5e or CAT6 cable, but instead to use even more advanced digital signal processing algorithms borrowed from other broadband digital communications systems…" [16]

This approach is to design and build equipment with improvements in signal encoding and decoding that can work with the various physical layer characteristics that currently exist in today's networks. This puts a much greater responsibility on high quality design and engineering of NICs and switches, but it opens up the possibilities of where the equipment may be used. It has been found that through proper design of the electronics circuitry in networking components, standard Category 5 cables may be used with Gigabit Ethernet, even at full specification distances.

The standard was established to be a minimum compliance level. The decision to improve the physical layer beyond the standard is an individual decision for each manufacturer. Improved performance usually comes with an associated cost. The ultimate decision on how good the product is made, becomes a marketing decision that reflect costs, potential marketplace, and the manufacturers perceptions of the needs and attitudes of the market.

This decision by some manufacturers to improve the physical layer characteristics of their components far beyond the standard gives network designers additional options and challenges. Only through extensive testing of the physical layer of these products can the improvements be verified.

WGNA Testing of Networking Products

The WideBand Gigabit Networking Alliance tested numerous 10/100BASE-T and Gigabit Ethernet products against a library of 100 different Category 5 and 5e cables. In the library there are 9 Cat 5e cables and the balance are Category 5 cables. This cable library represents about 95% of the installed cable base of Category 5 cables. Each of the cables is 100 meters long. Since the cables are at the maximum distance established by the Ethernet specification, this becomes a real stress test on networking equipment.

Testing is first done using identical networking components. Additional testing is then done between the networking component being tested and equipment that has been previously certified by the WGNA. These tests establish that not only does the equipment work properly with all 100 cables, but also that it will work in conjunction with other certified equipment.

The pass/failure is determined by the bit error rate (BER). Anytime the BER becomes greater than 1×10^{-6} then that channel is considered bad. To pass the test, a product must pass the channel test on all 100 cables within the cable library.

Any time a bad packet is received by a NIC, a request is sent to the network to retransmit the packet. Even a small amount of packet loss can impact the transmission rate significantly due to delays associated with re-transmitting the data. In addition, TCP/IP is designed to slow down the network in response to lost packets. The assumption in the protocol is that the lost packet is due to the network being overloaded; therefore dynamic adjustments take place to reduce the rate at which the packets are sent. Whenever a packet is lost due to a bad connection, a broken link, or difficulties with the encoding/decoding of the signal, an otherwise fast link becomes a slow one.

The larger the number of packet losses (and their resultant delays), the slower the effective data transmission rate will become. It is easy to identify when packet losses have become excessive by observing the time that it takes to transfer a given set of files across the network. If a channel has an observable increase in transfer time beyond that of a control cable then there is some sort of difficulty with the physical layer.

Cable Pass/Fail Percentages

Product A – 10/100				
Cable type	# Cables tested	# Cables Pass	# Cables Fail	% Cables PASS
Cat 5	91	27	64	29%
Cat 5e	9	8	1	88%

Product A was able to establish a 100 Mbps link with all the Category 5e cables and all but one of the Category 5 cables. The transmission rates varied tremendously from cable to cable. This particular component was very sensitive to any changes in the physical layer.

Product B– 10/100				
Cable type	# Cables tested	# Cables Pass	# Cables Fail	% Cables PASS
Cat 5	91	58	33	63%
Cat 5e	9	5	4	55%

On the failing cables, product B was not able to link at 100 Mbps, only at 10 Mbps. It is very interesting to note that some of the cables that failed were rated as Category 5e. T
physical layer worked very well if a link was established, but dropped quickly to 10BASE-
there were any problems at all.

Product C –				
Cable type	# Cables tested		# Cables Fail	% Cables PASS
Cat 5	91	91	0	100%
Cat 5e	9	9	0	100%

Product C was able to pass on all cables at 100 Mbps. The performance was excellent on every cable.

Product D – 10/100				
Cable type	# Cables tested	# Cables Pass	# Cables Fail	% Cables PASS
Cat 5	91		0	100%
Cat 5e	9	9	0	100%

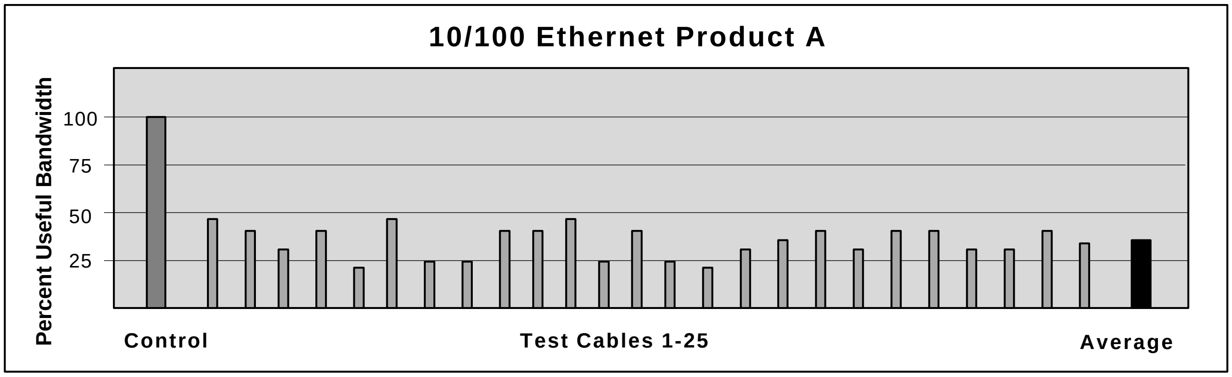
Product
substantially lower than Product C for the same cable.

Product E –				
Cable type	# Cables tested		# Cables Fail	% Cables PASS
Cat 5	91	91	0	100%
Cat 5e	9	9	0	100%

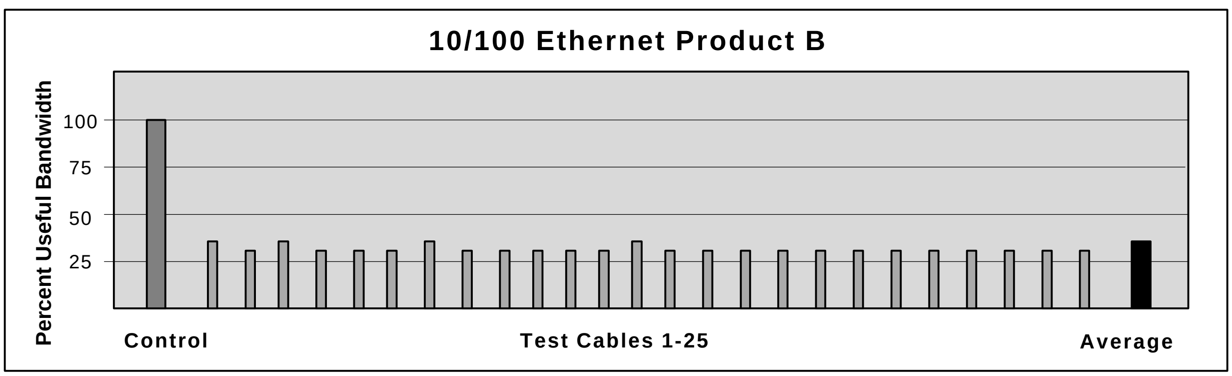
The physical layer of Product E was outstanding. Not only did it pass, but it passed at Gigabit Speeds on all of the cables. This product ran Gigabit speeds on cables that many of the 10/100 NIC cards would reduce their speed to 10 Mbps.

Average Useful Bandwidth

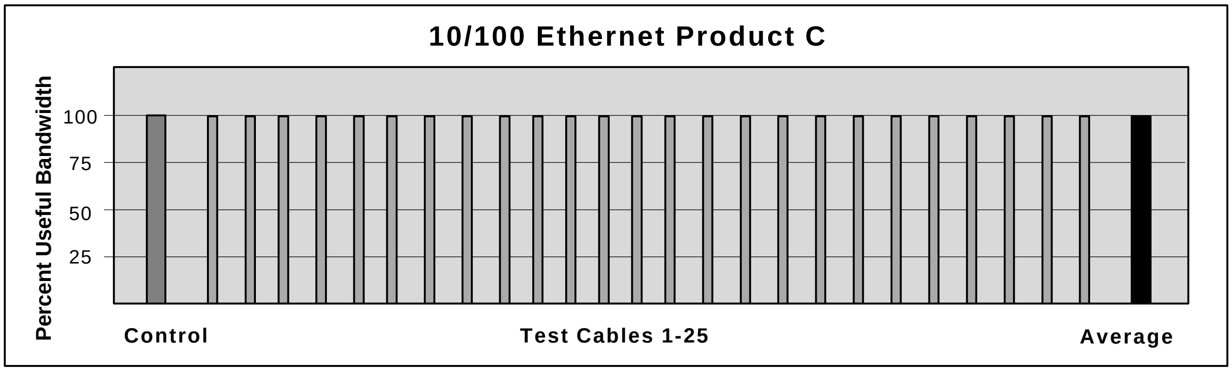
The Useful Bandwidth is the bandwidth available for transmission of data. A high performance network cable (Control) is used to establish the maximum possible transmission rate of a network component. The bandwidth obtained with the control cable is compared to the bandwidth of the test component using each of the test cables and the percentages are recorded. The charts show the test results using the 25 lowest performing cables.



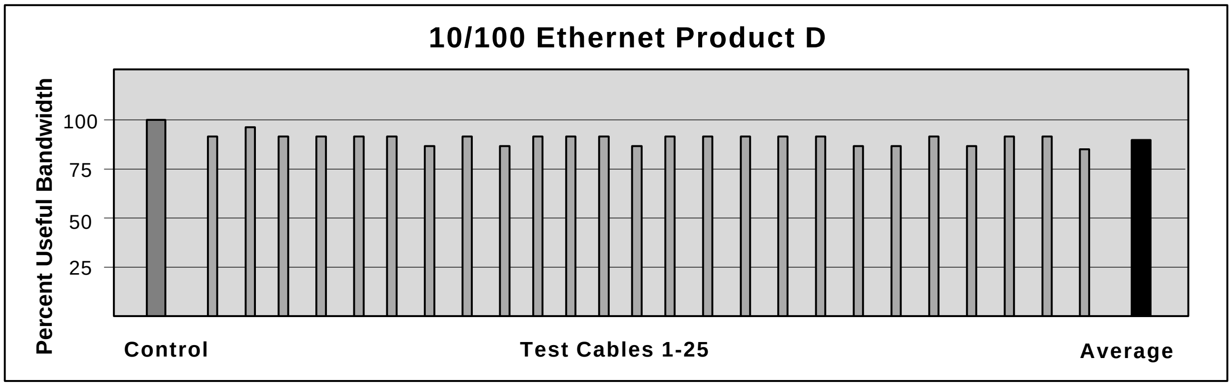
The average percent of Useful Bandwidth using the test cables on Product A was 34.2% compared to the Useful Bandwidth using the Control cable. This signal encoding / decoding of this product was very sensitive to differences in cable performance.



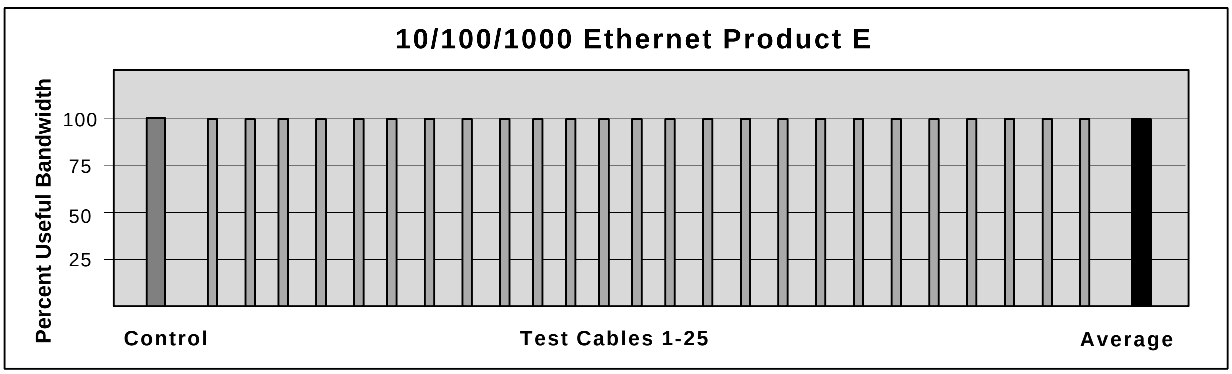
When Product B was used with the low performing cables, the Product reduced its speed from 100 Mbps to 10 Mbps and reduced the data transfer rate to an average of 30.8% of the bandwidth delivered when using the Control cable.



Product C operated at the maximum speed no matter which cable was used in the test.



The bandwidth of product D using these test cables was reduced to an average of 88.8% of the maximum transmission rate using the Control cable.



Product E was able to operate at full gigabit speed on all of the test cables. It is interesting to note that this product was able to run gigabit without errors on the same cables that some 10/100 products were forced to drop their speed down to 10 Mbps to operate satisfactorily.

Testing Summary

When the WideBand Gigabit Networking Alliance researched networks operating at slow speeds, it found that in most cases, the problem could be traced back to the physical layer of the network. The difficulties include: problems with the wiring, cable termination, and the signal encoding and decoding capabilities of the NICs and switches used. Even in ideal wiring environments it was found that some gigabit products just wouldn't reach the 100-meter design specification without excessive errors.

One of the unexpected discoveries was that NICs and switches from certain manufacturers were more sensitive to problems with the network wiring than were others. Using the same test cable, one manufacturer's NIC would link up and transmit data flawlessly and another manufacturer's NIC wouldn't even link up. When a short length of high-quality wire was used, both brands would work properly. This shows very clearly that the different signal detection methods various manufacturers use do not generate the same results, especially under the stressed conditions found in some networks.

In additional tests, it was found that NICs and switches were more sensitive to these problems with the physical layer as the length of the wiring was increased to the rated maximum distance of 100 meters. Short runs of wiring with any NIC almost always worked properly, but as cable run lengths approached specification limits, the performance would suddenly drop with some of the NICs and switches. The cable length at which a problem occurred for a specific NIC changed with the quality of the Category 5 cable used.

Through this testing, it has been established that there are significant differences in the performance of the signal encoding and decoding capabilities of the various manufacturers on the NICs, switches and routers. This determines the quality of the networking environment under which the equipment must be used in order to function properly. The networking environment is determined by the quality of the cable, its length, patch panels, installation practices, and local electrical noise.

Many networks have a low-quality networking environment. Under these conditions it is common to loose packets. This effect is seen at network speeds of 100 Megabits per second and becomes especially significant in gigabit networks. It can cause that portion of the network to operate slowly. The effect is referred to as "Local Area Zone Interruption", or a "LAZI" network connection. It is an indication of numerous lost packets and retransmissions taking place and/or the inability to link at the rated speed, reducing the effective bandwidth available for at least a portion of the network. Testing at the International Academy of Science has shown that the reduction in transfer speed may be as high as a factor of ten. In extreme cases the errors can be so excessive as to prevent linking at all.

In some installations, it was found that a section of 'marginal cabling' could be used if different network components were substituted. In these cases, both sets of network components were operating within the Ethernet standard, yet it was found that because some networking equipment is designed with better signal encoding and/or decoding it could overcome greater signal degradation that can exist in extremely long runs or noisy environments. The bottom line, some products will work on 'marginal cabling' and others won't. It became obvious that not all networking equipment is created equal, and that the best solution doesn't always rest with changing out the cable and terminations.

WGNA Certification Program

To help users determine how various networking equipment will perform in real world situations, the WideBand Gigabit Networking Alliance has developed a functional test and certification program that determines if a networking component will work reliably on any network wired to Category 5 specifications.

The testing criteria has a simple philosophy: any networking component should operate properly with 100 meters of any certified Category 5 cable produced by any manufacturer. Any component that cannot meet this requirement will exhibit degraded performance under common, real world conditions. The Alliance's testing procedure verifies the proper operation of networking equipment under a great variety of conditions.

This process began with the assembly of an extensive cable library for testing purposes. 100 different Category 5 and 5e cables were selected. These cables are representative of over 95% of all Category 5 installations. Special emphasis was given for older, low-performance cables. A full 100 meters of each cable was terminated with standard RJ-45 connectors. The testing channel was completed with patch cords added to each end of the cable being tested.

The network components that are being tested are installed into the test network. First they are tested with matching components connected together across the testing channel and then with other networking components previously certified by the WGNA. This eliminates questions of interoperability between certified networking components.

Over 200 Megabytes of data files are transferred between the computers in the test network, through the components being tested, the patch cords, and the selected cable. The link status, connection speed, transfer rate, and error counts are then monitored and recorded. Any problems with the connection will be seen as an increase of transfer time and various network errors, such as lost packets. The test is repeated with each of the cables from the cable library.

To be certified, the tested component must meet design transfer rates without exceeding maximum bit error rates for each and every cable in the library. It will also be tested at all of the supported operating speeds. For example a 10/100/1000BASE-T NIC will be tested at all three speeds for each of the wires within the cable library. 1000BASE-T devices, not being an exception, must pass on the entire library of cables, including the low-performance Category 5 cables that do not meet the official Gigabit Ethernet specification of Category 5e.

eE Certification is a good indicator that a particular component will work within the physical layer of your network having been tested in worst case conditions and verified as having an acceptable performance when used with networks that meet the Category 5 specifications.

All makers of networking equipment may submit equipment for testing by the Ethernet User Alliance. Those products passing the functional testing with every test cable in the library can be certified and then may display the eE logo on their products and literature. In addition, a current list of all passing products is available on the WGNA website.

Summary of Test Results & Certification

The WGNA has tested networking equipment from numerous manufacturers. It found that many 10/100 products will operate properly on the entire library of test cables. These products will perform at the highest possible speeds under a wide variety of conditions.

One manufacturer has submitted Gigabit Ethernet equipment that passed on all 100 of the cables. This is very significant. This shows that it is indeed possible to operate Gigabit Ethernet on practically any installed Category 5 cabling. There is a serious need for Gigabit networking equipment today that can utilize the installed base of Category 5 cable.

The WGNA Certification test procedure allows manufacturers to test and certify the performance of their networking products over many types of cabling. The cable library utilized in the test reflects the real world in which these products may be installed. Each product that passes the functional testing procedure may receive the eE Certification and may display the eE Certification logo on their products and literature.

By selecting components that are eE Certified, it is possible to improve the network performance of slow 10/100 network segments and to upgrade to Gigabit Ethernet without extensive physical layer testing or changing out standard Category 5 cable.

Conclusions

There is a problem with some of the networking products available today. It is wise to be careful when selecting your network components. The good news is that there are good solutions available. It is the goal of the WideBand Gigabit Networking Alliance to keep its members informed about the products that work in the real world. Users will be able to maximize their network performance by utilizing products that are eE certified.

Endnotes

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Category 5 Standard Cable Reference Library

The following cables constitute the Category 5 Standard Cable Reference Library that will be utilized for the WGNA Functional Testing. Additions and deletions to the list shall take place from time to time to keep the Library relevant to current market conditions.

Belden Datatwist 350 17019
Belden Datatwist Five Cat 5
Belden DataTwist Five YR43203
Belden MediaTwist
Belden Mini-fine Cat 5
Belden WideBand 4PR24
Berk-tek Hyper-plus Cat V
Berk-Tek LanMark – 350 ETL Cat V
Berk-Tek Lanmark 1000 Cat V
Berk-Tek Lanmark 350 Cat 5
Cable Systems Velo‘csi’ty Cat 5
Cable Systems Velo’csi’ty plus Cat 5
Champlain Dataclear CMPL-24-4PBRS
Champlain Dataclear EF gold Cat 5
Champlain Megaclean Cat 5
Coleman Cable Cat 5 E118963T
Coleman Cable Cat 5 FT4
Commscope Standard Cat 5
Commscope Ultra II Cat 5
Commscope ultramedia Cat 5
CSA LL31602 Cat 5
Dupont 5100 Alpha S6111 8501
E111071 verified Cat 5 38-22
E111077 verified Cat 5 40TW 38-34
Essex - 217 8 Cat 5
Essex - 427 Cobra 223 Cat 5
Essex - C0B19 236 8 Cat 5
Essex - CMR Cat 5 238
Essex - Datagain Cat 5
Essex - Residential Broadband Cat 5
ETL 58 EH1077 00-28
ETL 5e 24006
ETL Cat 5e e1110777
General Cable Cat 5 311806J3
General Cable Cat 5 plennum plus
General Cable DreamLan 2001 Cat 5
General Cable DreamLan –5
Harbour Industries Datalan 100 Cat 5
Hitachi Hi-Net plus 5e
HCM – Hi-Net plus Cat 5
HCM - International Cat 6
Hi-net Supra Hybrid 5e
International - 0.0228 PP
International Supra 22
International Supra HCM
Lucent - D Gigaspeed 2071A
Lucent - D Systimax 4-21 Cat 5
Lucent - D Systimax Cat 5
Lucent - D Systimax Gigaspeed
Lucent - D Systimax gigaspeed 10719 Cat 5
Lucent - D Systimax gigaspeed Cat 5
Mohawk Gigalan Cat 6
Nordx / CDT IBDN 4812
Nordx / CDT IBDN 4812LX
Nordx / CDT IBDN Flex 2413 Cat 5
Nordx / CDT IBDN plus Cat 5
Prestolite - Netlink 2000 Cat 5
Prestolite WideBand 55040192-21
Prestolite WideBand Cat 5
Prestolite-5 Netlink 2000 Cat 5
Quabbin Datamax – horiz 9443
Quabbin Datamax 6 #2010
RCM’s 22 awg Cat 6
Remee RemPro – 100E ETL 24 Awg
Remee RemPro – Cat 6 draft 5
Rexx J - Cat 5e 57899
Rexx J - turbolan 350 Cat 5
Southwire 23 Awg Cat 6 Sharp
Southwire Cyberlan 5
Southwire Cyberlan Cat 5
Southwire Cyberlan Cat 5 E189208
Superior cable marathon LAN
Superior Cable marathon Lg
Supra Hybrid
Supra-HCM Cat 5
Vatar Star PVC WideBand 9810292j6