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TCP/IP protocol interpreter for the HP 4972A

HP 18221A

The HP 18221A transmission control protocol/internet protocol (TCP/IP) interpreter is a software package for the HP 4972A local area network (LAN) protocol analyzer. It allows decode and display of the Department of Defense (DOD) TCP/IP protocol suite. The TCP/IP protocol interpreter decodes level 3 and 4 protocols of the TCP/IP suite, including:

- internet protocol (IP);
- internet control message protocol (ICMP);
- address resolution protocol (ARP);
- reverse address resolution protocol (RARP);
- transmission control protocol (TCP); and
- user datagram protocol (UDP).

This software assists LAN managers with the ability to examine TCP/IP traffic on a network. TCP/IP frames can be captured, decoded and displayed in an easy to read and understand mnemonic format. Checksum errors and illegal frame lengths are flagged so they can be easily spotted and acted upon.

The HP 18221A software allows a LAN manager to specify names for each address on a network in the IP address list. These names are then used in the display of information instead of the numeric address. This makes node recognition and problem pinpointing fast and easy. Addresses that do not have a user-defined name are displayed in dotted decimal notation.

The HP 4972A allows for many additional capabilities beyond decodes when testing in the TCP/IP environment. Program utilities are included with the HP 18221A TCP/IP protocol interpreter for conversational capture and triggering on events to allow exception analysis. Capture capabilities give a LAN manager great flexibility with frame distribution measurements, stimulus-response testing and timing, and protocol analysis of TCP connections.

Frame distribution measurements are performed in conjunction with the performance analysis application for

- TCP/IP data frame size;
- TCP window size;
- TCP port usage;
- IP time-to-live value; and
- TCP flag distribution.

Stimulus-response testing and timing can be performed using

- ARP messages;
- RARP messages; and
- ping (ICMP echo messages).

Protocol analysis of TCP connections will display

- connection establishment time;
- connection total time duration;
- total number of frames sent;
- number of acknowledgment frames; and
- number of urgent frames.

The HP 4972A can be configured to test and/or capture by using any of 16 filters (60 comparitor bytes available) and 16 messages (up to 2022 bytes definable). This filter capability is used with the HP 18221A TCP/IP protocol interpreter. A defined set of filters are included for your use or modification. These include:

- IP, ICMP, TCP, UDP filters;
- routing update capture;
- maximum segment size capture; and
- ICMP capture.

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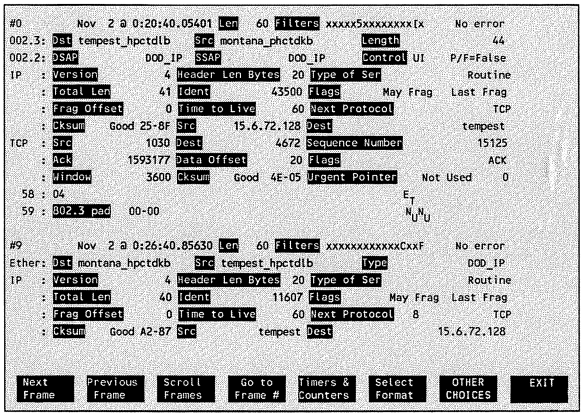
The HP 4972A local area network protocol analyzer addresses Ethernet/IEEE 802.3 and StarLAN networks. The HP 4972A includes performance analysis software which provides statistical information on network, node, or connection-level data. The analyzer is also well equipped for troubleshooting, with programs to generate traffic loads and to do various types of stimulus response testing.

If you want more information, request the HP 4972A data sheet, publication number 5952-5112, from your local Hewlett-Packard sales office.

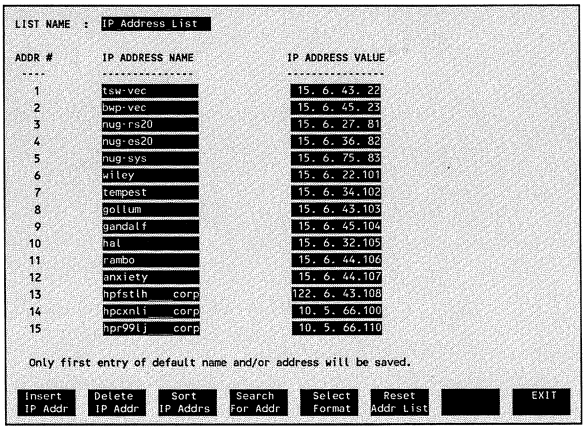
Ordering information

HP 4972A
local area network
protocol analyzer
HP 18221A TCP/IP
protocol interpreter

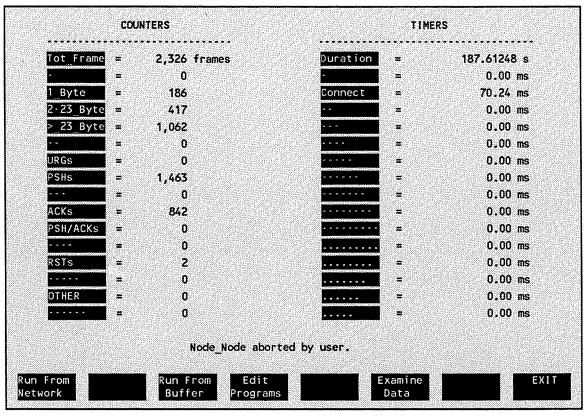
For a complete listing of options, accessories, peripherals and disk drives, request the Hewlett-Packard protocol analyzer system solutions ordering guide, publication number 5952-5116(D).



Isolate difficult protocol problems using the powerful detailed protocol display. The interpreter will flag checksum errors and invalid frame lengths.



The IP address list allows names to be defined for nodes on the network. The names are then used in information displays instead of numeric addresses. Addresses that do not have a user-defined name are displayed in dotted decimal notation.



Program utilities are included that allow conversational capture and triggering on events for further analysis. For example, this program displays the log-in time, number of frames that carry only one byte of data, number of frames that were an acknowledgment only, and total connection time.

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5952-5146
Data subject to change

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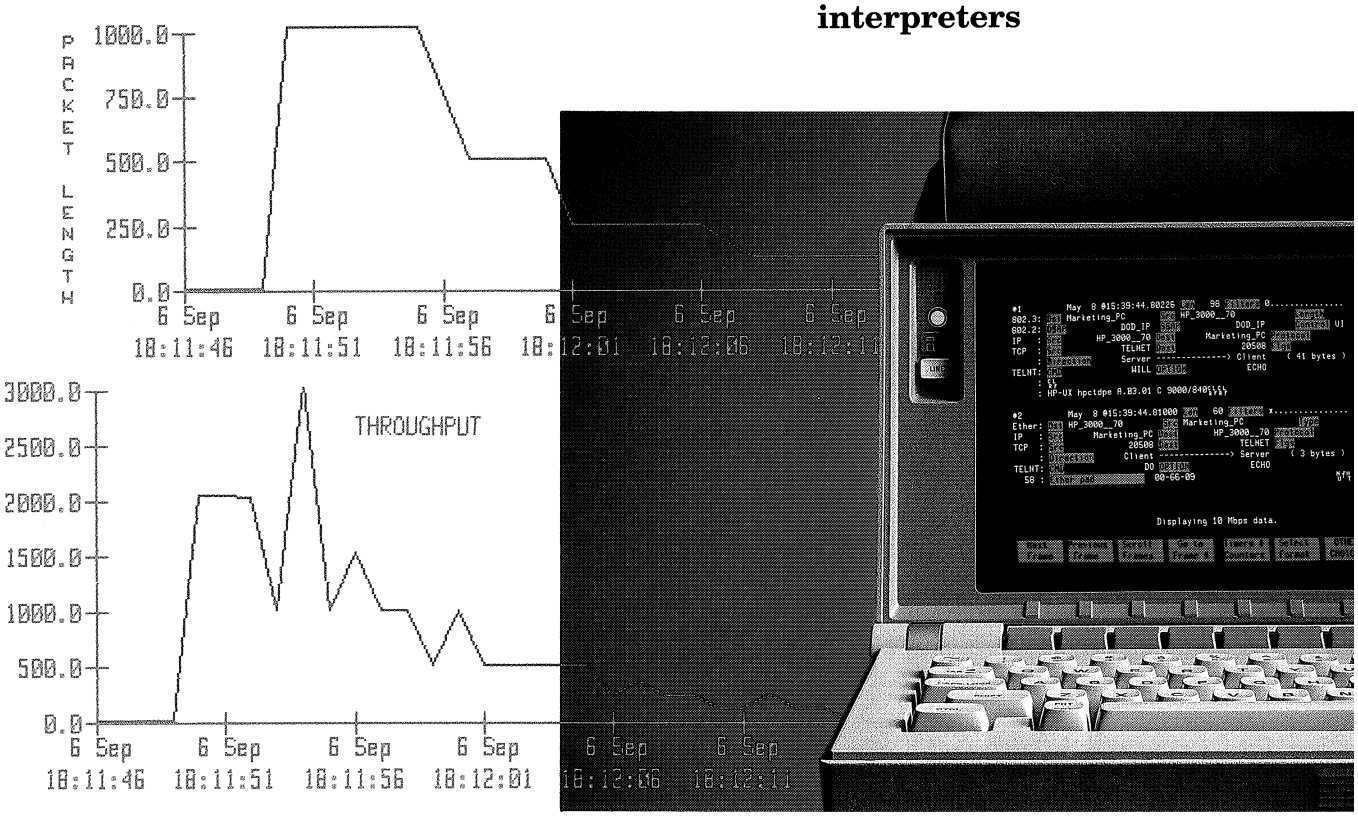
Analyzing TCP/IP networks with the HP 4972A

Data sheet brochure

HP 18221A TCP/IP protocol interpreters
HP 18222A TCP/IP network performance analysis
HP 18228A NFS protocol interpreters



The TCP/IP network environment

The complex networked environments that rely on TCP/IP transport mechanisms and services consist not only of data transmission components, but of interacting systems, applications, subnets and external networks.

Reliable and cost-effective distribution of information and resources in these environments requires intelligent planning and maintenance. As network loads continue to grow due to greater interconnection and more sophisticated applications, keeping a dynamic environment in an optimum state is an ongoing challenge.

Once a basic level of network reliability is achieved, users come to depend on networking services to carry out their day-to-day tasks. Response times, throughput rates and application performance then become the criteria for network effectiveness. Increasing use of a network causes longer response

times and user frustration. Users complain about delays in accessing files on a server, or of delays when using certain networked applications.

Solving these problems requires the collection and interpretation of data relating to all aspects of networking operation. Only then can a problem be accurately identified and the appropriate resources applied to its resolution. Without the proper tools, time and money are wasted in a hit-or-miss approach.

The HP 4972A is a powerful tool for keeping the entire environment running smoothly. TCP/IP network performance analysis and interpreter packages can be instrumental in detecting problems and verifying solutions.

This product note uses real-life examples to illustrate how these tools can contribute to the resolution of some fairly typical problems faced by network managers and system programmers who work with TCP/IP networks.

Common problems

Network managers frequently face a multitude of problems with their TCP/IP networks and supported applications. The HP 4972A's TCP/IP performance analysis and protocol interpreter tools can reduce troubleshooting time, eliminate guesswork, and provide the extra edge in solving tough problems.

Profiling network parameters builds a history of network usage and performance. Knowledge of the activity levels and the usage of services on a network, and by its systems, becomes invaluable in isolating problems and in proactively managing a TCP/IP network through growth stages.

Packet size optimization is important in fully utilizing the TCP/IP bit pipe and in avoiding retransmissions. Dynamic balancing of packet size according to receiver and network conditions will maintain the highest possible throughput rates with minimal retransmissions.

Network congestion can be a problem on routes that are heavily loaded or that have links with vastly different bandwidths. Congestion collapse may result where gateways drop so many frames that little or no data passes through them.

Interoperability problems may result from varying implementations of the protocol specifications or algorithms. Comprehensive testing of newly installed equipment or software can isolate potential problems before they become critical.

Increasing response times for systems on the network may be the result of flaws or inefficiencies in networking implementations. Bottlenecks can be avoided by careful selection of configuration parameters.

The remainder of this product note will examine case studies from each of these problem areas. The capabilities of the HP 4972A used in conjunction with TCP/IP (HP 18221A) and NFS (HP 18228A) protocol interpreters and the TCP/IP network performance analysis package (HP 18222A), are demonstrated.

Profiling network parameters

Tracking network loading and services

An important part of any network manager's job is to profile the character of his network on a regular basis. Archiving measurements of a variety of parameters can help when troubleshooting is necessary. With regular samples of data to compare, anomalies can be easily spotted and problem resolution can proceed at a faster pace. As a management tool, this type of attention can also help to recognize areas where optimization efforts will be most productive.

With the HP 4972A and the HP 18222A TCP/IP network performance analysis package, the network manager has the ability to use the network summary measurement to take an instantaneous snapshot of network activity. Taken at regular intervals, these snapshots can be compared to previous logs and the behavior of the network can be characterized.

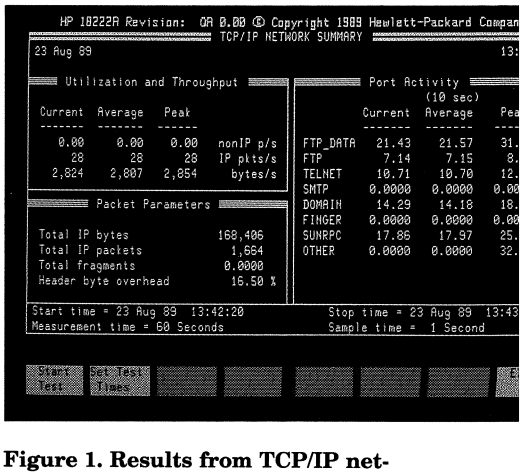


Figure 1. Results from TCP/IP network summary. Note packet rates peaking at 28 per second, with no IP fragmentation.

The node summary measurement provides similar information for individual systems on the network. System contributions to network activity become readily apparent.

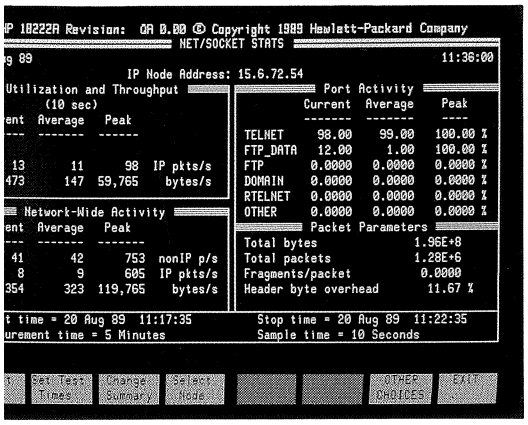


Figure 2. Node summary measurement for IP address 15.6.72.54 shows the majority of activity is due to TELNET transactions.

The network manager has set up a regular schedule to monitor his network. He logs the information via printout and compares the data on a daily and weekly basis. Because he is familiar with all the characteristics of his network, he is able to recognize anomalies immediately and can take action to head off potential problems. This technique of profiling the network has assisted the network manager in problem recognition and solution, and network resource planning. Visibility into the network is provided by the HP 4972A and the HP 18222A TCP/IP network performance analysis package.

Packet size optimization

Throughput reduction

Last month, users on the network were complaining of longer-than-anticipated delays in transferring large files. They were concerned that a file that was approximately three times larger than the normal file took 30 times longer to transfer.

The network manager used the HP 4972A with the HP 18222A TCP/IP network performance analysis package to monitor one personal-computer-to-host-server FTP file transfer. Using the connection-analysis measurements, he noticed that throughput was degrading as packet sizes decreased. Figure 3 shows the data collected.

The network manager then looked at the client's send-window and the server's packet-size behavior over the same time period. As the PC's receive buffers filled, smaller chunks of data were requested, until the

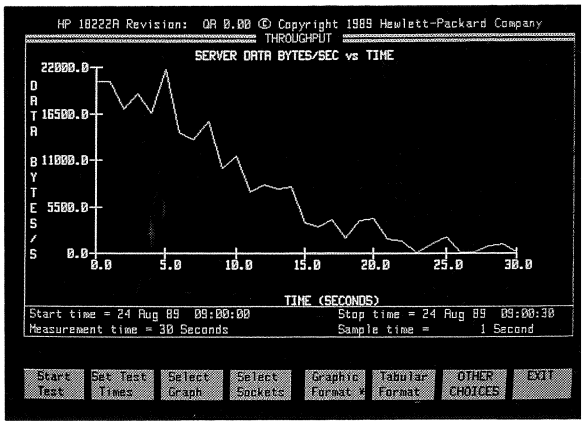
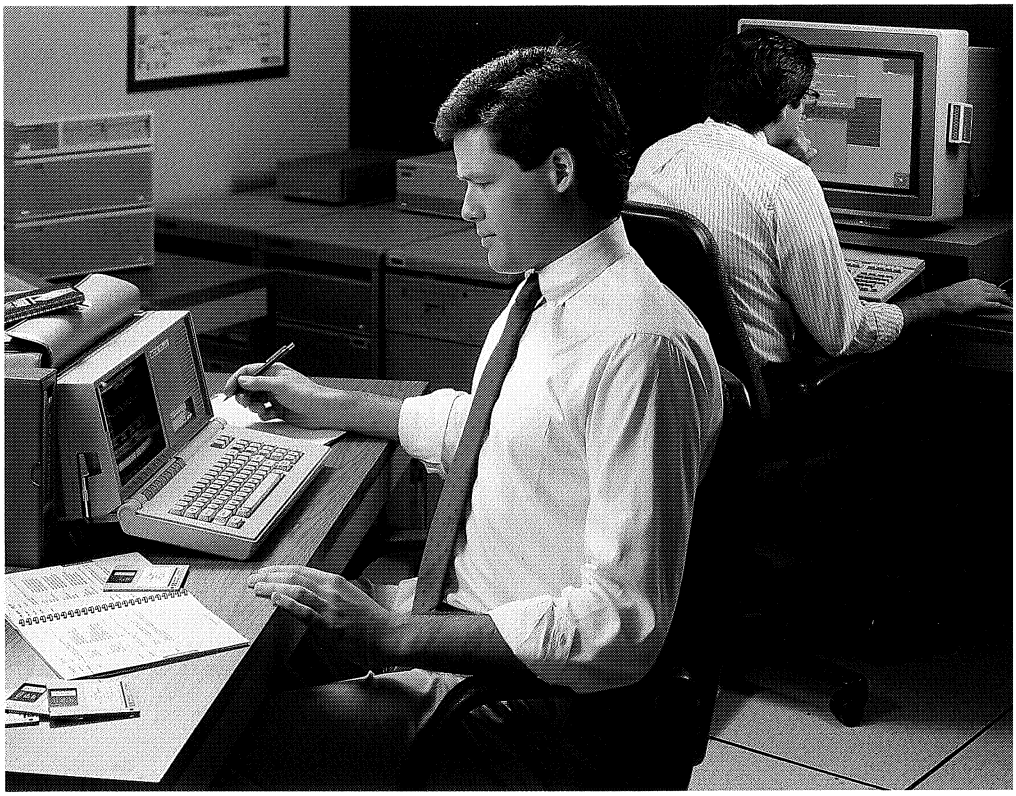


Figure 3. Connection statistics show a significant reduction in throughput as the file transfer proceeds.

size of the window no longer made sense. Figure 4 shows the window size shrinking from 2 KB to less than 100 bytes. As a result, the server reduced the size of the packets it sent, as illustrated in Figure 5. Since a PC's processing times are an order of magnitude slower than that of a streamlined host, the situation remained stable for the duration of the transaction.



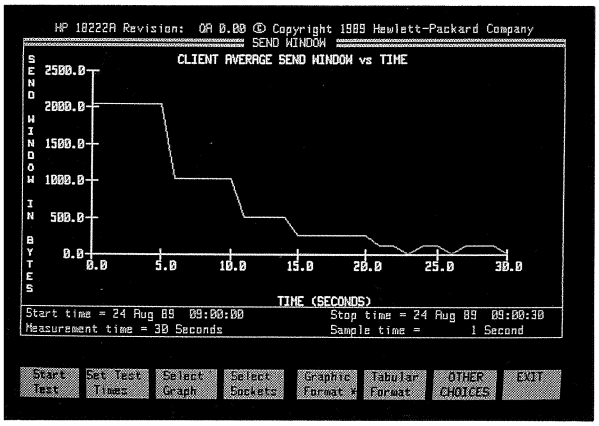


Figure 4. Tracking send window size depicts the send window closing to less than 100 bytes.

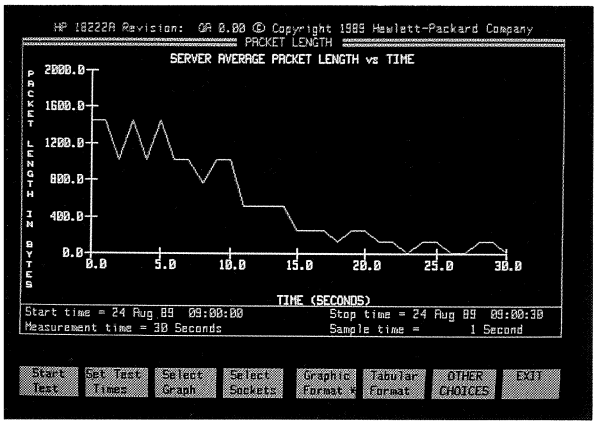


Figure 5. After starting off at greater than 1000 bytes, packet lengths adjust to a shrinking window, to a minimum of less than 256 bytes.

The network manager concluded that throughput would be markedly improved if data were transferred in larger packets, reducing protocol overheads and acknowledgement 'dead' times. Upgrading the software on the PC to a more recent version that avoids silly windows resulted in greatly improved transfer rates.

Network congestion

User delays

Users on the network were complaining of poor response times on transactions with systems external to the network. The network manager began monitoring some of these conversations using the connection analysis measurements. As response times increased, packets were retransmitted more frequently, and the average retransmission timeout grew to a maximum of 10 seconds. Figure 6 and Figure 7 show this activity.

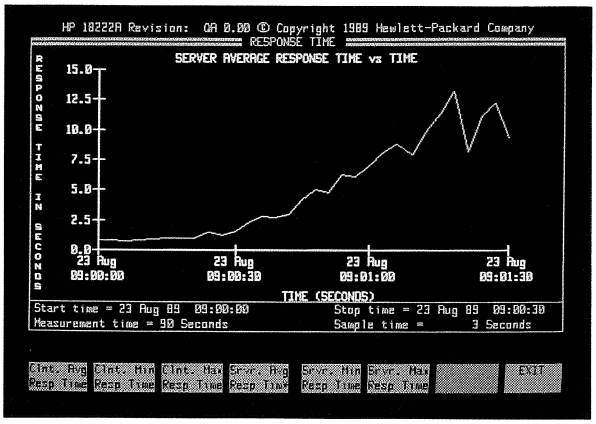


Figure 6. Response times increase as the transaction gets underway.

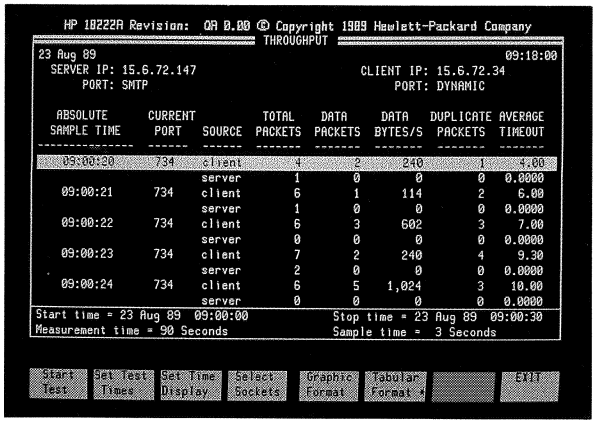


Figure 7. Duplicate packets increase and the average retransmission timeout nears its upper limit of 10 seconds.

Further investigation with the HP 4972A and HP 18222A TCP/IP network performance analyzer showed that the largest contributor to the gateway's traffic originated from CORP_HOST3. Results of a test using the gateway isolation option on the IP address list statistics are shown in Figure 8. These system statistics can be collected for all traffic on a segment, or as shown here, only for traffic destined for, or originating from, a system that is external to the subnet which is bounded by the specified gateway.

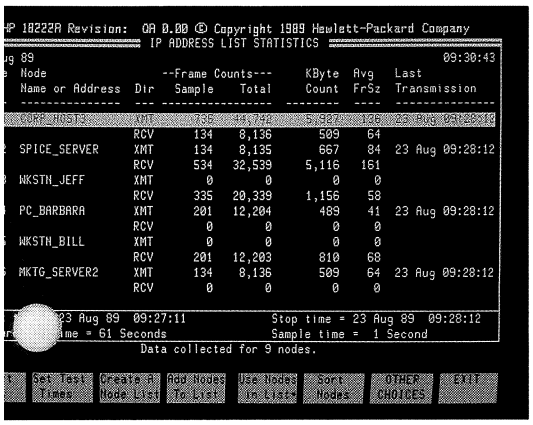


Figure 8. Gateway-isolated IP list statistics identify CORP_HOST3 as the largest contributor to gateway through-traffic.

The network manager's proposed solution to offload the gateway is to add a dedicated file server to the backbone net, effectively eliminating all internet traffic related to this service. Information can then be updated daily by scheduling 'dumps' from the corporate host at nonpeak times.

Interoperability

New installation

The network manager was installing a new host that would function as an FTP file server. Before the system could be used on-line, it was necessary for the network manager to verify interoperability of the new system with current network systems. Troubleshooting potential problems in a controlled environment makes the interoperability testing process much more manageable. This proactive stance also results in less user downtime after implementation, reducing the probability of encountering problems with this application in the future.

The HP 4972A was dispatched to the system test area. The HP 18221A TCP/IP protocol interpreter was used to monitor and interpret the information as it passed over the network. PING and TELNET sessions between the experimental host and a client workstation were successful. The FTP control connection was also successfully executed, but FTP data transfer attempts failed.

The HP 4972A helped identify the cause of this problem as the server's usage of its own uniquely designated port for FTP data transfers, rather than the well-known FTP_DATA port.

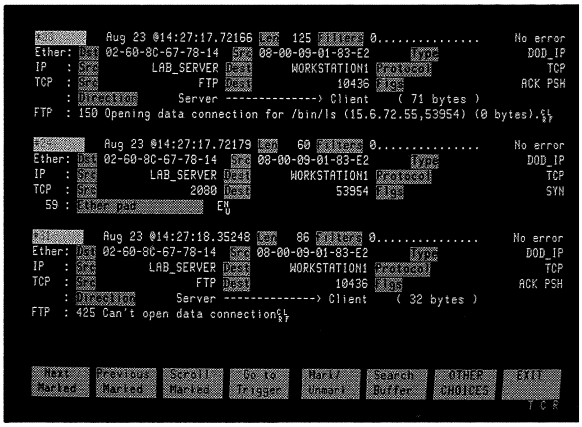


Figure 9. Trace of connection attempt shows server usage of port 2080 for FTP data transfers. Client expects to see well-known port 20, and does not respond.

This interoperability failure was solved by contacting the vendor supplying the new equipment, and acquiring a software patch so that the server uses the assigned port for FTP data transactions.

Increasing response times

Identifying server bottlenecks

Network users were complaining that the file server was very slow when delivering large files. The problem was worse during times of the day which had already been identified as periods of 'peak' server demands. The network manager dispatched the HP 4972A to the server site to help identify the bottleneck and solve the problem quickly.

The network file system (NFS) decode on the HP 4972A was used to identify the probable source of the problem. Modifications to user configurations were entered and the success of these modifications were verified using the HP 4972A and HP 18228A

NFS protocol interpreter. A trace of the NFS activity allowed the network troubleshooter to quickly isolate the cause of the server bottleneck. Frames 7 and 8, as shown in Figure 10, reveal information about a file transfer from the server to a client.

Frame 7 captured a read request to that file, and frame 8 shows the first frame of the transfer. Note that while the file was stored in 8K byte blocks, the client requested that the data be transferred in very small blocks of 64 bytes each. The effect on the server was an enormous increase in disk I/O activity, since each block was actually read 128 times (total block size of 8192 divided by the block transfer size of 64 bytes). When the server was under high loads, this behavior quickly consumed resources, significantly impairing the server's ability to provide timely service to its users.

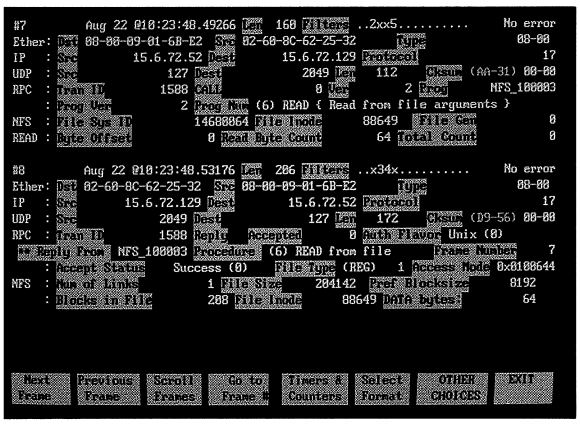


Figure 10. NFS read request sequence.

Client systems attached to the network were investigated and were adjusted so that their buffer size was more optimal to the average block size of files being transferred over this network. To test the fix, the HP 4972A was used to verify that transfers were made in optimally sized packets.

Conclusion

The performance of emerging network environments is determined by interactions among systems, applications and the network itself. For example, a poorly constructed application will consume excessive network resources leading to performance degradation while interfering with the work of other network users. Network congestion or errors can have an adverse impact on application performance.

Many protocol testing tools focus only on lower-layer network traffic, presenting a visibility barrier between the network and its associated systems and applications. Network professionals must be able to lower this barrier and observe the behavior of all the elements.

Knowledge of actual transactions, throughput rates, and activity levels rapidly clarifies problem sources. In heterogeneous networks, where different operating systems, hardware platforms and diagnostics are used, monitoring application/system performance without this knowledge is next to impossible.

Behavior of all elements of a networked environment can be studied using the analysis tools of the HP 4972A. With these tools, application-to-application response times and network delays can be measured and benchmarked. The mix of application programs and their relative traffic volumes can be determined. Demands on, and categories of services provided by, shared servers can be monitored, and program-to-program interactions across one or more networks are easily debugged.

Network services and active nodes are easily identified, and implementation efficiency can be quantified with the HP 4972A's TCP/IP network performance analysis package. Profiles of end-to-end throughput and other parameters can be generated for future benchmarking or troubleshooting purposes.

The protocol interpreters on the HP 4972A provide a simple and consistent way to examine the behaviors of various systems and applications. Instant access to protocol information reduces troubleshooting times, and acquisition consumes no network system resources.

Specifications

HP 18222A TCP/IP network performance analysis

Network summary
Measures overall network, including
- Network loading due to IP and nonIP traffic in bytes per second
- Distribution of services running over TCP in percentages by TCP port
- IP fragments, bytes and TCP packets
- TCP/IP header overhead by percentage

Node vs network summary
Measures a particular IP node, including
- Node-specific activity vs network-wide loading
- Distribution of TCP services used by the node in percentage by TCP port
- IP fragments, bytes and TCP packets
- TCP/IP header overhead by percentage

IP address list
- Tabulations for each IP node in list includes transmit and receive frame rates, data rates, most recent transmission time
- New IP addresses may be added to list as they appear on network
- Sort by network activity or by numeric address
- Gateway isolation option allows inspection of subnet activity

Connection analysis
Measures specific client/server conversations, including
- Transferred bytes and packets
- Application-to-application throughput rates
- Retransmitted packets and average retransmission times
- Response times
- Packet and send window sizes

HP 18221A TCP/IP protocol interpreter

Decodes
Network and transport level protocols of TCP/IP protocol suite, including
- internet protocol (IP)
- internet control message protocol (ICMP)
- address resolution protocol (ARP)
- reverse address resolution protocol (RARP)
- transmission control protocol (TCP)
- user datagram protocol (UDP)

Application level protocols for ARPA services including
- file transfer protocol (FTP)
- TELNET virtual terminal protocol (including commands embedded in data streams)
- simple mail transfer protocol (SMTP)

Software features
Directional arrows indicate data flow between client and server
Application command and response frames are identified
Maximum of 1000 internet addresses represented by logical names in IP address list
Checksum errors and invalid frame lengths highlighted
Summary or detailed display formats

Utility files
Custom TCP/IP tests are quickly and easily configured with "starter" set of filters and programs,including
- Conversational capture for IP, ICMP, TCP, UDP, routing updates, maximum segment size negotiation
- Trigger on events for exception analysis
- Stimulus/response testing for ARP, RARP, PING
- Analysis of TCP connections includes establishment time, duration, number of frames, ACKS sent

HP 18228A NFS protocol interpreter

Decodes
Network file system protocols developed by Sun Microsystems, including
- remote procedure call (RPC),
- network file system (NFS)
- port mapper (PMAP)
- disc mount (Mount)
- yellow pages (YP)

Software features
Error codes of rejected frames decoded
Invalid values highlighted
UNIX user-authentication data decoded
Program numbers mapped to symbolic names with a user-modifiable list
Remote procedure calls matched with replies, including multiple replies to broadcasts

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HEWLETT PACKARD

Analyzing TCP/IP networks with the HP 4972A

Product brief

HP 18221A TCP/IP protocol interpreters
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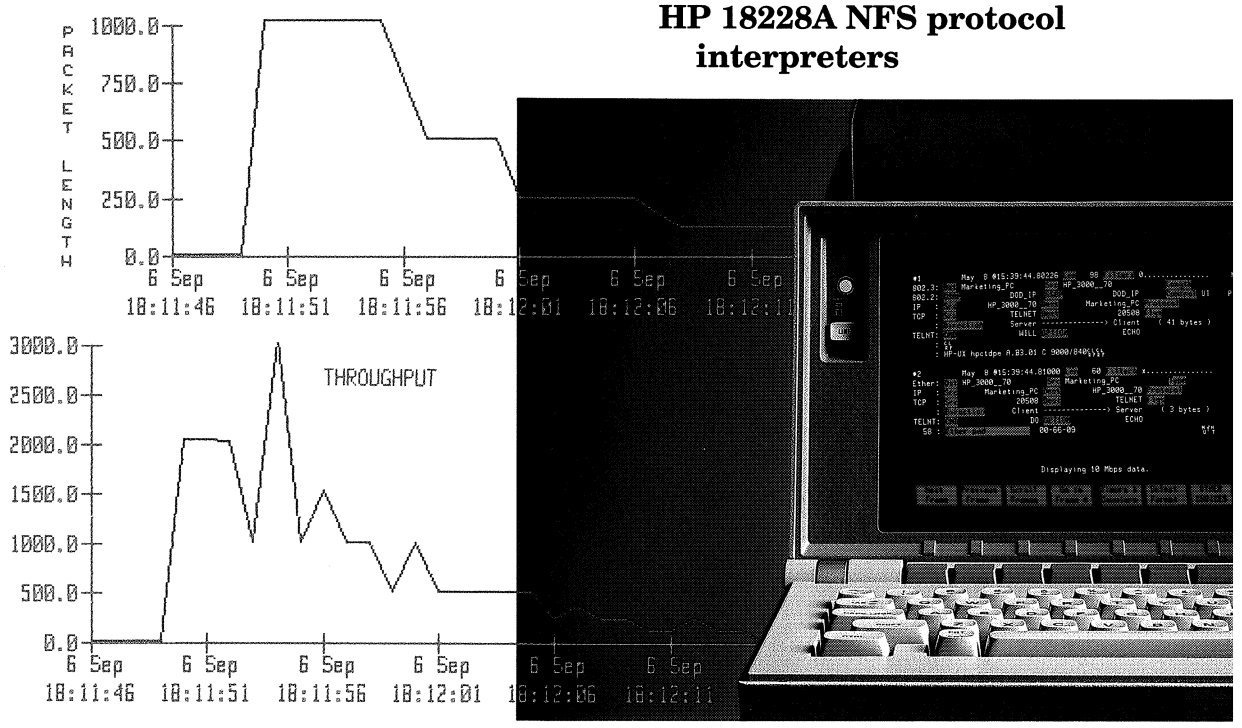
HP 18228A NFS protocol interpreters



Network performance and protocol interpretation tools to keep your TCP/IP network running smoothly

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Many protocol testing tools focus only on lower-layer network traffic, presenting a visibility barrier between the network and its associated systems and applications. Network professionals must be able to lower this barrier and observe the behavior of all the elements. Knowledge of actual transactions, throughput rates, and activity levels rapidly clarifies problem sources. In heterogeneous networks, where different operating systems, hardware platforms and diagnostics are used, monitoring application/system performance without this knowledge is next to impossible.

Behavior of all elements of a networked environment can be studied using the analysis tools of the HP 4972A. With these

tools, application-to-application response times and network delays can be measured and benchmarked. The mix of application programs and their relative traffic volumes can be determined. Demands on, and categories of, services provided by shared servers can be monitored, and program-to-program interactions across one or more networks are easily debugged.

Network services and active nodes are easily identified, and implementation efficiency can be quantified with the HP 4972A's TCP/IP network performance analysis package. Profiles of end-to-end throughput and other parameters can be generated for future benchmarking or troubleshooting purposes.

The protocol interpreters on the HP 4972A provide a simple and consistent way to examine the behaviors of various systems and applications. Instant access to protocol information reduces troubleshooting times, and acquisition consumes no network system resources.

HP 18222A TCP/IP network performance analysis package

With the HP 18222A, network managers and system administrators of IEEE 802.3 or Ethernet-based TCP/IP networks can rapidly characterize usage, activity and performance of all elements in the TCP/IP networked environment. Measurements available with this software include

- network-wide and node-specific loading and usage summaries;
- activity levels for entries in the IP address list; and
- server/client connection analysis of data throughput, retransmissions, response time, and packet and window sizes.

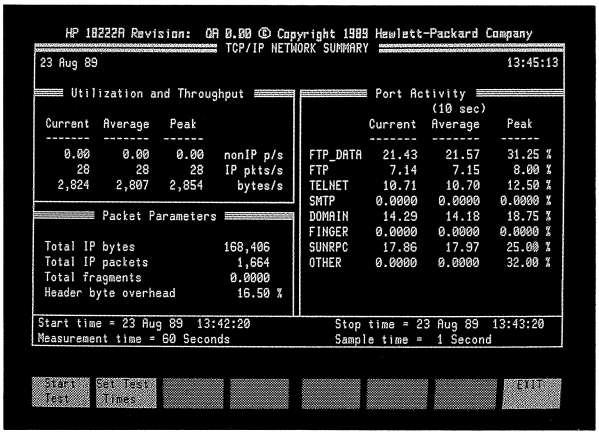

Figure 1. Network summary measurement provides a running snapshot of network activity and services. (HP 18222A)

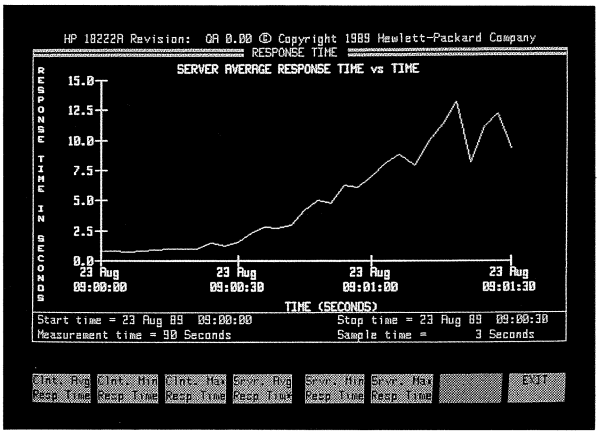

Figure 2. The connection statistics' response time measurement provides graphical representation of network (path) and acknowledgement delays over the duration of a TCP/IP conversation. (HP 18222A)

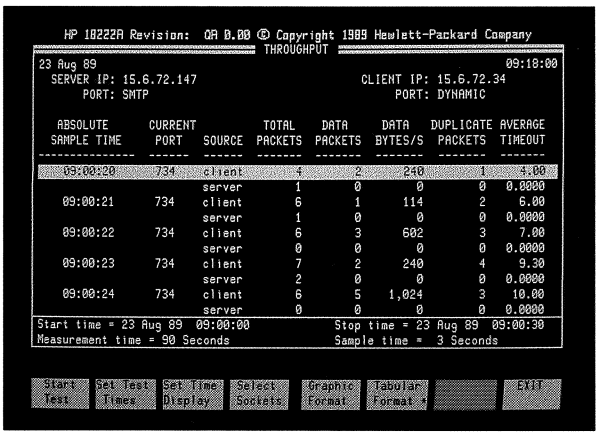

Figure 3. Throughput and retransmission measurements track efficiency and retransmission behavior throughout the conversation. (HP 18222A)

This information can help you control, manage, and troubleshoot problems on your network. Network usage and loading, and demands on shared servers can be profiled and monitored. Contributions to network activity by individual nodes provide valuable information for evaluating routing and load-balancing schemes. Connection analysis information (available in graphic format) makes end-to-end application behavior readily apparent. The network performance analysis package allows you to understand network limitations and bottlenecks so that improvement and purchase decisions will maximize network performance.

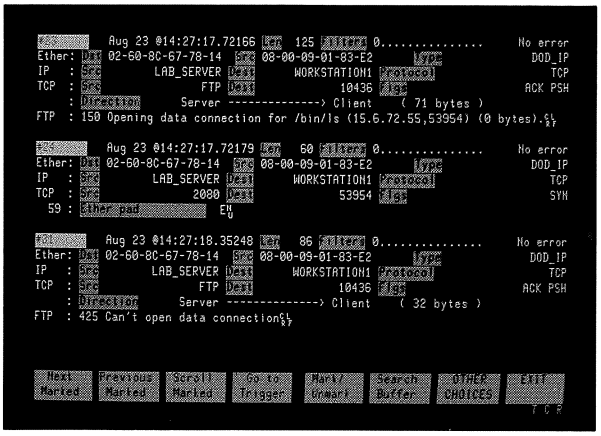

Figure 4. Summarized interpretation of FTP frame #24 indicates failure to establish an FTP data connection due to the server's use of port 2080 instead of the well-known FTP_DATA port expected by the client. (HP 18221A)

HP 18221A TCP/IP protocol interpreter

Revisions to the HP 18221A software provide additional decodes for upper layer protocols. Hewlett-Packard publication number 5952-5146 describes the original product in detail. Commonly used advanced research projects agency (ARPA) services have been added to this new revision of the HP 18221A. These include Telnet (virtual terminal protocol), file transfer protocol (FTP), and simple mail transfer protocol (SMTP). Full text descriptions of these protocols are easy to read and provide consistent data formats for multivendor networks. The HP 18221A provides for fast, efficient analysis of many frames in summary mode. This means your troubleshooting time is cut to a minimum because the behavior of your applications, as viewed with the HP 4972A and the HP 18221A, is accessible and easily understood.

The HP 18228A NFS protocol interpreter

The HP 18228A supports upper layer protocols based on Sun Microsystem's remote procedure calls (RPC). Decoded protocols include network file system (NFS), port mapper (PMAP), disk mount (Mount), and yellow pages (YP). Since these protocols use UDP/IP or TCP/IP as the transport mechanism, the decode solution for this environment also requires the HP 18221A TCP/IP protocol interpreter described above. With these decodes, problem isolation is expedited and troubleshooting time is cut to a minimum.

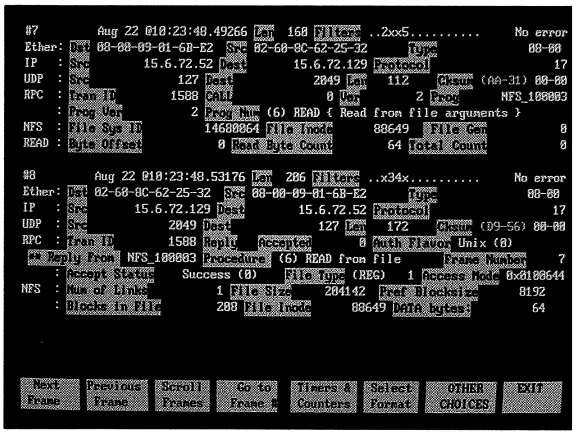

Figure 5. Decoded remote procedure call and reply frames illustrate initiation of an NFS file server transaction. (HP 18228A)

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Specifications

HP 18222A TCP/IP network performance analysis

Network summary
Measures overall network, including
- Network loading due to IP and nonIP traffic in bytes per second
- Distribution of services running over TCP in percentages by TCP port
- IP fragments, bytes and TCP packets
- TCP/IP header overhead by percentage

Node vs network summary
Measures a particular IP node, including
- Node-specific activity vs network-wide loading
- Distribution of TCP services used by the node in percentage by TCP port
- IP fragments, bytes and TCP packets
- TCP/IP header overhead by percentage

IP address list
- Tabulations for each IP node in list includes transmit and receive frame rates, data rates, most recent transmission time
- New IP addresses may be added to list as they appear on network
- Sort by network activity or by numeric address
- Gateway isolation option allows inspection of subnet activity

Connection analysis
Measures specific client/server conversations, including
- Transferred bytes and packets
- Application-to-application throughput rates
- Retransmitted packets and average retransmission times
- Response times
- Packet and send window sizes

HP 18221A TCP/IP protocol interpreter

Decodes
Network and transport level protocols of TCP/IP protocol suite, including
- internet protocol (IP)
- internet control message protocol (ICMP)
- address resolution protocol (ARP)
- reverse address resolution protocol (RARP)
- transmission control protocol (TCP)
- user datagram protocol (UDP)

Application level protocols for ARPA services including
- file transfer protocol (FTP)
- TELNET virtual terminal protocol (including commands embedded in data streams)
- simple mail transfer protocol (SMTP)

Software features
Directional arrows indicate data flow between client and server
Application command and response frames are identified
Maximum of 1000 internet addresses represented by logical names in IP address list
Checksum errors and invalid frame lengths highlighted
Summary or detailed display formats

Utility files
Custom TCP/IP tests are quickly and easily configured with "starter" set of filters and programs,including
- Conversational capture for IP, ICMP, TCP, UDP, routing updates, maximum segment size negotiation
- Trigger on events for exception analysis
- Stimulus/response testing for ARP, RARP, PING
- Analysis of TCP connections includes establishment time, duration, number of frames, ACKS sent

HP 18228A NFS protocol interpreter

Decodes
Network file system protocols developed by Sun Microsystems, including
- remote procedure call (RPC),
- network file system (NFS)
- port mapper (PMAP)
- disc mount (Mount)
- yellow pages (YP)

Software features
Error codes of rejected frames decoded
Invalid values highlighted
UNIX user-authentication data decoded
Program numbers mapped to symbolic names with a user-modifiable list
Remote procedure calls matched with replies, including multiple replies to broadcasts

Data subject to change
Printed in the U.S.A. 9/89
5952-5161

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