IBM 2210 Nways Multiprotocol Router Performance Results Release 3.0

Updated : December 12, 1995 (Release 3)

Document Contact: Steve Worley (SWORLEY at RALVM29)
2210 Development
Research Triangle Park, North Carolina

The performance data in this document apply to specific system configurations and was obtained in a controlled environment. Therefore, the results which may be obtained in other configurations or environments may vary significantly.

Further Information

Specific questions or comments concerning this document should be directed to the document contact, Steve Worley (2210 Development - tie line: 8-444-6071) Questions concerning the 2210 in general should be directed to the IBM Networking Support Center.

Summary

This document presents the results of performance measurements for the IBM 2210 Nways Multiprotocol Router. The measurement results reflect the performance of the IBM Nways Multiprotocol Routing Network Services (MRNS) Version 1 Release 3.0 unless indicated as results from an earlier release.

Release 3.0 includes both new hardware (14T, 24T, 24E, 24M) and software functional enhancements.

These performance results provide information on throughput, latency and other performance related issues for the LAN and WAN media and communication protocols supported by the 2210 including Data Link Switching (DLSw) and bridging.

As a component in the network, the 2210 will either route or bridge (source route or transparent) data at rates sufficient to support a remote site branch office and not be the limiting performance factor in most networks.

The 2210 models 12T, 12E, 127, and 128 use a 68360 processor to forward packets while the 14T, 24T, 24E, and 24M use a faster 68040 processor to forward packets. The performance of the 2210 models 12T and 12E are comparable to that of ISDN models 127 and 128 for equivalent configurations and protocols. The size of Flash memory or DRAM does not affect performance.

The 2210 12x Models will support media speeds across a T1 serial link for packet sizes of 128 bytes or greater with half-duplex (1.5Mbps) traffic. These Models are capable of approximately 4,000pps aggregate box throughput. The 14T and 24x Models with their faster processor are capable of approximately 15,000pps box capacity.

The 2210 performs very well compared to most branch office routers and was entered in the latest round of testing at the Harvard Network Device Test Lab in March 1995. Other independent tests at The Tolly Group have confirmed the 2210s stellar performance.

Data Link Switching (DLSw) performance on the 12T model is between 40 and 240 transactions per second depending on the user's input/output message sizes. 240 transactions per second equates to 480 data frames per second. Rates between 80-480 data frames per second, with a size range between 100-1988 bytes, allow the 2210 Model 12T to support a throughput of up to 1.6 Megabits per second of SNA user data. The addition of RFC 1795 support for DLSw has resulted in a 10%-20% decrease in DLSw performance on the Model 12T compared to Release 2. The new 2210 Models 14T and 24T provide approximately twice the DLSw performance of the 12T. These models support between 75 and 375 transactions per second depending on the user's input/output message sizes. These transactions rates translate into a throughput of up to 2.5 Megabits per second of SNA user data for frame sizes of 1988 bytes. Bandwidth reservation allows users flexibility in controlling priority of DLSw traffic.

Contents

1.0 Overview . . . 9
1.1 Performance in a Router Network . . . 10
1.2 Overview of the 2210 . . . 11
1.3 Performance Criteria . . . 12
1.4 Test Methodology . . . 14
1.4.1 Capacity and Throughput . . . 14
1.4.2 Benchmarking . . . 16

2.0 Competitive Information . . . 17
2.1 Comparison to Vendors . . . 17
2.1.1 Token Ring Throughput Comparisons . . . 17
2.1.2 Ethernet Throughput Comparisons . . . 19

3.0 Throughput Capacity Measurements . . . 21
3.1 Physical Configuration . . . 21
3.2 Results for 12x Models (68360 processor) . . . 21
3.2.1 Ethernet Capacity . . . 21
3.2.2 Token Ring Capacity . . . 24
3.3 Results for 24x and 14T Models (68040 processor) . . . 27
3.3.1 Ethernet Capacity (Model 24E) . . . 27
3.3.1.1 Ethernet IP Filtering . . . 29
3.3.2 Token Ring Capacity (Model 24T) . . . 30
3.3.3 Ethernet Remote Capacity (Models 24E and 24M) . . . 33
3.3.4 Token Ring Remote Capacity (Models 14T, 24T, and 24M) . . . 35

4.0 Box Throughput Capacity Measurements . . . 39

5.0 Data Link Switching Benchmark Tests . . . 41
5.1 DLSw Benchmark Configuration . . . 44
5.2 DLSw Token Ring SNA Tests . . . 45
5.2.1 DLSw SNA Test Environment . . . 45
5.2.1.1 Frame Sizes and Format . . . 45
5.2.2 DLSw Token Ring SNA Results Summary . . . 46
5.2.2.1 DLSw Token Ring SNA Performance Tuning . . . 46
5.2.2.2 DLSw Token Ring SNA Results for configuration 1 . . . 47
5.2.2.3 DLSw Token Ring SNA Results for configuration 2 . . . 51
5.2.3 DLSw Token Ring NetBIOS Results . . . 57

Appendix A. Media Capacity limitations . . . 59

Appendix B. References . . . 61

1.0 Overview

Performance has become one of the "hot" topics in the multiprotocol router market today. Therefore, performance results must provide sufficient information so valid comparisons can be made for the network which is to be built. The definition of performance in a multiprotocol router network has required revision as the router network has evolved. When the device was a single protocol, single media machine, performance could easily be reported in frames per second. This speed specification was a sufficient performance rating given the environment was simple and well understood. As multiple media interfaces and multiple connection-less protocols were added, performance was presented as maximum speed for the specific protocol or the generic maximum throughput for the box, leading to some confusion as the type of frames and environmental modifiers were not specified.

In today's network, where the router is used for LAN interconnection and WAN transport for connection-less and connection-oriented protocols, performance reporting must be standardized to allow for comparison in both the bridged and routed environments. This standardization must result in information valid for a production environment where multiple protocols are enabled in the router, frames of router exchange information flow, and filters are activated.

Many vendors still quote total theoretical box throughput for their boxes as sufficient input for the router decision. These reports often come without the specification of the environment in which the performance test was made. The test bed may have no likeness to production environments as the test may be chosen to optimize for maximum speed. Without a controlled environment to record the speed, these recordings are not easily compared to other vendors' performance information. To offset this, the Internet Engineering Task Force (IEFT) formed the Benchmark Methodology Working Group (BMWG) to establish guidelines for performance testing. Terminology, test environment (frame size, router information exchange, single and multiple protocol mixture, etc) and, in the future, packet content are specified to give the marketplace data which can be compared and contrasted when making purchase decisions.

This document describes the performance tests, validation activities, and results gathered for IBM 2210 Nways Multiprotocol Router Version 1 Release 3.0 unless otherwise specified. The terminology, test philosophy and benchmark configurations defined in this plan are consistent and comparable with the work being done by Benchmark Methodology Working Group (BMWG) of the Internet Engineering Task Force (IEFT) as defined in the following RFCs:

- Benchmarking Terminology (RFC1242) - Available
- Benchmarking Methodology - Draft
- Benchmarking Methodology: Test Frame Formats - Draft

This document does not attempt to resolve or address all of the previously mentioned concerns and characteristics. It is an attempt to present the performance characteristics of the 2210 consistent with the BMWG guidelines within the constraints of the existing measurement tools and technology.

In spite of the attention performance receives, it is only one of several important selection criteria and must always be weighed with the other critical determining factors in the network, such as:

- Required functions and protocols supported
- Reliability and Availability
- Network management capability
- Quality and level of service provided by vendor
- Total cost of ownership (hardware, software, service and support).

1.1 Performance in a Router Network

A customer perceives the network performance by the response time he sees for his application. The 2210 is one of the many contributors to response time, and its performance in the customer environment is really defined by its contribution to the overall system response time.

Performance varies by protocol and packet size in the router network. Kevin Tolly, in Network World (Aug 10, 1992), states "traffic on a typical corporate internet consists of larger frames, such as those used in Novell, Inc. NetWare or Microsoft Corp. LAN Manager file transfers. Measuring performance using 64-byte packets is largely of academic interest, since virtually no applications use such small packets."

Performance information then must be specified in such a way that expectations for a given LAN or WAN interface can be factored into the network design. WAN speed is often the limiting factor in throughput or response time measurements. Traffic patterns of the protocols being supported are also a factor when designing a network to support the necessary response time for an application.

Another performance consideration which is added to the aggregate of the performance and capacity is the overhead of router-to-router exchanges. As each protocol is added, a new flow of exchanges between the routers must occur. Network management is another internal flow which must be given consideration when determining the necessary box performance to support the system performance requirements.

Routers were designed with connection-less oriented protocols in mind. Each data packet finds its way through the network with the information available in its header. Path information is maintained via router information exchanges outlined in protocols like TCP/IP's RIP and OSPF. Broadcasts are used to learn locations of other end stations, services, and zones. Today's connection oriented protocols are encapsulated to take on these characteristics. Performance under this encapsulation may be more comparable from the end stations point of reference, such as response time, as each implementation provides unique function in its support of connection oriented protocols ranging from spoofing to broadcast and flow control.

Performance is limited by the hardware on which the function is being tested. Each interface must be tested with the protocols and function supported on it. After looking at the card level performance, box level performance information becomes one of the entities in the overall network performance information. Only then can performance be estimated for the network and bottlenecks pinpointed. End to end response time is the last of the performance information which can be gathered. The information provided in the following charts and tables are one specific environment's performance information. Any changes to this controlled environment when customizing it to a production environment will result in changes to the performance results of the 2210.

1.2 Overview of the 2210

The 2210 is a bridge/router whose protocol support includes TCP/IP, IPX, AppleTalk, DECnet, and Banyan Vines. Beginning in Release 3.0, DLSw supoorts NetBIOS as well as SNA traffic. Token Ring Source Route Bridging (SRB), Ethernet Transparent Bridging (TB), Source Route Transparent Bridging (SRT), and Source Route Translational Bridging (SR-TB) are all supported over PPP and Frame Relay. Another feature for 2210 is Frame Relay Boundary Access Node function which allows attached PU Type 2.0 and 2.1 end stations to bridge traffic directly to the Front End Processor (FEP) without frame conversion.

All data packets flowing through the 2210 models 12T, 12E, 127 and 128 are handled by a 68360 processor, while the 14T, 24T, 24E, and 24M utilize a 68040 for packet forwarding.

1.3 Performance Criteria

Performance criteria are used to define the capacity of the IBM 2210 Nways Multiprotocol Router. The criteria are defined and measured using the following attributes:

- **Rated Throughput**

  Objective

  To determine the maximum rate at which 100% of offered frames are passed by the device.

  Measurement
  - Throughput in Frames-per-Second (FPS)
  - Throughput in megabits/second (Mbps)
    M The amount of available bandwidth utilized.

    Rated throughput is determined by gradually increasing the number of frames submitted on a Token Ring, Ethernet, or Serial adapter input port. The frames are transferred to another adapter and the output port is monitored for loss of frames. The point at which the first frame is lost determines the rated throughput.

  Two other key measurement points are:
  - **Maximum Load Throughput** - The throughput achieved at the highest rate of offered frames (media speed or highest level support by test driver). It differs from 'Rated Throughput' in that the output measured is the number of frames received while the input port is transmitting data at media speeds.
  - **Maximum Throughput** - The highest level of throughput achieved across entire range of input data rates. It differs from 'Rated Throughput' and 'Maximum Load Throughput' in that as the number of input frames is increased, the output port is monitored for the maximum number of frames received per second. This measurement determines maximum absolute number of frames that the router can handle for each packet sizes.

  Test Procedure

  Send a specific number of frames at a specific rate through the device and then count the frames that are forwarded by the device. The rated throughput is the fastest rate at which the count of frames forwarded is equal to the number of frames sent plus any background "idle state" traffic.

- **Load Capacity or Frame Loss Rate**

  Objective

  To characterize the performance of a device throughout the entire range of input data rates. To measure the increase/decrease in throughput as the load is increased from rated throughput up to media speed.

  Measurement
  - Throughput in Frames/Sec. (FPS)
  - % of lost frames.

  Test Procedure

  Send a specific number of frames at a specific rate through the device to be tested and count the frames that are transmitted by the device. The frame loss rate at each point is calculated using the following equation:

  ```
  ( ( input_count - output_count ) * 100 ) / input_count
  ```

- **Latency**

  Objective

  Determine the time interval from when last bit enters input port till first bit leaves output port.

Measurement

The time in microseconds(usec.) or milliseconds (msec.)

Test Procedure

The latency should be measured at several frame rates, at a minimum at idle and at rated throughput as well as at various frame sizes.

- **Burst capacity**

  Objective

  Determine the number of back-to-back frames that can be handled without losing a frame. The frames within a burst are transmitted with the minimum legitimate inter frame gap to measure the device's buffering and burst handling capability.

  Measurement

  Number of consecutive frames

  Test Procedure

  During each test the number of back-to-back frames will be increased until a frame is lost or a time limit is reached. The time limit is still TBD but will be between 100 msec. and 1 sec. Tests should be run at the same frame sizes as throughput tests.

1.4 Test Methodology

The IBM 2210 Nways Multiprotocol Router performance evaluation is divided into 2 sets of activities: capacity and throughput measurements; and benchmarking.

1.4.1 Capacity and Throughput

These measurements establish the product's base performance characteristics, such as frame throughput rates for each card using each protocol under varying traffic loads.

Environment

The environment will normally be the minimum configuration to support the specified criteria.

- like-to-like LAN
- Minimum keep alive traffic
- No other activity in the router
- Across range of frame sizes
- Across range of protocols

Environment Modifiers

The following modifiers have been identified by the BMWG as having potential impact on performance of routers.

- With and without filtering

  Filters are added to routers and bridges to selectively inhibit the forwarding of frames that would normally be forwarded. Different products have different capabilities to implement filters.

- With Routing update frames

  The processing of dynamic routing protocol updates could have a significant impact on the ability of a router to forward data frames. The normal test scenario should be augmented with one routing update frame every one second during the duration of the test. The routing frames should be designed to change the routing to a number of networks that are not involved in the forwarding of the test data. A set of two repeated routing frames could be used. The first frame sets the routing table state to "A", the second one changes the state to "B".

- With Broadcast frames

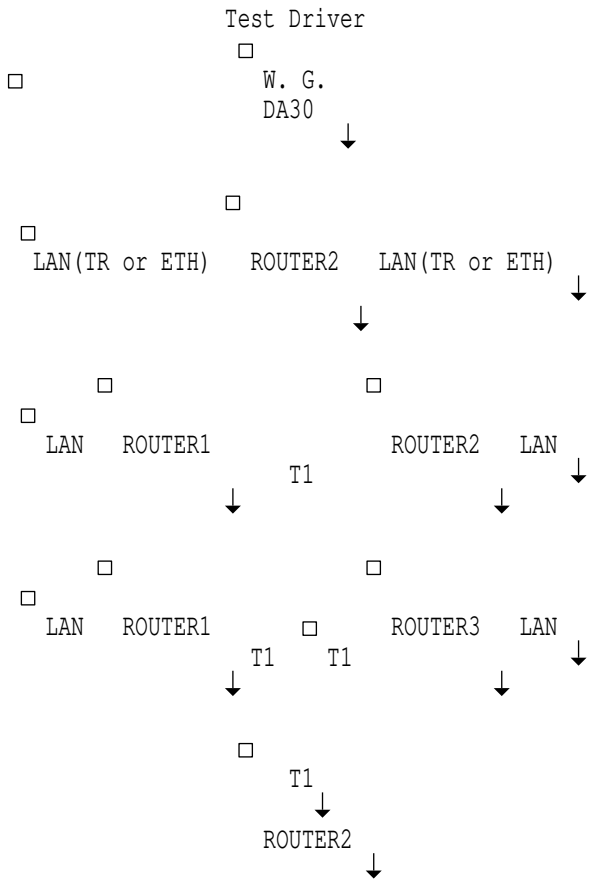
  In most router designs special processing is required when frames addressed to the hardware broadcast address are received. When bridging these broadcast frames must be flooded to a number of ports. The normal test scenario should be augmented with 1% frames addressed to the hardware broadcast address. It is understood that this level may be higher than many networks experience. The higher level is required to be able to gage the effect which would otherwise often fall within the normal variability of the system performance.

- With Management frames

  Most data networks now make use of management protocols such as SNMP. In many environments there could be a number of Network Management stations sending queries to the router at the same time. The normal test scenario should be augmented with one management query every one second during the duration of the test. The result of the query should fit into one response frame.

The following figure describes the physical test configuration used for making the card/port throughput measurements. A Wandel & Goltermann DA 30 Multiprotocol Analyzer was used as the primary test driver because of it's multiport capability. Also, as it is one of the test drivers used by Scott Bradner in his test measurements. The use of a W&G DA30 results in data which is compatible to his independent tests.

Physical Configuration



1.4.2 Benchmarking

The benchmarking activity is designed to compare results against competitive solutions, IBM or other vendors. The key area of benchmark evaluation will be the DLSw area. These tests differ from those in 1.3, HPerformance Criteria< on page 12 in that they represent more customer like scenarios.

Primary Scenarios

- 3270 interactive workload (A1200) composed of transactions of 40 bytes input and 1400 bytes output.
- Echo response - n bytes in / n bytes out (n=100,200,400,800,1600,1988)

Criteria

The key performance criteria/characteristics measured will include:

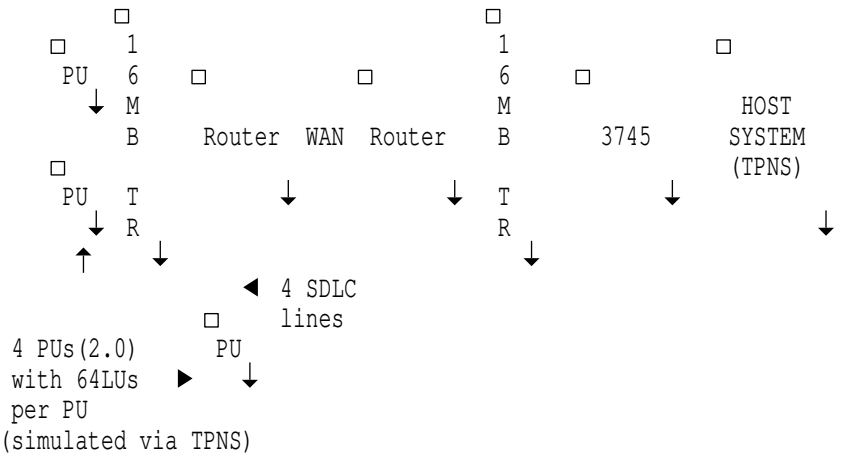
- Transaction Rate - the interactive transaction rate in trans/sec.
- Transaction Byte Rate - Kbytes of data (I frame data)/sec.
- End user response time - mean and 90% response time

Environment

The test environment will be:

- LAN or Link(PU2.0) attached LUs - WAN - LAN - 37xx - HOST

Physical Configuration



2.0 Competitive Information

2.1 Comparison to Vendors

Definitions

- Rated Throughput - Throughput at the highest point that no frames are lost.
- Maximum Load Throughput - Throughput when the maximum number of frames are offered (media speed or test driver limit)
- Maximum Throughput - The highest level of throughput achieved across the entire range of of input data rates.
- Media speed - The maximum theoretical throughput for a media for a given frame size. It is derived by dividing the media capacity by the frame size plus applicable media overhead. It is expressed in Frames per Second (FPS) or Megabits per Second (Mbps).

Routers and bridges display one of the three following basic performance characteristics. As the load increases the rated throughput point will be reached and :

1. throughput will continue to increase slightly
2. throughput will remain constant. (Rated = Max = Max Load).
3. throughput will begin to drop, in extreme cases to almost zero.

The test results in the following tables were gathered from several sources using different test environments and frame sizes. This accounts for not having measurements at all points.

The maximum frame lengths supported by the 2210 are:

- Ethernet - 1518 bytes
- 4M Token Ring - 2052 bytes
- 16M Token Ring - 2052 bytes
- T1 Serial Card - 2048 bytes

Specific protocols may have additional size limitations.

2.1.1 Token Ring Throughput Comparisons

The following charts compare Token Ring throughput in various configurations. Table 4 on page 19 and Table 5 on page 19 compare IP and SRB measurements made by Scott Bradner of Harvard [1] with 2210 measurements made by IBM. The measurements were made with all traffic flowing in one direction.

[1] The Bradner results were obtained via anonymous FTP to hsdndev.harvard.edu. Access to these results is unrestricted and available to anyone with access to the Internet.

Table 1. 16M TR-to-TR (local card to card) 1-way IP traffic

THROUGHPUT (fps)	Rated Tput	Max Load	Maximum Throughput					
VENDOR - Model								
Frame size (bytes)	**64**	**64**	**64**	**256**	**512**	**1024**	**1518**	**2048**
IBM 2210 Model 24T Rel 3.0[1]	+6339	+6339 4(1)	+6339	+4462	+3124	+1823	+1257	+943
IBM 6611 Rel 3.0[2]	+6352	+6352 4(1)	+6352	+4462	+3126	+1825	+1258	+943
Proteon CNX500[3]	8949	14828 4(2)	14828	+6100	+3433	+1823	+1258	+943
Proteon DNX300[3]	4458	4733 4(2)	4730	4312	+3433	+1823	+1258	+943
Cisco AGS+[3]	14651	14651 4(2)	14651	+6100	+3433	+1823	+1258	+943
Novell MultiProtocol Router Plus[3]	7486	7358 4(2)	8259	+6100	+3433	+1823	+1258	+944
ACC ACS 4200[3].	2313	6 4(2)	2313	1854	1220	957	747	450
MEDIA SPEED	**28986**	**28986**	**28986**	**7663**	**3868**	**1944**	**1313**	**974**

Note:

1. Measurement Source - IBM, 2210 Development - 11/95
2. Measurement Source - IBM, Router Performance Testing- 8/94
3. Measurement Source - Bradner - 6/92, 10/92, 8/93
4. Differences in Max. Load Throughput is due to capacity of test drivers. Numbers in parentheses indicate highest load generated.

   (1)= 6352 fps.

   (2)= 14836 fps.

\+ = capacity exceeded highest measurement made.

Table 2. 16M TR-to-TR (local card to card) SRB -Traffic 1 direction

THROUGHPUT (fps)	Rated Tput	Max Load	Maximum Throughput					
VENDOR - Model								
Frame size (bytes)	**64**	**64**	**64**	**256**	**512**	**1024**	**2048**	**3960**
IBM 2210 Model 24T Rel 3.0[1]	5205	5595 4(1)	5595	3869	2659	1566	886	471
IBM 6611 Rel 3.0[2]	+6338	+6338 4(1)	+6338	+4462	+3162	+1825	+943	+496
Proteon CNX500[3]	8950	14132 4(2)	14132	+6100	+3433	+1823	+943	+495
Proteon DNX300[3]	4459	4964 3(4)	4980	+4343	+3433	+1823	+943	+496
Cisco AGS+[3]	14625	14625 4(2)	14625	+6100	+3433	1640	+943	+496
ACC ACS 4200[3]	2231	1218 4(1)	2196	1925	1234	985	749	642
Novell MultiProtcol Router[3].	7445	6514 4(2)	7445	5883	+3433	+1826	+944	+496
Netronix TokenMaster[3].	2935	2 4(2)	2935	2515	1936	1276	761	448
Fibronics FR 9500[3].	1583	3 4(2)	1731	1360	1030	731	324	178
MEDIA SPEED	**28986**	**28986**	**28986**	**7663**	**3868**	**1944**	**1313**	**974**

Note:

1. Measurement Source - IBM, 2210 Development - 11/95
2. Measurement Source - IBM, Router Performance Testing- 8/94
3. Measurement Source - Bradner - 6/92, 10/92, 8/93
4. Difference in Max. Load Throughput is due to capacity of test drivers. Numbers in parentheses indicate highest load generated.

   (1)= 6338 fps.

   (2)= 14625 fps.

\+ = capacity exceeded highest measurement made.

Table 3. 16M TR-to-TR (local card to card) SRB -Traffic both directions

THROUGHPUT (fps)	Maximum Throughput							
VENDOR - Model								
frame size (bytes)	**32**	**64**	**100**	**256**	**512**	**1024**	**2048**	**4096**
IBM 2210 Model 24T Rel 3.0[1]		6246		4464	3124	1793	+729	
IBM 6611 Rel 3.0[2]	6775	6455	5230	4860	+3800	+1944	+974	+488
IBM TR Bridge 2.2[3,4]	3920	3795	3600		1786	1160	693	346
IBM 8209[3]	3970	3970	3685		2011	1180	634	331
IBM 8229[3]		+22500		+7377	+3904	+1952	+885	

Note:

1. Measurement Source - IBM, 2210 Development - 11/95
2. Measurement Source - IBM, Router Performance Testing - 8/94
3. Measurement Source - IBM, Bridge Performance 7/92, 6/94
4. PS2 Mod 70-386(25MHZ)

\+ = capacity exceeded highest measurement made.

Table 4. 16M TR-to-TR via T1 WAN IP Traffic 1 direction									
THROUGHPUT (fps)	**Rated Tput**	**Maximum Throughput**							
VENDOR - Model									
LAN Frame size (bytes)	64	52	64	256	512	1024	1518	2048	3960
IBM 2210 Model 12T Rel 3.0 [2]	3123	2178	3123	801	389	190	127	94	n/a
IBM 2210 Model 24T Rel 3.0 [2]	+3903	+5205	4134	804	388	190	128	95	n/a
IBM 6611 Rel 3.0 [1]	4151	5606	4152	803	387	189	127	94	n/a
Proteon CNX500 [2]	2603	3903	3123	744	381	190	127	94	48*
Proteon DNX300 [2]	1420	2918	2477	723	367	185	125	93	none
Cisco AGS+ [2]	+3123	+3903	+3323	+743	+381	190	127	94	48
Timeplex Time/Lan 100 [2]	1201	1201	1201	744	381	190	129	99*	49**
ACC ACS 4200 [2]	2231	2548	2540	+744	+381	190	129*	99**	49***
3Com Netbuilder [2]	1420		1550	+779	+381	190	127	none	none
HP 27286A [2]	3123	3726	3310	768	379	188	127	101	62

Note:

1. Measurement Source - IBM, Router Performance Testing - 8/94
2. Measurement Source - Bradner - 6/92, 10/92, 8/93, 3/95

\+ = capacity exceeded highest measurement made.

Frame sizes on WAN vary depending on WAN protocol and vendor implementation.

Packet segmenting:

- * = Packet segmented into 2 frames
- ** = Packet segmented into 3 frames
- *** = Packet segmented into > 3 frames

Table 5. 16M TR-to-TR via T1 WAN SRB 1 direction									
THROUGHPUT (fps)	**Rated Tput**	**Maximum Throughput**							
VENDOR - Model									
Frame size (bytes)	64	52	64	256	512	1024	1518	2048	3960
IBM 2210 Model 12T Rel 3.0 [1]	2231	2546	2389	718	366	185	125	92	n/a
IBM 2210 Model 24T Rel 3.0 [1]	2231	2585	2585	720	367	186	125	93	n/a
IBM 6611 Rel 3.0 [2]	2612	3123	2612	721	367	185	125	93	n/a
Proteon CNX 500 [3]	2231	2962	2489	728	371	186	125	93	n/a
Proteon DNX300 [3]	1420	2150	1871	652	347	180	123	92	none
CISCO AGS+ [3]	2108	2426	2210	678	356	182	124	92	48
3Com Netbuilder [3]	2231		2550	718	367	185	125	93	48
HP27286A [3]	1952	2028	1978	682	357	183	124	none	none
IBM 8229 [4]	2565	3057	2565	710	363	186	125	90	49

Note:

1. Measurement Source - 2210 Development - 11/95
2. Measurement Source - IBM, Router Performance Testing- 8/94
3. Measurement Source - Bradner - 6/92, 10/92, 8/93, 3/95
4. Measurement Source - IBM, Bridge Performance Testing - 7/94

2.1.2 Ethernet Throughput Comparisons

The following chart compares measurements of Ethernet to Ethernet via a T1 for various vendors based on measurements made by Scott Bradner of Harvard. The measurements were made with all traffic flowing in 1 direction.

Table 6. Ethernet to Ethernet (local card to card) IP traffic 1 direction

THROUGHPUT (fps)	**Rated Tput**	**Max Load**	**Maximum Throughput**							
VENDOR - Model										
Frame size (bytes)	**64**	**64**	**64**	**128**	**256**	**512**	**768**	**1024**	**1280**	**1518**
IBM 2210 Model 24E Rel 3.0[1]	14730	14745	14745	8415	4524	2348	1583	1197	959	810
IBM 6611 Rel 3.0[2]	11476	11617	11950	8200	4366	2307	1553	1181	960	792
Proteon DNX300[3]	3964	3952	4052	3934	3891	2276	1552	1175	949	803
Proteon CNX500[3]	12802	12768	12802	7836	4349	2296	1583	1184	952	806
Proteon CNX600[3]	13391	14461	14461	8315	4489	2339	1580	1193	959	810
Cisco AGS+[3]	14666	14666	14579	8118	4496	2344	1577	1190	957	809
Cisco 7000[3]	14879	14879	14879	8445	4528	2248	1585	1196	961	812
Wellfleet BCN[3]	10343	14838	14838	7600	4521	2347	1584	1196	961	811
HP J2430A[3]	13393	14863	14863	8445	4528	2348	1585	1196	961	812
ACC ACS 4200[3]	4735	4827	4848	4684		2114	1427	1077	864	730
3Comm Netbuilder II:[3]	14679	14803	14803	8421	4521	2347	1585	1196	961	812
Media speed	**14880**	**14880**	**14880**	**8445**	**4528**	**2349**	**1586**	**1197**	**961**	**812**

Note:

1. Source - IBM, 2210 Development - 11/95
2. Source - IBM, Router Performance Testing- 9/94
3. Source - Bradner - 6/92, 10/92, 8/93, 4/94

Table 7. Ethernet to Ethernet (remote via T1 (1.536)) IP traffic 1 direction

THROUGHPUT (fps)	**Rated Tput**	**Max Load**	**Maximum Throughput**							
VENDOR - Model										
LAN frame size (bytes)	**64**	**64**	**64**	**128**	**256**	**512**	**768**	**1024**	**1280**	**1518**
IBM 2210 Model 12E Rel 3.0[3]	3133	2108	3133	1621	783	382	252	189	150	127
IBM 2210 Model 24E Rel 2.0[3]	3532	3529	3532	1625	783	381	252	188	150	127
IBM 6611 Rel 3.0[1]	3548	3555	3555	1626	780	382	253	189	151	128
Proteon CNX500[2]	+3271	+3300	+3300	1577	773	380	250	186	125	105
Proteon DNX300[2]	2301	2301	2302	1298	694	360	244	184	124	105
Cisco AGS+[2]	+2976	+2976	+2976	1586	770	380	252	189	127	106
HP 27285A[2]	+2976	+2976	+2976	1626	780	382	253	189	127	107
Vitalink/NS 6600[2]	+2976	+2976	+2976	1621	779	382	253	189	127	106
3Com Netbuilder I[2]	2639	2639	2638	1467	739	371	246	156	125	105
N.A.T. LANB/280[2]	2494	2494	2478	1535	771	387	257	163	130	110

Note:

1. Source - IBM, Router Performance Testing - 9/94
2. Source - Bradner - 6/92, 10/92, 3/95
3. Source - IBM, 2210 Development - 11/95

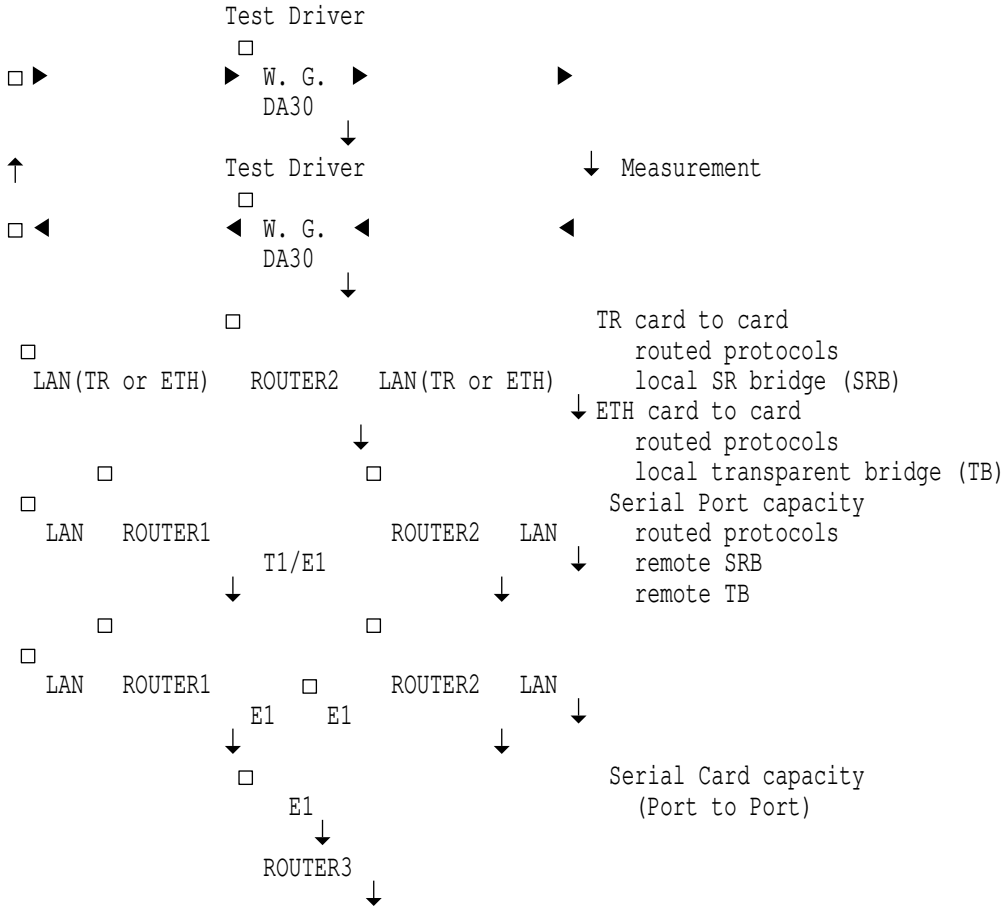
+ = capacity exceeded highest measurement made.

The 6611 results are higher than competition at 64 byte frames due to Bradner tests not driving to full media speed. The 2210 and 6611 results are also higher at large frames, possible explanations include differences in test driver, CSU/DSU and packet headers/ trailers. Interestingly the TR remote results are almost identical for large packets.

3.0 Throughput Capacity Measurements

The 12x Models (2 WAN ports) of the 2210 utilize a 68360 processor for packet forwarding, while the 14T and 24x Models (4 WAN ports) utilize a much faster 68040 processor for packet forwarding. Results for both types of 2210 are presented in this section.

3.1 Physical Configuration



Note: The DA-30 is not capable of generating packets at full media speed for 16M Token Ring. For limitations of the DA-30 see Appendix A.

3.2 Results for 12x Models (68360 processor)

3.2.1 Ethernet Capacity

The Ethernet measurements are for the routed protocols and transparent bridging. The configuration is LAN-to-WAN across a T1 link and includes IP, IPX, DECnet, Appletalk, and transparent bridge (TB) measurements. VINES throughput is not included at this time due to problems with the DA-30 test bed. VINES throughput should be consistent with the other protocols. Both PPP and Frame Relay were tested as WAN link protocols. Measurements were taken with all protocols configured. It was determined that there is little difference in performance based on the number of protocols configured.

Note: Frame rates of 14,000 fps on an Ethernet network are usually only possible in a test environment or on Ethernet switches. When multiple stations are attached to a non-switched Ethernet network, rates of only 4000-5000pps are practical due to the CSMA/CD method of media access.

Detailed results of all protocols for Version 1 Release 3.0 are shown in the tables below.

Table 8. Ethernet IP (remote) LAN to LAN via T1

		Frames/Sec (FPS)				*Megabits/Sec (Mbps)*				*Delay (usec.)*	
Frame Size	WAN size	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Total Delay	Box Delay
64	52	3133	3133	2108	3623	1.30	1.30	0.88	1.51	1119	424
128	116	1612	1623	1623	1641	1.50	1.51	1.51	1.52	1215	306
256	244	770	783	779	784	1.50	1.53	1.52	1.53	2024	377
512	500	378	382	382	383	1.51	1.53	1.53	1.53	3332	364
1024	1012	187	189	189	190	1.51	1.53	1.53	1.53	6047	389
1518	1506	127	127	127	127	1.53	1.53	1.53	1.53	8563	360

Release 3.0

One way traffic generated by W&G DA30

Table 9. Ethernet IPX (remote) LAN to LAN via T1

		Frames/Sec (FPS)				*Megabits/Sec (Mbps)*				*Delay (usec.)*	
Frame Size	WAN size	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Total Delay	Box Delay
64	52	3114	3495	3377	3623	1.30	1.45	1.40	1.51	1036	382
128	116	1612	1616	1616	1641	1.50	1.50	1.50	1.52	1368	382
256	244	771	771	771	784	1.50	1.50	1.50	1.53	2063	396
512	500	377	377	377	383	1.51	1.51	1.51	1.53	3761	578
1024	1012	187	189	189	190	1.51	1.53	1.53	1.53	6303	517
1518	1506	127	127	127	127	1.53	1.53	1.53	1.53	8902	529

Release 3.0

One way traffic generated by W&G DA30

Table 10. Ethernet DECnet (remote) LAN to LAN via T1

		Frames/Sec (FPS)				*Megabits/Sec (Mbps)*				*Delay (usec.)*	
Frame Size	WAN size	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Total Delay	Box Delay
64	52	1937	1937	1167	3623	0.80	0.80	0.49	1.51		
128	116	1636	1636	1271	1641	1.52	1.52	1.18	1.52		
256	244	770	781	781	784	1.50	1.52	1.52	1.53		
512	500	378	381	381	383	1.51	1.52	1.52	1.53		
1024	1012	187	188	188	190	1.51	1.52	1.52	1.53		
1518	1506	127	127	126	127	1.53	1.53	1.52	1.53		

Release 3.0

One way traffic generated by W&G DA30

Table 11. Ethernet AppleTalk (remote) LAN to LAN via T1

		Frames/Sec (FPS)				*Megabits/Sec (Mbps)*				*Delay (usec.)*	
Frame Size	WAN size	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Total Delay	Box Delay
64	52	1948	1948	1437	3623	0.81	0.81	0.60	1.51	1343	536
128	116	1641	1641	1641	1641	1.52	1.52	1.52	1.52	1643	520
256	244	784	784	784	784	1.53	1.53	1.53	1.53	2338	534
512	500	383	383	383	383	1.53	1.53	1.53	1.53	3800	598

Release 3.0

One way traffic generated by W&G DA30

Table 12. Ethernet Transparent Bridging (remote) LAN to LAN via T1

		Frames/Sec (FPS)				*Megabits/Sec (Mbps)*				*Delay (usec.)*	
Frame Size	WAN size	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Total Delay	Box Delay
64	74	2095	2335	2020	2594	1.24	1.38	1.20	1.53	1401	565
128	138	1383	1385	1385	1391	1.53	1.53	1.53	1.53	1701	548
256	266	710	719	719	721	1.51	1.53	1.53	1.53	2421	576
512	522	366	366	366	367	1.53	1.53	1.53	1.53	3896	646
1024	1034	185	185	185	185	1.53	1.53	1.53	1.53	6649	690
1518	1528	125	125	125	125	1.53	1.53	1.53	1.53	9158	657

Release 3.0

One way traffic generated by W&G DA30

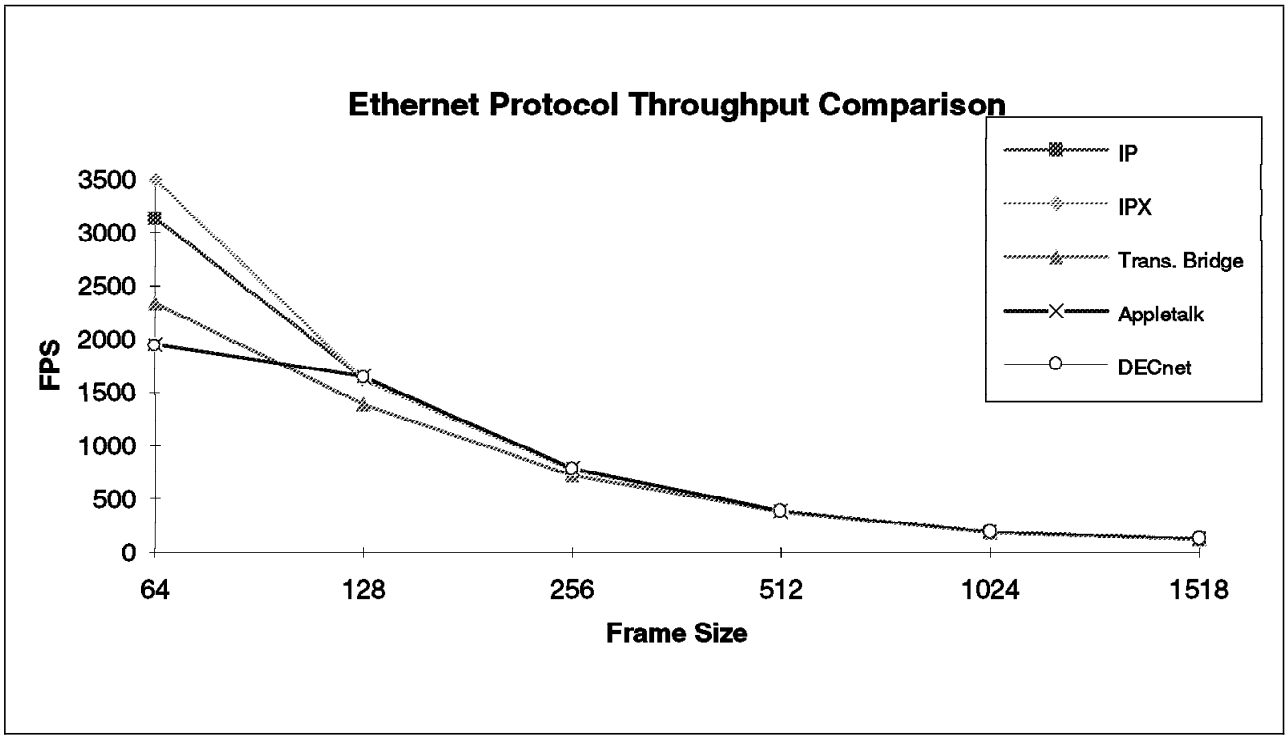


Figure 1. IBM 2210 Nways Multiprotocol Router Model 12E Ethernet Protocol Throughput Comparison

As the data shows, all the routed protocols approach media speed for 128 byte frames. All the protocols handle large frames with virtually no loss providing efficient file transfer capabilities.

3.2.2 Token Ring Capacity

The Token Ring measurements are divided into two categories, routed protocols and Source Route Bridging. The routed protocols tested were IP, IPX, DECnet, and Appletalk. VINES throughput is not included at this time due to problems with the DA-30 test bed. VINES throughput should be consistent with the other protocols. Measurements of the routed protocols were made with all protocols configured except SRB. SRB measurements were made with all the protocols configured and the following SRB filters set to deny: IPX SAP=E0, DECnet SNAP=6003, Appletalk SNAP=809B. These filters prevent the routed protocols from being bridged. It was determined that there is little difference in performance based on the number of protocols configured.

The following figure shows the Token Ring performance for all protocols for the 2210.

Table 13. 16M Token Ring IP (remote) LAN to LAN via T1

		Frames/Sec (FPS)				*Megabits/Sec (Mbps)*				*Latency (usec.)*	
Frame Size	WAN Size	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Total Delay	Box Latency
52	32	3123	3527	3521	5818	0.80	0.90	0.90	1.49	1378	605
64	44	3123	3123	2178	4267	1.10	1.10	0.76	1.50	1311	541
128	108	1735	1735	1716	1761	1.49	1.49	1.48	1.50	1745	591
256	236	780	803	803	810	1.47	1.51	1.51	1.53	2415	593
512	492	389	389	387	389	1.53	1.53	1.52	1.53	3902	670
1024	1004	185	190	190	191	1.49	1.53	1.53	1.53	6905	838
1518	1498	123	127	127	128	1.47	1.52	1.52	1.53	9801	1000
2048	2028	93	94	94	95	1.51	1.53	1.53	1.54	12891	1164

Release 3.0

One way traffic generated by W&G DA30

Table 14. 16M Token Ring SRB (remote) LAN to LAN via T1

		Frames/Sec (FPS)				*Megabits/Sec (Mbps)*				*Latency (usec.)*	
Frame Size	WAN Size	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Total Delay	Box Latency
52	62	2232	2546	2064	3096	1.10	1.26	1.02	1.53	1646	739
64	74	2231	2389	1988	2594	1.34	1.41	1.18	1.53	1624	698
128	138	1301	1374	1374	1391	1.44	1.52	1.52	1.53	2007	722
256	266	709	719	718	732	1.51	1.53	1.53	1.53	2607	621
512	522	362	366	366	371	1.51	1.53	1.53	1.53	4120	711
1024	1034	185	185	185	186	1.52	1.52	1.52	1.53	7122	879
1518	1528	123	125	125	125	1.53	1.53	1.53	1.53	10000	1031
2048	2058	93	93	92	93	1.53	1.53	1.51	1.53	13147	1225

Release 3.0

One way traffic generated by W&G DA30

Table 15. 16M Token Ring IPX (remote) LAN to LAN via T1

		Frames/Sec (FPS)				*Megabits/Sec (Mbps)*				*Latency (usec.)*	
Frame Size	WAN Size	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Total Delay	Box Latency
52	32	2603	2736	2731	5818	0.67	0.70	0.70	1.49	1422	627
64	44	2603	2714	2710	4267	0.91	0.95	0.95	1.50	1426	598
128	108	1562	1644	1644	1761	1.35	1.42	1.42	1.50	1860	648
256	236	780	785	785	810	1.47	1.48	1.48	1.53	2422	597
512	492	371	383	383	389	1.46	1.51	1.51	1.53	3972	705
1024	1004	185	189	189	191	1.49	1.52	1.52	1.53	7039	905
1518	1498	123	127	127	128	1.47	1.52	1.52	1.53	9903	1051
2048	2028	93	93	93	95	1.51	1.51	1.51	1.54	13013	1225

Release 3.0

One way traffic generated by W&G DA30

Table 16. 16M Token Ring DECnet (remote) LAN to LAN via T1

		Frames/Sec (FPS)				*Megabits/Sec (Mbps)*				*Latency (usec.)*	
Frame Size	WAN Size	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Total Delay	Box Latency
52	32	1562	1562	1143	5818	0.40	0.40	0.30	1.49	2011	922
64	44	1562	1562	1089	4267	0.55	0.55	0.38	1.50	1989	880
128	108	1562	1562	955	1761	1.35	1.35	0.83	1.50	2410	923
256	236	781	805	805	810	1.47	1.52	1.52	1.53	3075	923
512	492	389	389	388	389	1.53	1.53	1.53	1.53	4676	1056
1024	1004	186	190	190	191	1.49	1.53	1.53	1.53	7660	1215
1518	1498	125	128	128	128	1.52	1.53	1.53	1.53	10620	1409

Release 3.0

One way traffic generated by W&G DA30

Table 17. 16M Token Ring AppleTalk (remote) LAN to LAN via T1

		Frames/Sec (FPS)				*Megabits/Sec (Mbps)*				*Latency (usec.)*	
Frame Size	WAN Size	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Total Delay	Box Latency
52	32	1420	1613	1417	5818	0.36	0.41	0.36	1.49		
64	44	1562	1574	1384	4267	0.55	0.55	0.49	1.50		
256	236	780	803	803	810	1.47	1.52	1.52	1.53		
512	492	389	389	387	389	1.53	1.53	1.52	1.53		

Release 3.0

One way traffic generated by W&G DA30

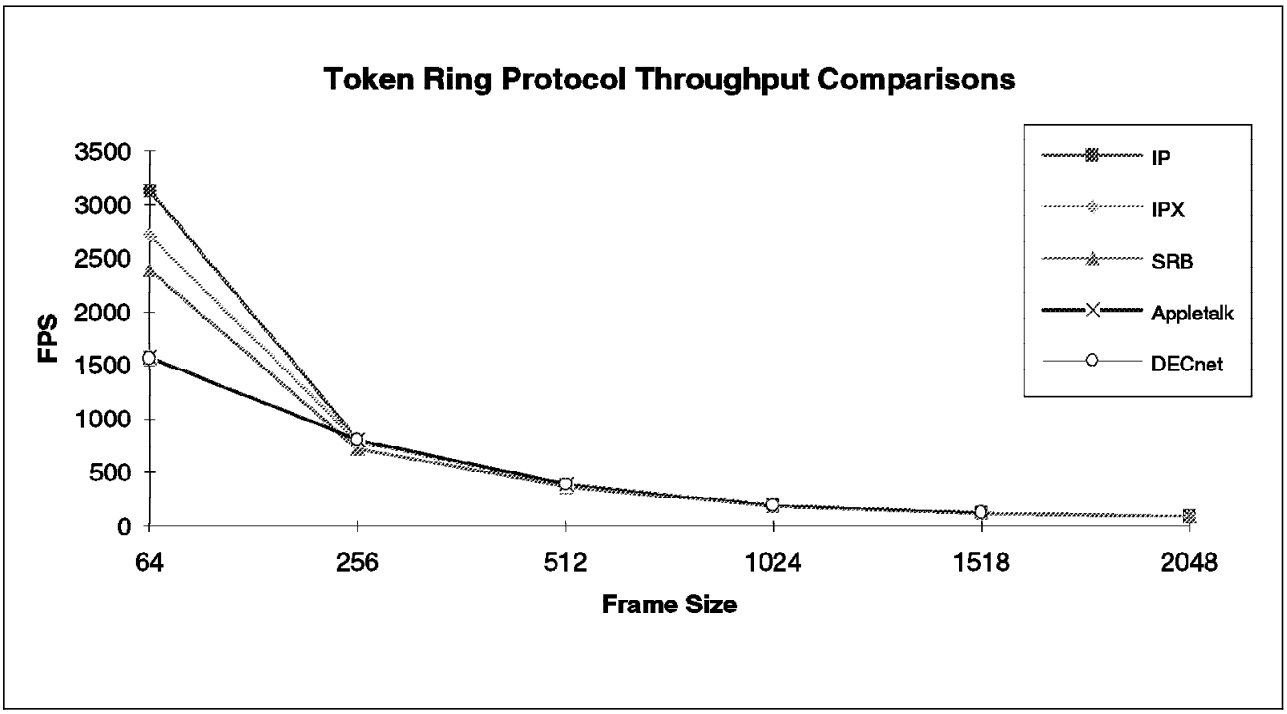


Figure 2. IBM 2210 Nways Multiprotocol Router Model 12T Token Ring Protocol Throughput Comparison

The data in the previous tables shows that Token Ring IP, SRB, IPX, and AppleTalk reach media speeds for frame sizes larger than 256 bytes.

The 2210 provides multi-interface serial ports which can support any of the following interfaces on any port, including a mix of different interfaces and speeds per box:

- CCITT V.35 -- at speeds from 9600 bps to 2.048 Mbps.
- CCITT V.36 -- at speeds from 9600 bps to 2.048 Mbps.
- EIA 232/CCITT V.24 -- at speeds from 4800 bps to 19.2 Kbps.
- CCITT X.21 -- at speeds from 2400 bps to 2.048 Mbps.

The serial adapter ports have been successfully clocked (external clocking) at speeds up to 12 Mbps for use with an inverse multiplexer.

Each serial port supports full duplex (FDX) data flow, therefore the full capacity of the WAN is twice the rated speed. A FDX T1 (1.536 Mbps) has a total throughput capacity of 3.072 Mbps.

Determining performance across the WAN is a little more complicated than LAN-LAN configurations. The frame sizes across the WAN are different than the LAN input frames, and the sizes differ depending on the LAN type, Token Ring or Ethernet, and the protocol.

As the above tables show the 2210 provides very efficient utilization of T1 links.

The DELAY column in the tables show two values. The total delay includes the latency through both 2210s plus the WAN media transfer time. The box latency shows the calculated latency for a single 2210. It is calculated by subtracting the media transfer time and dividing the remaining latency in half.

The size of the frame on the WAN varies from the LAN input depending on whether the protocol is routed or bridged and the presence or absence of SNAP headers. The length of the RI field may also vary depending on the number of hops on SRB.

3.3 Results for 24x and 14T Models (68040 processor)

This section contains performance data for the new 14T, 24T, 24E, and 24M models of the 2210. These models are based on a Motorola 68040 processor which is faster than the 68360 used in the smaller 12x models.

3.3.1 Ethernet Capacity (Model 24E)

The Ethernet measurements are for the routed protocols (IP, IPX, DECnet, and AppleTalk) and transparent bridging. Detailed results for Version 1 Release 3.0 are shown in the tables below.

Table 18. Ethernet IP (local) Port-to-Port

	Frames/Sec (FPS)				*Megabits/Sec (Mbps)*				*Latency (usec.)*	*Back to*
Frame Size	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.	Back frames
64	14730	14745	14745	14880	7.54	7.55	7.55	7.62	102	>448
128	8390	8415	8415	8445	8.59	8.62	8.62	8.65	0	>224
256	4514	4524	4524	4528	9.24	9.27	9.27	9.27	79	>112
512	2348	2348	2348	2349	9.62	9.62	9.62	9.62	100	>56
1024	1197	1197	1197	1197	9.81	9.81	9.81	9.81	172	>28
1518	810	810	810	812	9.84	9.84	9.84	9.86	173	>19

Release 3.0

One way traffic generated by W&G DA30

Table 19. Ethernet IPX (local) Port-to-Port

	Frames/Sec (FPS)				*Megabits/Sec (Mbps)*				*Latency (usec.)*	*Back to*
Frame Size	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.	Back frames
64	13331	13397	13357	14880	6.83	6.86	6.84	7.62	95	64
128	8385	8433	8433	8445	8.56	8.64	8.64	8.65	50	>224
256	4524	4524	4524	4528	9.27	9.27	9.27	9.27	79	>112
512	2343	2343	2343	2349	9.60	9.60	9.60	9.62	152	>56
1024	1197	1197	1197	1197	9.81	9.81	9.81	9.81	249	>28
1518	812	812	812	812	9.86	9.86	9.86	9.86	262	>19

Release 3.0

One way traffic generated by W&G DA30

Table 20. Ethernet DECnet (local) Port-to-Port

	Frames/Sec (FPS)				*Megabits/Sec (Mbps)*				*Latency (usec.)*	*Back to*
Frame Size	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.	Back frames
64	8893	9631	6316	14880	4.55	4.93	3.23	7.62	262	32
128	8442	8442	8442	8445	8.64	8.64	8.64	8.65	69	>224
256	4524	4524	4524	4528	9.27	9.27	9.27	9.27	181	64
512	2345	2345	2345	2349	9.61	9.61	9.61	9.62	196	>56
1024	1195	1195	1195	1197	9.79	9.79	9.79	9.81	255	>28
1518	812	812	812	812	9.86	9.86	9.86	9.86	390	>19

Release 3.0

One way traffic generated by W&G DA30

Table 21. Ethernet AppleTalk (local) Port-to-Port										
	Frames/Sec (FPS)				*Megabits/Sec (Mbps)*				*Latency (usec.)*	*Back to*
Frame Size	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.	Back frames
64	7778	8039	6644	14880	3.98	4.12	3.40	7.62	227	32
128	7600	7612	7588	8445	7.78	7.79	7.70	8.65	127	48
256	4514	4524	4524	4528	9.24	9.27	9.27	9.27		>112
512	2343	2343	2343	2349	9.60	9.60	9.60	9.62		>56
Release 3.0 One way traffic generated by W&G DA30										

Table 22. Ethernet Transparent Bridging (local) Port-to-Port										
	Frames/Sec (FPS)				*Megabits/Sec (Mbps)*				*Latency (usec.)*	*Back to*
Frame Size	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.	Back frames
64	14722	14737	14737	14880	7.54	7.54	7.54	7.62	25	>448
128	8385	8415	8415	8445	8.58	8.61	8.61	8.65	10	>224
256	4512	4524	4524	4528	9.24	9.27	9.27	9.27	72	>112
512	2345	2345	2345	2349	9.61	9.61	9.61	9.62	81	>56
1024	1192	1192	1192	1197	9.76	9.76	9.76	9.81	223	>28
1518	809	809	809	812	9.82	9.82	9.82	9.86	230	>19
Release 3.0 One way traffic generated by W&G DA30										

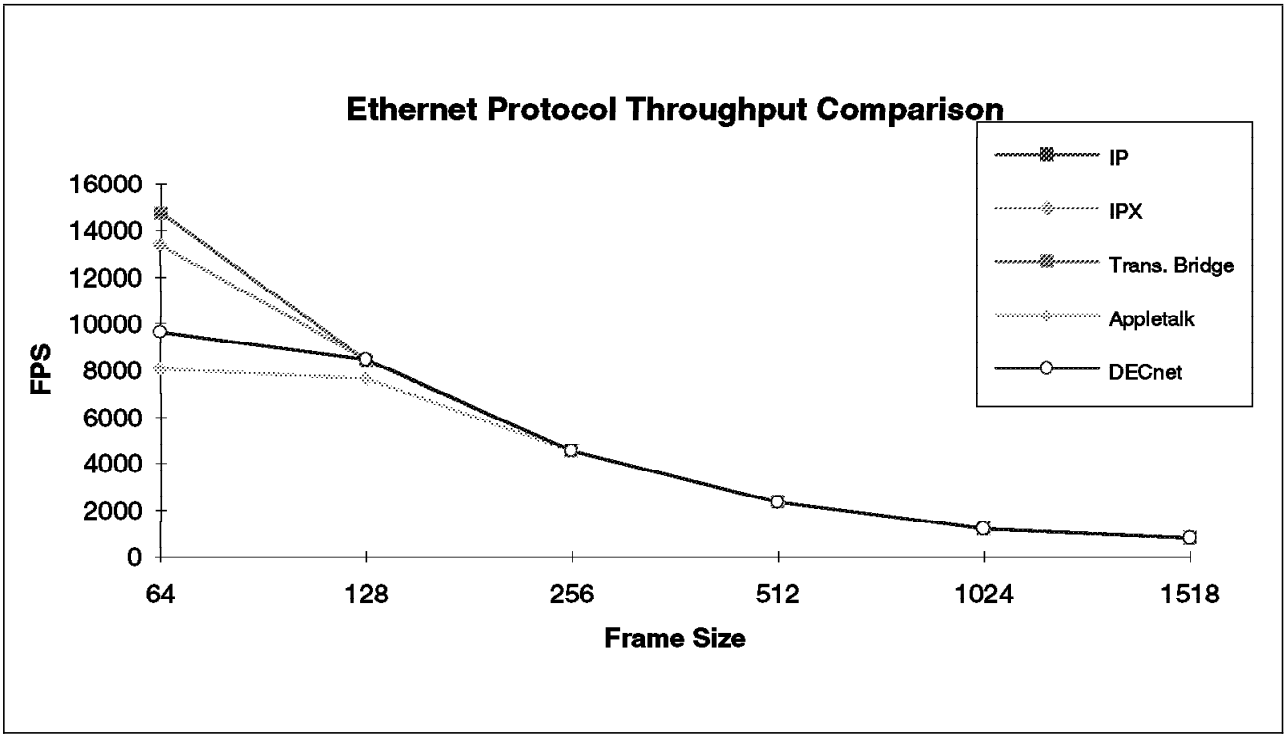


Figure 3. IBM 2210 Nways Multiprotocol Router Model 12E Ethernet Protocol Throughput Comparison

3.3.1.1 Ethernet IP Filtering

Setting IP filters has no affect on performance if there is a small number of stations on the network. This is because the most previous packets sent are cached. If there is no hit in the cache then the filter list is searched. However, setting access controls which are similar to filters does affect performance. Twenty-four exclude and one include access control were added to the configuration and the results are shown below. Access controls require additional processing by the router and therefore affect smaller packet sizes which have higher media speed frame rates.

Table 23. Ethernet IP Access Controls 25E + 1I (local) Port-to-Port

	Frames/Sec (FPS)				*Megabits/Sec (Mbps)*				*Latency (usec.)*	*Back to*
Frame Size	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.	Back frames
64	11132	11301	11279	14880	5.70	5.79	5.77	7.62		
128	8402	8442	8442	8445	8.60	8.64	8.64	8.65		
256	4524	4524	4524	4528	9.27	9.27	9.27	9.27		
512	2348	2348	2348	2349	9.62	9.62	9.62	9.62		
1024	1195	1195	1195	1197	9.79	9.79	9.79	9.81		
1518	812	812	812	812	9.86	9.86	9.86	9.86		

Release 3.0

One way traffic generated by W&G DA30

3.3.2 Token Ring Capacity (Model 24T)

The Token Ring measurements are divided into two categories, routed protocols and Source Route Bridging. The routed protocols tested were IP, IPX, DECnet and Appletalk. VINES throughput is not included at this time due to problems with the DA-30 test bed. VINES throughput should be consistent with the other protocols. Measurements of the routed protocols were made with all protocols configured except SRB. SRB measurements were made with all the protocols configured and the following SRB filters set to deny: IPX SAP=E0, DECnet SNAP=6003, Appletalk SNAP=809B. These filters prevent the routed protocols from being bridged. It was determined that there is little difference in performance based on the number of protocols configured.

Note: The maximum load (Max. Load) measurements may be misleading because the DA-30 tester cannot generate media speed packet rates for small frame sizes. In the following charts the packet rates used in determining Max. Load are not media speed. The DA-30 packet generation limits at various frame sizes are contained in Appendix A. The 2210 throughput numbers which are limited by the DA-30 capacity are indicated with a "+".

The following tables show the Token Ring performance for all protocols for the 2210 Model 24T.

Table 24. 16M Token Ring IP (local) Port-to-Port

	Frames/Sec (FPS)				*Megabits/Sec (Mbps)*				*Latency (usec.)*
Frame Size	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.
52	6998+	6998+	6998+	35088	2.91+	2.91+	2.91+	14.60	354
64	6339+	6339+	6339+	28986	3.25+	3.25+	3.25+	14.84	261
128	5213+	5213+	5213+	15038	5.34+	5.34+	5.34+	15.40	349
256	4462+	4462+	4462+	7663	9.14+	9.14+	9.14+	15.69	425
512	3124+	3124+	3124+	3868	12.80+	12.80+	12.80+	15.85	555
1024	1823+	1823+	1823+	1944	14.93+	14.93+	14.93+	15.92	825
1518	1257+	1257+	1257+	1313	15.27+	15.27+	15.27+	15.95	1154
2048	943+	943+	943+	974	15.45+	15.45+	15.45+	15.96	1416
3960	496+	496+	496+	504	15.71+	15.71+	15.71+	15.98	2492

Release 3.0

One way traffic generated by W&G DA30

Table 25. 16M Token Ring SRB (local) Port-to-Port

	Frames/Sec (FPS)				*Megabits/Sec (Mbps)*				*Latency (usec.)*
Frame Size	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.
52	5205	5595	5595	35088	2.16	2.32	2.32	14.60	411
64	5205	5422	5422	28986	2.66	2.78	2.78	14.84	300
128	3852	4818	4811	15038	3.94	4.93	4.92	15.40	349
256	3123	3869	3869	7663	6.40	7.92	7.92	15.69	406
512	2602	2663	2659	3868	10.65	10.90	10.89	15.85	612
1024	1420	1567	1566	1944	11.63	12.84	12.82	15.92	889
1518	1041	1163	1163	1313	12.64	14.12	14.12	15.95	1180
2048	867	886	886	974	14.20	14.51	14.51	15.96	1441
3960	471	471	471	504	14.92	14.92	14.92	15.98	2499

Release 3.0

One way traffic generated by W&G DA30

Table 26. 16M Token Ring IPX (local) Port-to-Port

	Frames/Sec (FPS)				*Megabits/Sec (Mbps)*				*Latency (usec.)*
Frame Size	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.
52	6997+	6997+	6997+	35088	2.91+	2.91+	2.91+	14.60	418
64	6351+	6351+	6351+	28986	3.25+	3.25+	3.25+	14.84	319
128	5212+	5212+	5212+	15038	5.34+	5.34+	5.34+	15.40	407
256	4461+	4461+	4461+	7663	9.14+	9.14+	9.14+	15.69	483
512	3124+	3124+	3124+	3868	12.80+	12.80+	12.80+	15.85	600
1024	1822+	1822+	1822+	1944	14.92+	14.92+	14.92+	15.92	844
1518	1257+	1257+	1257+	1313	15.27+	15.27+	15.27+	15.95	1199
2048	943+	943+	943+	974	15.45+	15.45+	15.45+	15.96	1461
3960	496+	496+	496+	504	15.71+	15.71+	15.71+	15.98	2537

Release 3.0

One way traffic generated by W&G DA30

Table 27. 16M Token Ring DECnet (local) Port-to-Port

	Frames/Sec (FPS)				*Megabits/Sec (Mbps)*				*Latency (usec.)*
Frame Size	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.
52	5205	5432	5432	35088	2.16	2.26	2.26	14.60	610
64	5205	5364	5364	28986	2.66	2.78	2.78	14.84	530
128	3852	4832	4825	15038	3.94	4.95	4.94	15.40	554
256	3123	4011	4011	7663	6.40	8.21	8.21	15.69	598
512	2838	2995	2995	3868	11.62	12.27	12.27	15.85	792
1024	1823+	1823+	1823+	1944	14.93+	14.93+	14.93+	15.92	940
1518	1256+	1256+	1256+	1313	15.25+	15.25+	15.25+	15.95	1378

Release 3.0

One way traffic generated by W&G DA30

Table 28. 16M Token Ring AppleTalk (local) Port-to-Port

	Frames/Sec (FPS)				*Megabits/Sec (Mbps)*				*Latency (usec.)*
Frame Size	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.
52	7000+	7000+	7000+	35088	2.91+	2.91+	2.91+	14.60	379
64	6341+	6341+	6341+	28986	3.25+	3.25+	3.25+	14.84	300
256	4462+	4462+	4462+	7663	9.14+	9.14+	9.14+	15.69	
512	3123+	3123+	3123+	3868	12.79+	12.79+	12.79+	15.85	

Release 3.0

One way traffic generated by W&G DA30

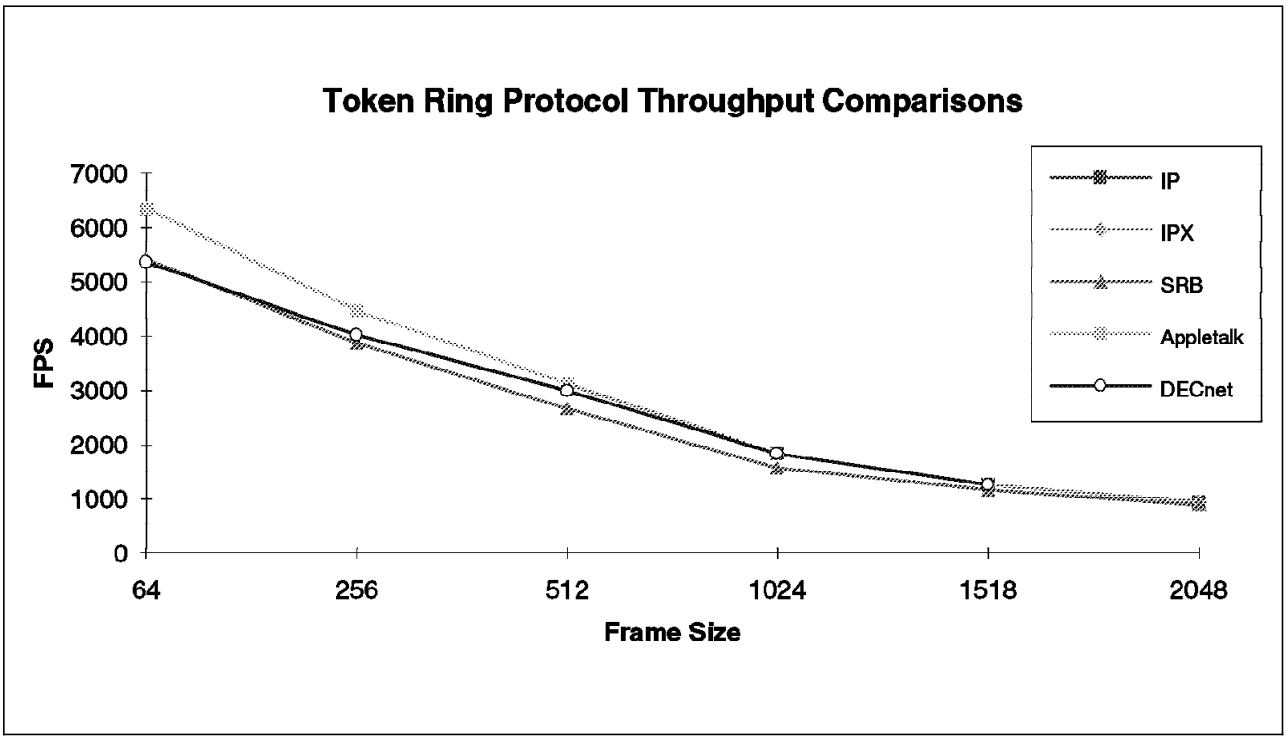


Figure 4. IBM 2210 Nways Multiprotocol Router Model 24T Token Ring Protocol Throughput Comparison

The data in the previous tables shows that Token Ring IP, SRB, IPX, and AppleTalk reach media speeds for frame sizes larger than 512 bytes.

3.3.3 Ethernet Remote Capacity (Models 24E and 24M)

The Ethernet measurements are for the routed protocols and transparent bridging. Detailed results of all protocols for Version 1 Release 3.0 are shown in the tables below.

Table 29. Ethernet IP (remote) LAN to LAN via T1

		Frames/Sec (FPS)				*Megabits/Sec (Mbps)*				*Delay (usec.)*	
Frame Size	WAN size	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Total Delay	Box Delay
64	52	3532	3532	3529	3623	1.47	1.47	1.47	1.51	895	312
128	116	1625	1625	1621	1641	1.51	1.51	1.51	1.52	1125	260
256	244	770	783	778	784	1.50	1.53	1.52	1.53	1909	320
512	500	378	381	381	383	1.51	1.52	1.52	1.53	3268	332
1024	1012	187	188	188	190	1.51	1.52	1.52	1.53	6079	404
1518	1506	127	127	127	127	1.53	1.53	1.53	1.53	8595	751

Release 3.0

One way traffic generated by W&G DA30

Table 30. Ethernet IPX (remote) LAN to LAN via T1

		Frames/Sec (FPS)				*Megabits/Sec (Mbps)*				*Delay (usec.)*	
Frame Size	WAN size	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Total Delay	Box Delay
64	52	3507	3514	3514	3623	1.46	1.46	1.46	1.51	857	293
128	116	1612	1616	1616	1641	1.50	1.50	1.50	1.52	1144	514
256	244	770	776	776	784	1.50	1.51	1.51	1.53	1877	304
512	500	378	380	380	383	1.51	1.52	1.52	1.53	3288	342
1024	1012	186	188	188	190	1.51	1.52	1.52	1.53	6034	382
1518	1506	127	127	126	127	1.53	1.53	1.52	1.53	8621	389

Release 3.0

One way traffic generated by W&G DA30

Table 31. Ethernet DECnet (remote) LAN to LAN via T1

		Frames/Sec (FPS)				*Megabits/Sec (Mbps)*				*Delay (usec.)*	
Frame Size	WAN size	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Total Delay	Box Delay
64	52	3608	3608	3604	3623	1.50	1.50	1.50	1.51		
128	116	1634	1635	1635	1641	1.52	1.52	1.52	1.52		
256	244	783	783	781	784	1.53	1.53	1.52	1.53		
512	500	378	381	381	383	1.51	1.52	1.52	1.53		
1024	1012	187	188	188	190	1.51	1.52	1.52	1.53		
1518	1506	127	127	126	127	1.53	1.53	1.52	1.53		

Release 3.0

One way traffic generated by W&G DA30

Table 32. Ethernet AppleTalk (remote) LAN to LAN via T1

		Frames/Sec (FPS)				*Megabits/Sec (Mbps)*				*Delay (usec.)*	
Frame Size	WAN size	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Total Delay	Box Delay
64	52	3623	3623	3623	3623	1.51	1.51	1.51	1.51		
128	116	1641	1641	1641	1641	1.52	1.52	1.52	1.52	1234	315
256	244	784	784	784	784	1.53	1.53	1.53	1.53	1948	339
512	500	383	383	383	383	1.53	1.53	1.53	1.53	3320	358

Release 3.0

One way traffic generated by W&G DA30

Table 33. Ethernet Transparent Bridging (remote) LAN to LAN via T1											
		Frames/Sec (FPS)				*Megabits/Sec (Mbps)*				*Delay (usec.)*	
Frame Size	WAN size	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Total Delay	Box Delay
64	74	2569	2569	2567	2594	1.52	1.52	1.52	1.53	1068	399
128	138	1382	1384	1384	1391	1.53	1.53	1.53	1.53	1701	548
256	266	721	721	719	721	1.53	1.53	1.53	1.53	2120	425
512	522	366	366	366	367	1.53	1.53	1.53	1.53	3531	464
1024	1034	185	185	184	185	1.53	1.53	1.52	1.53	6284	507
1518	1528	125	125	125	125	1.53	1.53	1.53	1.53	9158	657
Release 3.0 One way traffic generated by W&G DA30											

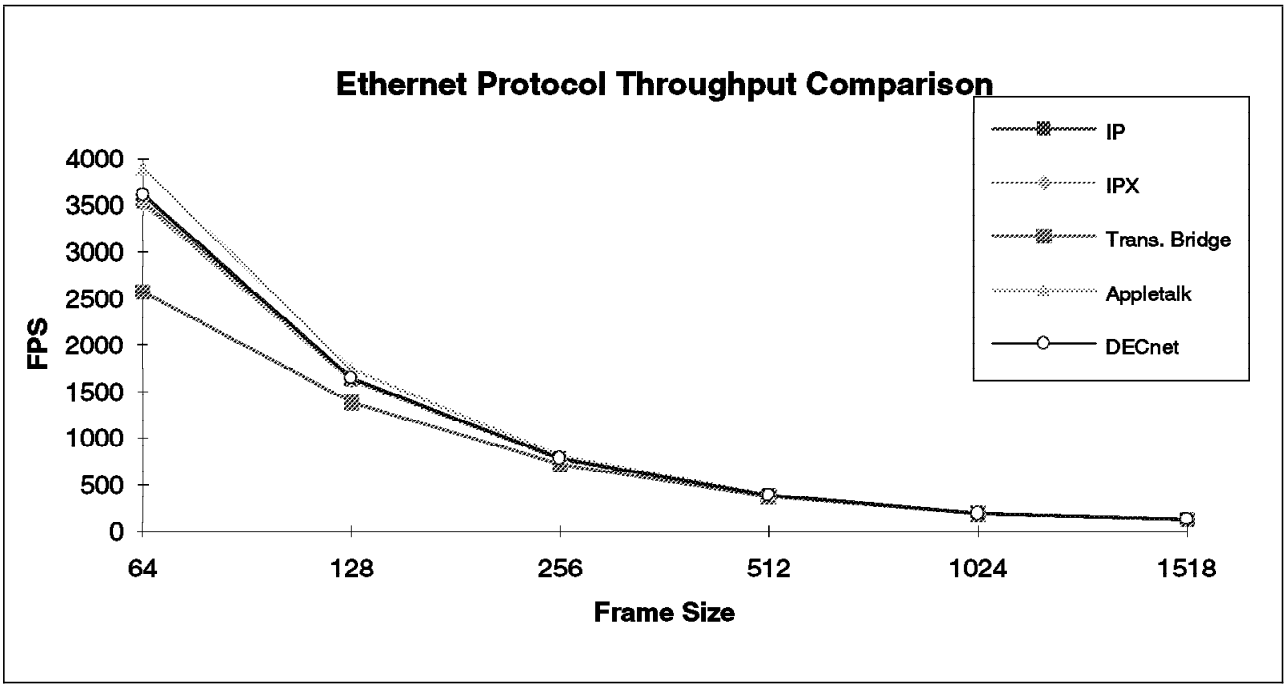


Figure 5. IBM 2210 Nways Multiprotocol Router Model 24E Ethernet Remote - Throughput Comparison

As the data shows, all the routed protocols approach media speed for 128 byte frames. All the protocols handle large frames with virtually no loss providing efficient file transfer capabilities.

3.3.4 Token Ring Remote Capacity (Models 14T, 24T, and 24M)

The Token Ring measurements are divided into two categories, routed protocols and Source Route Bridging. The routed protocols tested were IP, IPX, DECnet, and Appletalk. VINES throughput is not included at this time due to problems with the DA-30 test bed. VINES throughput should be consistent with the other protocols. Measurements of the routed protocols were made with all protocols configured except SRB. SRB measurements were made with all the protocols configured and the following SRB filters set to deny: IPX SAP=E0, DECnet SNAP=6003, Appletalk SNAP=809B. These filters prevent the routed protocols from being bridged. It was determined that there is little difference in performance based on the number of protocols configured.

Table 34. 16M Token Ring IP (remote) LAN to LAN via T1

		Frames/Sec (FPS)				*Megabits/Sec (Mbps)*				*Latency (usec.)*	
Frame Size	WAN Size	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Total Delay	Box Latency
52	32	5205+	5205+	5205+	5818	1.33+	1.33+	1.33+	1.49	1128	480
64	44	3903	4134	4134	4267	1.37	1.46	1.46	1.50	1100	435
128	108	1735	1735	1735	1761	1.50	1.50	1.50	1.52	1482	460
256	236	781	804	804	810	1.47	1.51	1.51	1.53	2236	504
512	492	389	389	388	389	1.53	1.53	1.53	1.53	3704	550
1024	1004	186	190	190	191	1.49	1.53	1.53	1.53	6758	765
1518	1498	125	128	128	128	1.50	1.53	1.53	1.53	9577	888
2048	2028	95	95	94	95	1.54	1.54	1.53	1.54	12622	1030

Release 3.0

One way traffic generated by W&G DA30

Table 35. 16M Token Ring SRB (remote) LAN to LAN via T1

		Frames/Sec (FPS)				*Megabits/Sec (Mbps)*				*Latency (usec.)*	
Frame Size	WAN Size	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Total Delay	Box Latency
52	62	2603	3071	3071	3303	1.29	1.52	1.52	1.53	1256	544
64	74	2231	2585	2585	2594	1.32	1.53	1.53	1.53	1234	503
128	138	1301	1384	1384	1391	1.44	1.53	1.53	1.53	1623	530
256	266	710	720	720	721	1.51	1.53	1.53	1.53	2377	574
512	522	367	367	367	367	1.53	1.53	1.53	1.53	3832	634
1024	1034	186	186	185	186	1.53	1.53	1.53	1.53	6930	851
1518	1528	125	125	125	125	1.53	1.53	1.53	1.53	9743	970
2048	2058	93	93	93	93	1.53	1.53	1.53	1.53	12750	1093

Release 3.0

One way traffic generated by W&G DA30

Table 36. 16M Token Ring IPX (remote) LAN to LAN via T1

		Frames/Sec (FPS)				*Megabits/Sec (Mbps)*				*Latency (usec.)*	
Frame Size	WAN Size	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Total Delay	Box Latency
52	32	3903	4828	4828	5818	1.00	1.23	1.23	1.49	1115	474
64	44	3123	3719	3718	4267	1.10	1.31	1.31	1.50	1125	448
128	108	1562	1655	1654	1761	1.35	1.43	1.43	1.50	1476	456
256	236	781	786	786	810	1.47	1.48	1.48	1.53	2262	516
512	492	381	383	383	389	1.50	1.51	1.51	1.53	3748	592
1024	1004	186	189	189	191	1.49	1.52	1.52	1.53	6866	818
1518	1498	125	127	127	128	1.50	1.52	1.52	1.53	9609	903
2048	2028	95	95	94	95	1.54	1.54	1.53	1.54	12705	1071

Release 3.0

One way traffic generated by W&G DA30

Table 37. 16M Token Ring DECnet (remote) LAN to LAN via T1											
		Frames/Sec (FPS)				*Megabits/Sec (Mbps)*				*Latency (usec.)*	
Frame Size	WAN Size	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Total Delay	Box Latency
52	32	2603	2892	2891	5818	0.67	0.74	0.74	1.49	1365	599
64	44	2603	2836	2834	4267	0.92	1.00	1.00	1.50	1394	582
128	108	1735	1751	1751	1761	1.50	1.51	1.51	1.52	1745	591
256	236	781	808	808	810	1.47	1.53	1.53	1.53	2467	619
512	492	389	389	389	389	1.53	1.53	1.53	1.53	4017	727
1024	1004	186	190	190	191	1.49	1.53	1.53	1.53	6841	806
1518	1498	125	128	128	128	1.52	1.53	1.53	1.53	9871	1034
Release 3.0 One way traffic generated by W&G DA30											

Table 38. 16M Token Ring AppleTalk (remote) LAN to LAN via T1											
		Frames/Sec (FPS)				*Megabits/Sec (Mbps)*				*Latency (usec.)*	
Frame Size	WAN Size	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Rated Tput.	Max. Tput.	Max. Load	Media Speed	Total Delay	Box Latency
52	32	5205	5205	5205	5818	1.33	1.33	1.33	1.49		
64	44	3903	4150	4150	4267	1.37	1.46	1.46	1.50		
256	236	781	800	800	810	1.47	1.51	1.51	1.53		
512	492	372	387	387	389	1.46	1.52	1.52	1.53		
Release 3.0 One way traffic generated by W&G DA30											

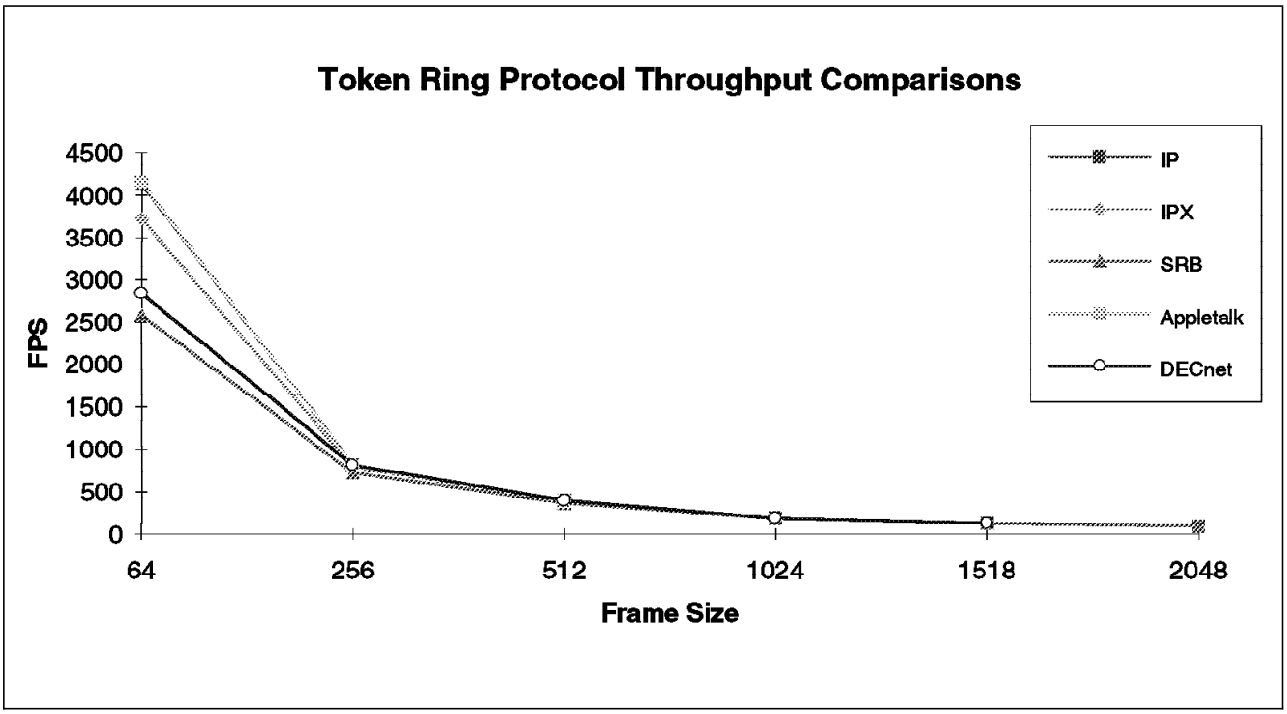


Figure 6. IBM 2210 Nways Multiprotocol Router Model 24T Token Ring Remote - Throughput Comparison

The data in the previous tables shows that Token Ring IP, SRB, IPX, and AppleTalk reach media speeds for frame sizes larger than 256 bytes.

The 2210 provides multi-interface serial ports which can support any of the following interfaces on any port, including a mix of different interfaces and speeds per box:

- CCITT V.35 -- at speeds from 9600 bps to 2.048 Mbps.
- CCITT V.36 -- at speeds from 9600 bps to 2.048 Mbps.
- EIA 232/CCITT V.24 -- at speeds from 4800 bps to 19.2 Kbps.
- CCITT X.21 -- at speeds from 2400 bps to 2.048 Mbps.

The serial adapter ports have been successfully clocked (external clocking) at speeds up to 12 Mbps for use with an inverse multiplexer.

Each serial port supports full duplex (FDX) data flow, therefore the full capacity of the WAN is twice the rated speed. A FDX T1 (1.536 Mbps) has a total throughput capacity of 3.072 Mbps.

Determining performance across the WAN is a little more complicated than LAN-LAN configurations. The frame sizes across the WAN are different than the LAN input frames, and the sizes differ depending on the LAN type, Token Ring or Ethernet, and the protocol.

As the above tables show the 2210 provides very efficient utilization of T1 links.

The DELAY column in the tables show two values. The total delay includes the latency through both 2210s plus the WAN media transfer time. The box latency shows the calculated latency for a single 2210. It is calculated by subtracting the media transfer time and dividing the remaining latency in half.

The size of the frame on the WAN varies from the LAN input depending on whether the protocol is routed or bridged and the presence or absence of SNAP headers. The length of the RI field may also vary depending on the number of hops on SRB.

4.0 Box Throughput Capacity Measurements

Box capacity is a measure of the routers ability to handle multiple cards and ports concurrently. It is intended to address the question what is the maximum capacity of the router. The answer to the question is highly dependent on the physical configuration, logical network configuration and traffic characteristics.

There are two box capacity limits that should be considered.

1. What is the maximum number of small frames that can be supported.
2. What is the maximum data throughput for large frames in Megabits per second (Mbps.)

With 2210 Release 3.0 code the Model 12x supports approximately 4,000pps for 64 byte frames and the Models 14T and 24x support approximately 15,000pps. These numbers were obtained by utilizing three DA-30 protocol analyzers to generate sufficient traffic to load all LAN and WAN ports on the router under test. For large frames 24x models are capable of transfering 21 Megabits per second (Mpbs) of data.

5.0 Data Link Switching Benchmark Tests

The key purpose of these measurements is to identify the throughput capabilities of the 2210 Data Link Switching (DLSw) function as well as its latency characteristics. It is also important to be able to relate those characteristics to other network alternatives. The results are most significant when they can be compared in an apples-to-apples comparison of various alternatives to attaching SNA devices. These measurements attempt to make the comparisons of the following configurations:

- Remote bridging (SRB on Token Ring)
- Data Link Switching (DLSw) across a WAN.

For these tests the configuration is defined as SNA traffic originating on a LAN, flowing into a 2210 across a WAN to another 2210 onto a LAN to a host which will echo a response (see Figure 8 on page 44). For the initial comparison the WAN is assumed to provide sufficient bandwidth and not be the limiting performance factor (T1 1.536Mb/sec.). Measurements with narrower bandwidths will also be made to compare how efficiently the WAN is utilized and congestion controlled

Because of the way DLSw works, Frames per Second (FPS) is not the most appropriate measure of performance. Results will be measured in total usable bandwidth of the router to handle DLSw user data traffic (Mbps.) and Transactions per second. (Trans./Sec.). User Data traffic is defined as only the RU data portion of SNA PIUs which contain User data (TH+RH+RU data). Refer to 5.2.1.1, HFrame Sizes and Format< on page 45 for a complete description of frame sizes and formats. Transactions typically consist of 2 data frames, a request and a response, and 2 Receiver Ready (RR) frames, for a total of four frames.

Since the WANs are Full Duplex (FDX) the throughput reported will be the aggregate total throughput in both directions. A T1 (1.536 Mbps) WAN has a total capacity of 3.072 Mbps.

Latency is also difficult to measure for DLSw because of the TCP/IP encapsulation and buffering. End user response time is a better measurement. The effects of the routers can be determined by examining the differences in end user response times for DLSw and a base measurement.

The following results apply to the models 121 and 123 using IBM Nways Multiprotocol Routing Network Services (MRNS) Version 1 Release 3.0 unless specifically identified as an earlier release or different model.

When to Bridge, When to DLSw ...

The question is often asked; ***"When should I use bridging and when should I use Data Link Switching (DLSw)".*** As you might expect, the answer is not as simple as the question. It will depend on many factors in your network design, including from a performance standpoint the throughput characteristics and response time criteria you need to achieve.

To start with it should be helpful to review the characteristics of DLSw and bridging and their advantages and disadvantages. Since DLSw was conceived to address some problems with bridging, let's start with bridging.

Bridging in a router network

Bridging provides all protocols, including SNA and NETBIOS, equal transport function by building one large flat LAN over WAN links. Bridges are transparent to the end stations. The protocols in the end stations must provide guaranteed data delivery, as well as congestion and flow control. Bridges do not provide dynamic re-routing in the WAN or LAN traffic isolation. Since end stations expect data to be transported on a high speed LAN, SNA and NETBIOS sessions may time out due the delays introduced by the

slower speed WANS. Bridging through the WANs may not provide sufficient control functions, such as priority, needed to transport the data in a multi-protocol internetwork.

- 2210 Bridging advantages
  - High throughput - 2600 FPS, enough to fill a full duplex T1 WAN with 128 byte frames.
  - Low latency - 600 usec. End user response times across a T1 WAN of less than .03 second for 1K byte or smaller transactions at low traffic rates.
- 2210 Bridging disadvantages
  - No Congestion control - Lost sessions on Slower speed WANS.
  - No Dynamic rerouting

Data Link Switching (DLSw) in a router network

The primary function of DLSw is to maintain the integrity of SNA sessions across low speed WANs. It accomplishes this by providing congestion control and minimizing the amount of data that has to flow across the WAN. DLSw terminates the LLC at the edge routers masquerading as the destination end station. This ensures local media response speeds to acknowledge layer 2 timers. It also provides the opportunity to perform active congestion control with the end stations using the LLC dialog. In addition it reduces the WAN bandwidth requirements for the LLC overhead. DLSw terminates the Source Route Bridging routing information (RI) at the edge routers. This extends the seven hop limit and eliminates the need to pass the RI information across the WAN. DLSw also supports SDLC links by providing the polling at the edge routers and conversion to LLC2, again reducing overhead traffic on the WANs. Broadcasting of search frames throughout the network is reduced by DLSw's caching and filtering capabilities. DLSw uses TCP encapsulation to supply dynamic reliable transport through the network. DLSw does dynamic buffering at the TCP layer to minimize the number of frames on the WAN and reduce the amount of frame overhead.

- 2210 DLSw advantages
  - Session Protection
    - Elimination of LLC2 timeouts and session termination.
  - Efficient WAN Utilization
    - Elimination of LLC2 traffic across the WAN
    - Reduction of broadcast traffic
    - TCP buffering - blocking of multiple DLSw frames into one TCP frame.
  - Congestion and flow control
    - 2210 to end station (LLC2 busy - Receiver Not Ready)
    - DLSw to DLSw flow control
    - TCP flow control - dynamic windowing algorithm
  - Dynamic rerouting via IP and OSPF
  - Reliable transport across WAN via TCP
  - Prioritization of traffic
  - Extension of SRB "hop" count by terminating bridge at edge router.
- 2210 DLSw disadvantages
  - Lower throughput - 750 FPS (frames per second) including LLC2 frames (e.g. Receiver Ready). 750 FPS is approx. 375 echo transactions/second.
  - Longer latency - The data flow and the TCP buffering increases the latency through the router.

Which one to use?

The following recommendations are based primarily on the performance considerations.

- Use bridging if:

  - High throughput is required which exceeds DLSw capacity.
  - WAN bandwidth has excess capacity.
  - Small number of concurrent connections and sessions.

- Use DLSw if:
  - WANs are lower speed and subject to periodic congestion.
  - The WANs will be carrying multiple protocols and WAN congestion requires some level of prioritization.
  - Large number of concurrent connections and sessions share the WAN.
  - Broadcast traffic is congesting WAN

The TCP buffering scheme works well for maximizing WAN utilization and DLSw throughput under heavy traffic.

5.1 DLSw Benchmark Configuration

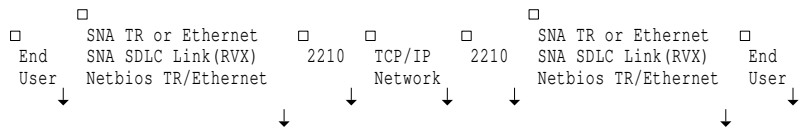


Figure 7. DLSw Supported Configurations

DLSw supports SNA end users on Token Ring, Ethernet, or SNA SDLC serial links, and Netbios end user on Token Ring or Ethernet. The primary focus of these measurements will address SNA 3270 end users on Token Ring environments. The following are the primary test configurations.

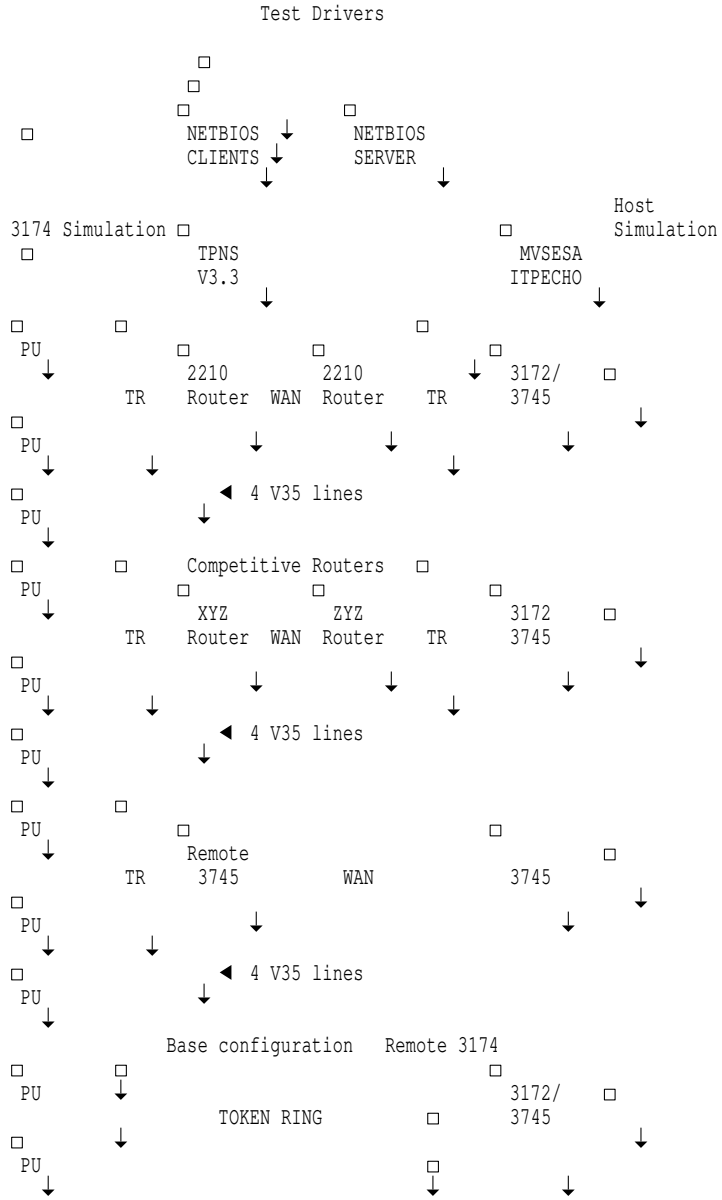


Figure 8. DLSw Test Configurations

5.2 DLSw Token Ring SNA Tests

This section covers the tests and results of token ring attached SNA users.

5.2.1 DLSw SNA Test Environment

Two primary test configurations were used.

1. **Configuration 1** - A network of 4 simulated 3174s (PU2)
   on a 16M token Ring, each with 64 LUs attached, for a total of 256 LUs.
2. **Configuration 2** - A network of 255 simulated PU2s,
   each one with a single LU, representing a network of PCs running a 3270 emulation program.

The majority of the tests were run with configuration 2 which is more representative of the direction customer configurations are moving in. It also better demonstrates the 2210's capability to handle a larger number of link stations.

TPNS V3R3 was used to simulate interactive 3270 traffic and measure response time. The echo program (ITPECHO) supplied with TPNS was used as the host application program. The transaction start times are randomized which causes some variability in the results. It is not unusually to observe variations of +/- 5% in the test results.

5.2.1.1 Frame Sizes and Format

The message lengths used throughout this section are the user data length only. The following table define the actual number of bytes which are transmitted on the input LAN and interconnecting WANs. (Note: additional interframe gaps may exist on the WANs depending on physical configuration/hardware).

Table 39. Frame Content and Overhead

	LAN IN	*LAN OUT*	*WAN IN*	*WAN OUT*	*COMMENTS*
Media Overhead	3	3	2	2	SD, ED, FS
MAC Frame Overhead	28	28			
-MAC HDR	18	18			HDR + FCS
-LLC	4	4			
-RI	6	6			4+2*hops
Protocol Overhead	9	9	69	69	
-PPP/Frame Relay			4	4	
-IP HDR			20	20	
-TCP HDR			20	20	Note (1)
-DLSw HDR			16	16	per SNA PIU
SNA HDR	9	9	9	9	TH + RH
3270 Overhead	3	19	3	19	
Total Overhead	43	59	74	90	

Note: (1) Multiple SNA PIUs can be encapsulated in 1 TCP/IP frame.

The following table illustrates the actual length of the frames transmitted across the Token Ring and WAN.

Table 40. Frame Lengths			
User Data **IN/OUT**	***SNA PIU*** **IN/OUT**	***TR LAN*** **IN/OUT**	***T1 WAN(PPP)*** **IN/OUT**
100/100	112/128	143/159	174/190
40/1400	52/1428	83/1459	114/1490
Note: (1) WAN lengths assumes no TCP/IP buffering			

5.2.2 DLSw Token Ring SNA Results Summary

This section presents the detailed results of the DLSw Token Ring SNA measurements. The primary test scenario was an echo transaction consisting of sending 'n' bytes from a simulated 3270 to a host program which echoed back 'n' bytes (see Figure 8 on page 44). Each transaction consists of 2 data frames, a request and a response, and 2 Receiver Ready (RR) frames. ECHO transactions with from 100 bytes to 1988 bytes of user data were run (see 5.2.1.1, HFrame Sizes and Format< on page 45). Simulated 3270 inquiry transactions of 40 bytes in and 1400 bytes out were also run in both Exception Response (ER) mode and Definite Response (DR) mode.

For tests performed with a one-to-one LLC2 acknowledgement of each data frame the following throughputs were achieved for the Model 12T

- Using 4 DLSw Link Stations
  - 240 Transactions/Sec. at 100 byte transactions
  - 1.6 Megabits/Sec at 1988 byte transactions
- Using 255 DLSw Link Stations
  - 120 Transactions/Sec. at 100 byte transactions
  - 1.5 Megabits/Sec at 1988 byte transactions

The Model 14T or 24T showed the following results:

- Using 4 DLSw Link Stations
  - 375 Transactions/Sec. at 100 byte transactions
  - 2.5 Megabits/Sec at 1988 byte transactions
- Using 255 DLSw Link Stations
  - 330 Transactions/Sec. at 100 byte transactions
  - 2.5 Megabits/Sec at 1988 byte transactions

The Model 14T and 24T are significantly faster than the Model 12T for DLSw performance. This is because of the faster Motorola 68040 processor which is used in the new Release 3.0 hardware.

Note from the following tables that TPNS can be the limiting factor in some of the performance runs. If the SRB or DLSw run is approximately equal to the Base run then TPNS is the limiting factor not the router. This is the case for small data sizes for the Model 24T running Configuration 1.

5.2.2.1 DLSw Token Ring SNA Performance Tuning

The amount of memory available for each LLC or SDLC session can have an impact on performance. If there are multiple LUs per PU, then the memory allocated per PU (LLC) session may have to be increased to provide maximum performance. For example, if 1988 byte data frames are being used and MAXOUT=7, then 1988 x 7 = 13,916 bytes need to be allocated per session. The number of bytes allocated per LLC session can be changed on the 2210 by using the **set mem** from the **DLSw config>** prompt. For the performance runs in this section the memory allocated per LLC session was set above 20,000 bytes.

5.2.2.2 DLSw Token Ring SNA Results for configuration 1

The results are presented in comparison to a base run and a SRB run for the same traffic configurations.

The following test runs were used:

- **Base Run** - 4 simulated 3174s 16M Token Ring attached to 3172 host gateway.
- **SRB Run** -4 simulated 3174s 16M Token Ring attached through a network of 2 2210's connected via a T1 WAN to the 3172 host gateway.
- **DLSw Run** - Same configuration as SRB run except DLSw was used between the 2210's instead of SRB.

The response times and CPU utilizations are shown for a series of Traffic rates. The traffic rates are controlled by the TPNS UTI value. The UTI values selected represent the following DLSw Run Traffic rates.

- UTI=50 - Low traffic
- UTI=25 - Med traffic
- UTI=10 - High traffic
- UTI=5 - Maximum (Max.) traffic
- UTI=1 - Overload Traffic

The overload and maximum traffic conditions do not represent an environment where a customer should normally operate. The response times are not what a customer would typically expect or demand. These measurements are included to indicate how well the 2210 handles severe load conditions.

Not all UTI values were run for all transactions sizes. UTI values of 50 was not run for 100 and 200 byte transactions since they did not reveal any significant performance characteristics. UTI values of 5 and 1 were not run for transaction sizes above 1600 since the traffic rate at UTI of 10 already exceeded the capacity of the WAN and 2210.

Configuration 1. T1 (1.536 Mbps) Test Results										
Data Size	**Base Run**			**SRB Run**			**DLS_T1 Run**			
TPNS UTI value	Trans. /Sec.	Mbps. (SNA PIU)	Resp. Time (Sec.)	Trans. /Sec.	Mbps. (SNA PIU)	Resp. Time (Sec.)	Trans. /Sec.	Mbps. (SNA PIU)	Resp. Time (Sec.)	% CPU Util.
100/100										
UTI=25	39.5	0.070	0.01	39.5	0.070	0.01	39.4	0.070	0.02	
UTI=10	99.9	0.177	0.02	99.9	0.177	0.03	99.1	0.176	0.05	
UTI=5	196.0	0.348	0.03	195.0	0.346	0.04	184.6	0.328	0.07	
UTI=1	356.6	0.633	0.50	316.3	0.562	0.43	239.7	0.426	0.64	
200/200										
UTI=25	39.8	0.134	0.01	41.1	0.139	0.01	40.4	0.136	0.02	
UTI=10	99.6	0.336	0.02	99.1	0.335	0.03	99.5	0.336	0.05	
UTI=5	196.8	0.664	0.03	191.8	0.647	0.05	178.4	0.602	0.09	
UTI=1	302.6	1.021	0.62	269.8	0.911	0.56	197.5	0.667	0.87	
400/400										
UTI=50	20.1	0.132	0.01	20.4	0.134	0.01	20.2	0.133	0.01	
UTI=25	40.1	0.264	0.01	40.1	0.263	0.02	40.5	0.266	0.04	
UTI=10	100.6	0.661	0.03	98.3	0.646	0.04	98.0	0.645	0.06	
UTI=5	193.0	1.269	0.04	188.7	1.241	0.06	147.9	0.972	0.25	
800/800										
UTI=50	20.9	0.271	0.01	19.8	0.256	0.01	20.1	0.261	0.01	
UTI=25	40.6	0.527	0.03	40.1	0.521	0.04	40.1	0.521	0.06	
UTI=10	98.7	1.281	0.04	98.9	1.284	0.06	92.5	1.200	0.10	
UTI=5	171.1	2.220	0.08	144.6	1.876	0.34	99.2	1.287	1.00	
1600/1600										
UTI=50	20.6	0.530	0.01	20.1	0.517	0.01	19.9	0.514	0.05	
UTI=25	39.9	1.028	0.03	40.2	1.037	0.06	40.1	1.034	0.08	
UTI=10	98.6	2.542	0.05	88.1	2.271	0.25	60.5	1.559	1.24	
1988/1988										
UTI=50	20.3	0.650	0.01	20.2	0.646	0.03	20.4	0.652	0.08	
UTI=25	40.6	1.297	0.03	40.5	1.295	0.07	39.8	1.272	0.10	
UTI=10	96.4	3.084	0.07	73.8	2.360	0.74	50.4	1.613	2.02	
40/1400										
UTI=50	20.6	0.241	0.01	20.6	0.241	0.01	20.4	0.239	0.01	
UTI=25	40.6	0.475	0.01	40.7	0.476	0.04	40.1	0.468	0.05	
UTI=10	99.3	1.162	0.03	97.2	1.136	0.07	89.2	1.043	0.11	
40/1400 DR										
UTI=50	20.3	0.238	0.01	20.2	0.236	0.01	20.4	0.234	0.01	
UTI=25	40.9	0.478	0.01	40.8	0.477	0.04	39.9	0.466	0.05	
UTI=10	99.3	1.161	0.03	97.7	1.143	0.07	84.1	0.984	0.15	
DLS_T1 results are from 2210 Release 3 SRB results are from from 2210 Release 3 ENV: 256 LUs, 4 PUs, 64 LU per PU/LLS running 3270 data streams with MAXOUT=7										

Figure 9. 2210 Model 12T DLSw Configuration 1 Test Results

Configuration 1. T1 (1.536 Mbps) Test Results										
Data Size	**Base Run**			**SRB Run**			**DLS_T1 Run**			
TPNS UTI value	Trans. /Sec.	Mbps. (SNA PIU)	Resp. Time (Sec.)	Trans. /Sec.	Mbps. (SNA PIU)	Resp. Time (Sec.)	Trans. /Sec.	Mbps. (SNA PIU)	Resp. Time (Sec.)	% CPU Util.
100/100										
UTI=25	39.5	0.070	0.01	39.6	0.070	0.01	39.4	0.070	0.01	
UTI=10	99.9	0.177	0.02	100.0	0.178	0.03	99.8	0.177	0.03	
UTI=5	196.0	0.348	0.03	195.6	0.347	0.04	195.0	0.346	0.05	
UTI=1	356.6	0.633	0.50	334.9	0.595	0.37	376.4	0.669	0.40	
200/200										
UTI=25	39.8	0.134	0.01	40.7	0.137	0.01	40.3	0.136	0.01	
UTI=10	99.6	0.336	0.02	99.4	0.336	0.03	99.7	0.337	0.04	
UTI=5	196.8	0.664	0.03	193.2	0.652	0.05	194.0	0.655	0.05	
UTI=1	302.6	1.021	0.62	282.6	0.954	0.51	318.5	1.075	0.52	
400/400										
UTI=50	20.1	0.132	0.01	19.6	0.129	0.01	20.2	0.133	0.01	
UTI=25	40.1	0.264	0.01	40.6	0.267	0.02	40.1	0.264	0.03	
UTI=10	100.6	0.661	0.03	98.7	0.649	0.04	100.2	0.659	0.05	
UTI=5	193.0	1.269	0.04	189.0	1.243	0.06	190.2	1.251	0.07	
800/800										
UTI=50	20.9	0.271	0.01	20.2	0.262	0.01	20.5	0.266	0.01	
UTI=25	40.6	0.527	0.03	40.6	0.526	0.04	40.6	0.526	0.04	
UTI=10	98.7	1.281	0.04	98.4	1.277	0.05	98.0	1.271	0.06	
UTI=5	171.1	2.220	0.08	148.8	1.931	0.30	179.1	2.324	0.14	
1600/1600										
UTI=50	20.6	0.530	0.01	20.3	0.522	0.01	20.4	0.527	0.03	
UTI=25	39.9	1.028	0.03	40.1	1.033	0.05	40.7	1.050	0.06	
UTI=10	98.6	2.542	0.05	87.6	2.257	0.23	94.0	2.423	0.17	
1988/1988										
UTI=50	20.3	0.650	0.01	20.6	0.659	0.03	20.5	0.654	0.06	
UTI=25	40.6	1.297	0.03	40.5	1.296	0.06	40.5	1.296	0.08	
UTI=10	96.4	3.084	0.07	74.7	2.389	0.69	78.5	2.510	0.67	
40/1400										
UTI=50	20.6	0.241	0.01	20.6	0.241	0.01	20.4	0.239	0.01	
UTI=25	40.6	0.475	0.01	40.1	0.469	0.03	40.5	0.473	0.04	
UTI=10	99.3	1.162	0.03	97.3	1.137	0.07	98.5	1.151	0.06	
40/1400 DR										
UTI=50	20.3	0.238	0.01	20.7	0.242	0.01	20.2	0.237	0.01	
UTI=25	40.9	0.478	0.01	40.4	0.472	0.03	40.5	0.473	0.04	
UTI=10	99.3	1.161	0.03	97.8	1.144	0.06	98.3	1.150	0.07	
DLS_T1 results are from 2210 Release 3 SRB results are from from 2210 Release 3 ENV: 256 LUs, 4 PUs, 64 LU per PU/LLS running 3270 data streams with MAXOUT=7										

Figure 10. 2210 Model 14T or 24T DLSw Configuration 1 Test Results

The 2210 Model 12T is capable of handling approximately 240 DLSw transactions per second. This equates to 480 data frames per second (IN+OUT). In addition each data message usually has a LLC Receiver Ready (RR) message associated with it for a total of approximately 960 total FPS, not including SNA definite response and pacing response frames. The DLSw user data throughput measured was from 0.426 Mbps (100 byte Transaction) to 1.61 Mbps (1988 byte Trans.). The 2210 CPU utilization was the limiting factor.

The 2210 Model 24T is capable of handling approximately 375 DLSw transactions per second. This equates to 750 data frames per second (IN+OUT). The DLSw user data throughput measured was from 0.669 Mbps (100 byte Transaction) to 2.51 (1988 byte Trans.). Note that for small data sizes the Model 24T Configuration 1 Test results are limited by the TPNS test bed.

End user response time was measured for each of the three runs. Before discussing the results a description of how the response time is measured is appropriate.

TPNS allows two types of response times to be gathered - ACTUAL and SYSTEM response times. ACTUAL response times are measured from the simulated entry of the ENTER key till the last byte of the response is received. SYSTEM response times are measured from the transmission of the first byte of data till the last byte of the response is received, eliminating the time waiting to be polled or in the case of Token Ring waiting for a free token. For the Token Ring DLSw measurement the SYSTEM measurements were used. The ACTUAL response times were only slightly longer since the wait for a free token is usually very short.

The differences in response time between the base run and the SRB or DLSw run identifies the increase in response time due to the routers and the WAN connecting them. As you can see the difference between the Base and SRB runs is very small indicating the speed at which the 2210 can route or bridge frames and the high speed of the T1 links. The DLSw response times are longer due to:

- The frames having to undergo additional DLSw processing
- Buffering between the 2210's

DLSw uses buffering between routers to maximize WAN utilization. This allows for efficient WAN utilization at high traffic because the multiple SNA frames can be buffered in the same TCP/IP packet minimizing TCP, IP and WAN protocol headers. This is especially effective in increasing the amount of user data forwarded on slower speed WANs.

The Response time numbers represent four passages through two 2210's and four additional media transit times.

REQUEST- (IN>TR>2210>WAN>2210>TR>HOST)

RESPONSE- (HOST>TR>2210>WAN>2210>TR>OUT)

A rough calculation of average latency through a single 2210 would be to calculate the response time delta number (DLSw - BASE) and divide the delta by four. You could subtract the four additional TR LAN and WAN media transfer times if you wanted to be more exact. For example, the 100 byte transaction (at UTI=10) calculation is:

```
Response delta  = .02 Sec. (.05 - .03)
Approx. Latency = (delay - media transfer)/4
Approx. Latency = (.02 - .003)/4
Approx. Latency = .00425 Sec.
```

5.2.2.3 DLSw Token Ring SNA Results for configuration 2

The results presented here are similar to those in the previous section. A comparison of a base run, a SRB run and a DLSw run were made for the same traffic configurations. The main differences are:

- The physical configuration, 255 Link Stations (PUs) with 1 LU on each PU.
- Tests were run at two WAN speeds. (T1, 56KB)

The following test cases were run:

- **Base Run** - 255 Link Stations (PU) with 1 LU per PU on a local 16M Token Ring attached to 3172 host gateway.
- **SRB_T1** - 255 Link Stations (PU) with 1 LU per PU remotely connected to 3172 host gateway through two 2210 via T1 WAN.
- **DLS_T1** - 255 Link Stations (PU) with 1 LU per PU remotely connected to 3172 host gateway through two 2210 via T1 WAN.
- **SRB_56** - 255 Link Stations (PU) with 1 LU per PU remotely connected to 3172 host gateway through two 2210 via 56KB WAN.
- **DLS_56** - 255 Link Stations (PU) with 1 LU per PU remotely connected to 3172 host gateway through two 2210 via 56KB WAN.

DLSw results for T1 WAN

The result of these test cases are very similar to those in the previous section. The main purpose was to determine the effects of DLSw having to manage 255 Link Stations instead of 4.

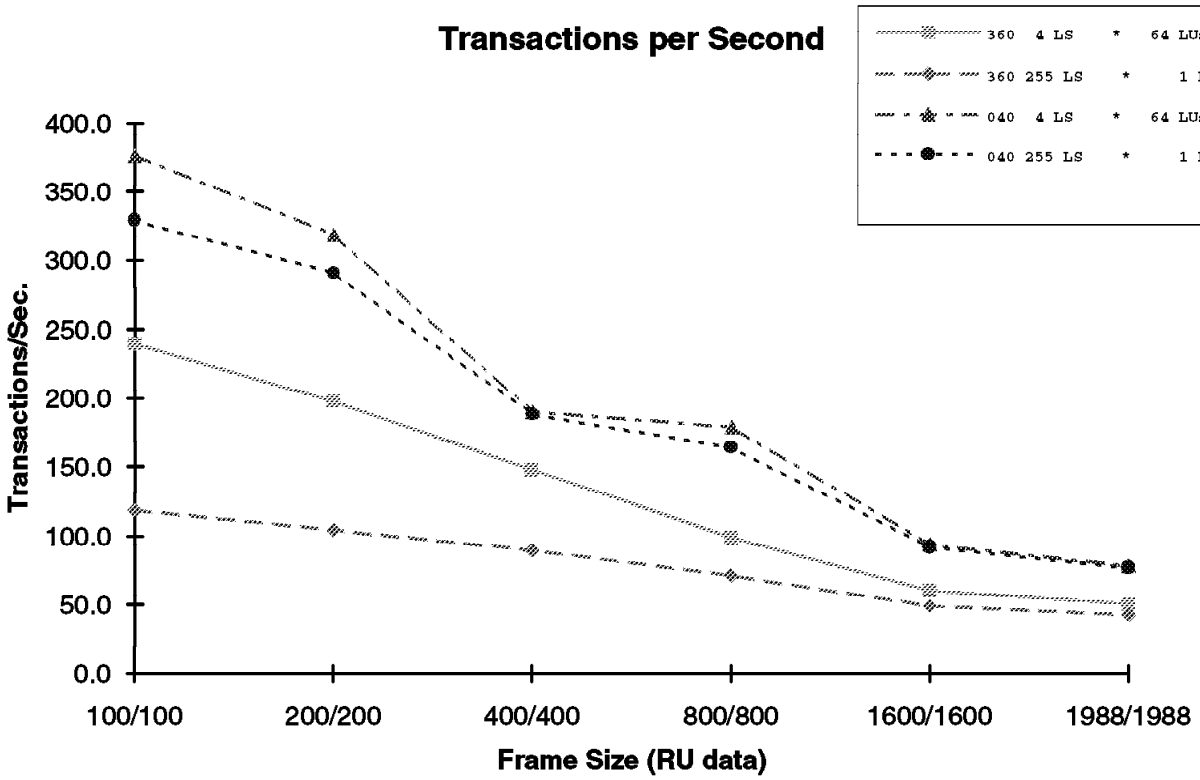
Configuration 2. T1 (1.536 Mbps) Test Results										
Data Size	**Base Run**			**SRB Run**			**DLS_T1 Run**			
TPNS UTI value	Trans. /Sec.	Mbps. (SNA PIU)	Resp. Time (Sec.)	Trans. /Sec.	Mbps. (SNA PIU)	Resp. Time (Sec.)	Trans. /Sec.	Mbps. (SNA PIU)	Resp. Time (Sec.)	% CPU Util.
100/100										
UTI=25	39.5	0.070	0.01	39.5	0.070	0.01	39.4	0.070	0.04	
UTI=10	99.8	0.177	0.02	99.6	0.177	0.02	96.3	0.171	0.10	
UTI=5	196.1	0.348	0.02	195.1	0.347	0.03	119.0	0.211	0.85	
UTI=1	431.5	0.766	0.09	435.8	0.774	0.07	118.7	0.211	1.85	
200/200										
UTI=25	40.2	0.136	0.01	40.4	0.136	0.01	40.5	0.137	0.04	
UTI=10	98.7	0.333	0.02	98.3	0.332	0.03	95.1	0.321	0.12	
UTI=5	195.3	0.659	0.02	194.8	0.658	0.04	104.3	0.352	1.14	
UTI=1	347.1	1.172	0.04	348.2	1.176	0.05	104.4	0.352	2.15	
400/400										
UTI=50	20.3	0.133	0.01	20.1	0.132	0.01	20.1	0.132	0.01	
UTI=25	40.5	0.267	0.01	40.9	0.269	0.02	40.2	0.264	0.05	
UTI=10	99.1	0.652	0.02	98.6	0.648	0.04	89.0	0.585	0.30	
UTI=5	191.6	1.260	0.03	193.3	1.271	0.05	89.9	0.591	1.52	
800/800										
UTI=50	20.2	0.262	0.01	20.6	0.267	0.01	20.2	0.262	0.03	
UTI=25	40.1	0.521	0.02	39.9	0.518	0.04	40.7	0.528	0.07	
UTI=10	98.8	1.282	0.03	98.3	1.275	0.04	71.3	0.925	0.99	
UTI=5	189.1	2.454	0.03	186.3	2.417	0.07	71.5	0.927	2.25	
1600/1600										
UTI=50	20.3	0.523	0.01	20.3	0.523	0.01	20.3	0.524	0.08	
UTI=25	40.1	1.033	0.02	39.9	1.028	0.05	39.3	1.014	1.12	
UTI=10	98.6	2.542	0.02	96.8	2.496	0.08	49.2	1.268	2.56	
1988/1988										
UTI=50	20.2	0.647	0.01	20.0	0.638	0.03	19.9	0.636	0.09	
UTI=25	40.1	1.281	0.03	39.9	1.277	0.06	38.9	1.245	0.21	
UTI=10	97.8	3.126	0.03	89.3	2.855	0.21	42.6	1.362	3.38	
40/1400										
UTI=50	20.5	0.240	0.01	20.4	0.238	0.01	20.2	0.236	0.05	
UTI=25	40.4	0.472	0.01	40.4	0.472	0.04	40.2	0.471	0.09	
UTI=10	99.8	1.167	0.02	98.6	1.153	0.05	71.2	0.832	1.02	
40/1400 DR										
UTI=50	19.9	0.233	0.01	20.3	0.238	0.01	19.9	0.233	0.05	
UTI=25	40.3	0.472	0.01	40.7	0.475	0.03	40.2	0.470	0.11	
UTI=10	98.6	1.153	0.02	98.0	1.146	0.05	56.7	0.663	1.87	
DLS_T1 results are from 2210 Release 3										
SRB results are from 2210 Release 3										
ENV: 255 PUs, 1 LU per PU/LLS running 3270 data streams with MAXOUT=7										

Figure 11. 2210 Model 12T DLSw Configuration 2 Test Results

Configuration 2. T1 (1.536 Mbps) Test Results										
Data Size	**Base Run**			**SRB Run**			**DLS_T1 Run**			
TPNS UTI value	Trans. /Sec.	Mbps. (SNA PIU)	Resp. Time (Sec.)	Trans. /Sec.	Mbps. (SNA PIU)	Resp. Time (Sec.)	Trans. /Sec.	Mbps. (SNA PIU)	Resp. Time (Sec.)	% CPU Util.
100/100										
UTI=25	39.5	0.070	0.01	39.5	0.070	0.01	39.6	0.070	0.01	
UTI=10	99.8	0.177	0.02	99.6	0.177	0.03	99.4	0.177	0.03	
UTI=5	196.1	0.348	0.02	193.6	0.326	0.05	193.1	0.343	0.05	
UTI=1	431.5	0.766	0.09	393.3	0.699	0.06	329.1	0.584	0.46	
200/200										
UTI=25	40.2	0.136	0.01	40.7	0.137	0.01	40.6	0.137	0.02	
UTI=10	98.7	0.333	0.02	99.0	0.334	0.03	98.9	0.334	0.04	
UTI=5	195.3	0.659	0.02	193.1	0.652	0.03	183.4	0.619	0.07	
UTI=1	347.1	1.172	0.04	346.2	1.169	0.05	290.8	0.982	0.57	
400/400										
UTI=50	20.3	0.133	0.01	20.5	0.135	0.01	20.1	0.132	0.01	
UTI=25	40.5	0.267	0.01	39.9	0.263	0.02	40.2	0.264	0.03	
UTI=10	99.1	0.652	0.02	99.5	0.655	0.03	97.8	0.643	0.05	
UTI=5	191.6	1.260	0.03	191.8	1.261	0.04	188.2	1.237	0.07	
800/800										
UTI=50	20.2	0.262	0.01	20.5	0.265	0.01	20.0	0.260	0.01	
UTI=25	40.1	0.521	0.02	40.6	0.526	0.03	40.0	0.519	0.04	
UTI=10	98.8	1.282	0.03	98.8	1.282	0.04	98.2	1.274	0.05	
UTI=5	189.1	2.454	0.03	185.8	2.411	0.07	164.1	2.129	0.24	
1600/1600										
UTI=50	20.3	0.523	0.01	20.4	0.527	0.01	20.3	0.522	0.03	
UTI=25	40.1	1.033	0.02	39.8	1.025	0.05	40.0	1.032	0.06	
UTI=10	98.6	2.542	0.02	97.3	2.508	0.08	92.1	2.374	0.19	
1988/1988										
UTI=50	20.2	0.647	0.01	20.1	0.643	0.04	20.4	0.652	0.06	
UTI=25	40.1	1.281	0.03	40.0	1.278	0.06	40.3	1.288	0.08	
UTI=10	97.8	3.126	0.03	89.5	2.862	0.20	77.0	2.463	0.73	
40/1400										
UTI=50	20.5	0.240	0.01	20.5	0.239	0.01	20.5	0.240	0.01	
UTI=25	40.4	0.472	0.01	40.0	0.468	0.03	39.7	0.464	0.04	
UTI=10	99.8	1.167	0.02	99.0	1.158	0.05	97.8	1.144	0.07	
40/1400 DR										
UTI=50	19.9	0.233	0.01	19.9	0.233	0.01	20.5	0.240	0.01	
UTI=25	40.3	0.472	0.01	40.3	0.471	0.03	40.4	0.472	0.04	
UTI=10	98.6	1.153	0.02	98.7	1.154	0.05	98.3	1.150	0.07	
DLS_T1 results are from 2210 Release 3 SRB results are from 2210 Release 3 ENV: 255 PUs, 1 LU per PU/LLS running 3270 data streams with MAXOUT=7										

Figure 12. 2210 Model 14T or 24T DLSw Configuration 2 Test Results

Note from the tables above that the 14T/24T performance is significantly higher than the 12T results. The DLSw results in the preceding tables are slightly lower than the configuration 1 results due to the higher overhead required by the 2210 to manage 255 Link Station instead of 4. Throughput averaged 10%-35% lower than with configuration 1. Configuration 2 response times were longer than Configuration 1 at equivalent traffic rates. The graph below summarizes the DLSw transaction rate results of Configuration 1 and 2 for both the 2210 Model 12T and 14T/24T.


Transactions per Second
360 4 LS * 64 LUs
360 255 LS * 1 LUs
040 4 LS * 64 LUs
040 255 LS * 1 LUs
Transactions/Sec.
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
100/100
200/200
400/400
800/800
1600/1600
1988/1988
Frame Size (RU data)

Page 1

Figure 13. 2210 DLSw Transaction Rate Summary

DLSw Results 56KB WAN

As you saw from the T1 WAN results, Source Route Bridge (SRB) performance was much closer to the Base Run than Data Link Switching (DLSw). The main reason for the difference is that SRB requires less processing and, in most cases, has much lower latency and much higher throughput capacity than DLSw. On the surface this might lead you to believe that SRB performance is always superior to DLSw. However, this is not the case as the following table shows conditions where DLSw performs better than SRB.

The TPNS UTI values were changed from the T1 measurements to provide a lower traffic rate for the slower WAN speeds. The traffic rates, especially for the larger transactions sizes still place a heavy load on the WAN to evaluate overload characteristics.

The overload traffic conditions do not represent an environment where a customer should normally operate. The response times are not what a customer would typically expect or demand. These measurements are included to indicate how well the 2210 handles severe load conditions.

Configuration 2. 56 Kbps Test Results						
Data Size	**SRB_56 RUN**			**DLS_56 RUN**		
TPNS UTI value	Trans. /Sec.	Mbps. (SNA PIU)	Resp. Time (Sec.)	Trans. /Sec.	Mbps. (SNA PIU)	Resp. Time (Sec.)
100/100						
UTI=100	10.1	0.018	0.08	10.1	0.018	0.11
UTI=50	19.8	0.035	0.08	19.8	0.035	0.10
UTI=25	31.7	0.056	1.41	36.2	0.064	0.61
UTI=10	31.7	0.056	3.77	40.9	0.073	3.59
200/200	(-0)					
UTI=100	9.1	0.031	0.10	9.8	0.033	0.12
UTI=50	17.2	0.058	0.18	19.6	0.066	0.23
UTI=25	21.0	0.071	2.95	24.6	0.083	4.03
UTI=10	31.7	0.072	6.78	24.6	0.083	7.76
400/400	(-30)					
UTI=200	4.3	0.028	0.16	5.1	0.033	0.20
UTI=100	8.6	0.057	0.22	10.1	0.066	0.26
UTI=50	10.5	0.069	5.35	13.8	0.090	5.47
UTI=25	10.4	0.068	6.54	13.8	0.091	>10
800/800	(-35)					
UTI=200	3.1	0.040	0.31	4.7	0.061	0.64
UTI=100	6.1	0.079	0.56	7.6	0.099	6.52
UTI=50	6.0	0.077	7.66	7.5	0.097	>10
UTI=25	5.8	0.075	9.96	7.3	0.094	>10
1600/1600	(-101)					
UTI=200	2.2	0.057	0.76	2.8	0.073	>10
UTI=100	3.6	0.092	6.34	4.1	0.106	>10
UTI=50	3.4	0.088	11.93	3.8	0.099	>10
1988/1988	(-130)					
UTI=200	1.8	0.058	0.91	2.1	0.067	>10
UTI=100	3.0	0.094	4.87	3.6	0.114	>10
UTI=50	2.7	0.085	11.67	3.3	0.106	>10
40/1400	(-159)					
UTI=200	1.8	0.021	0.28	4.3	0.050	>10
UTI=100	3.2	0.038	0.43	4.8	0.056	>10
UTI=50	3.6	0.042	7.11	4.5	0.053	>10
40/1400 DR	(-172)					
UTI=200	1.6	0.019	0.30	3.2	0.037	>10
UTI=100	3.2	0.037	0.43	4.8	0.056	>10
UTI=50	3.7	0.043	7.01	4.7	0.055	>10
	(-174)					
(-xxx) = Number of SNA sessions lost due to timeouts All SRB and DLSw results from Rel. 2 ENV: 255 PUs, 1 LU per PU/LLS running 3270 data streams with MAXOUT=7						

Figure 14. 2210 DLSw Configuration 2 56KB Test Results

In an effort to maximize the wide area (WAN) resources, DLSw terminates the LLC at the end routers. This eliminates the need for sending Receiver Ready (RR) frames across the WAN. DLSw also allows the router to perform flow control to the end stations to prevent them from overloading the network. DLSw encapsulated the SNA PIU's in TCP/IP to send them across the WAN. This allows DLSw to take advantage of TCP's buffering and route recovery capability. This makes DLSw very efficient in it's utilization of the WAN. SRB, on the other hand, must send all messages across the WAN and has no means of providing flow control or buffering. In a heavy overload condition, SRB may discard frames and the end stations must provide the recovery. In extreme conditions, this may cause sessions to terminate and connections to be lost. The numbers in parenthesis in Figure 14 represent the number of lost sessions. You will notice that SRB lost sessions in both the SRB_56 run while DLSw never lost any sessions. Because of these factors, DLSw has an advantage over SRB on a heavily utilized WAN.

You will also notice that DLSw appears to have higher response times than SRB at the higher traffic levels. The differences in response time should not be directly compared. Under SRB sessions are being terminated allowing the remaining sessions to have shorter response time while under DLSw higher throughput is being obtained and congestion control is being used to maintain the session integrity. For example, Compare the results of SRB_56 and DLS_56 at 400/400 with a UTI=50. SRB is running at 10.5 trans/sec with a response time of 5.35 but 30 session have already timed out and terminated. DLSw is running at 13.8 trans/sec. with a response time of 5.47 sec. but no sessions have been lost. DLSw's congestion control is protecting the session integrity. When the overload condition is removed the response times will return to normal. In the SRB case the sessions that were terminated would have to be restarted by the end users.

5.2.3 DLSw Token Ring NetBIOS Results

This section presents the detailed results of several Netbios tests. These tests were not designed to measure the maximum throughput of the 2210 as the previous tests were, but to compare the performance of a small number of clients interacting with a server to perform file transfers of various size files. The main limiting factors are the capacity of the client/servers and the latency through the network.

A series of NetBIOS file transfer comparison tests was run to measure the time it would take to transfer files on a local TR, local SRB, Remote SRB or Remote DLSw across a WAN at speeds of T1, 256KB and 64KB. The results are presented in Kilobytes per second (KBps.) The physical configuration for the test runs was:

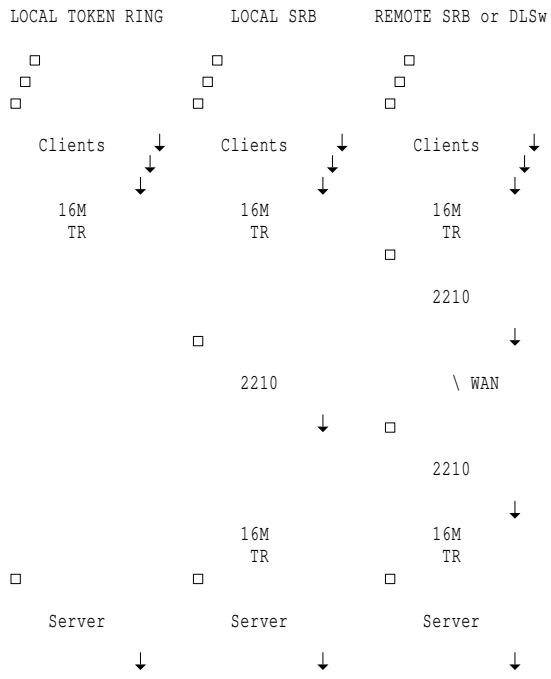


Figure 15. NetBIOS Test Configurations

- 1 Server, 1-4 Clients
  - IBM PS/2 Model 80 (25Mhz Intel 80386)
  - DOS 5.0
  - Lan Support Program (LSP) V1.3
  - PC Lan Program (PCLP) V1.3
- Two 2210 routers
  - PPP was running on the serial link between the routers.
  - IP, SNA and NetBIOS enabled on both 2210s.
  - No data traffic on network except NetBIOS file transfer.
  - All other network traffic is protocol chat and overhead.

The PERFORM3 test case is one that is often used with NETWARE IPX. The test was run with 4 clients communicating with one server. Short file transfers were run back to back. This environment is most sensitive to latency. The DLSw buffering was an advantage in the previous tests that contained 255 Link Stations, because it allowed for efficient WAN utilization. It is less of an advantage here because of the small number of Link stations and because the WAN is not usually the limiting factor when using small frames. Because of the buffering care should be used when benchmarking DLSw performance with a small number of stations. The DLSw results would be much better with a larger number of clients and would more closely approximate DLSw performance documented in previous sections of this report.

The FT_256 and FT_2M test case are less effected by latency than PERFORM3 since multiple frames are sent without waiting for a response. While the test cases are set up to read large blocks, actual frame sizes that are transmitted are limited. The maximum frame size on the Local TR configuration is 8KB. The maximum for Local SRB is 4KB and the maximum for remote SRB or DLSw is 2KB.

Table 41. DLSw Netbios Results - Model 24T

TEST CASE	LOCAL	T1 WAN		256Kb WAN		64Kb WAN	
Read Size (in bytes)	*TR (KBps)*	*SRB (KBps)*	*DLSW (KBps)*	*SRB (KBps)*	*DLSW (KBps)*	*SRB (KBps)*	*DLSW (KBps)*
PERFORM3 (4 clients)							
128	60	39.9	32.8	14.5	14.1	3.6	3.5
256	130	75.4	61.45	19.67	19.26	4.9	4.8
512	130	129.3	98.57	19.7	19.3	6.0	5.9
1024	240	162.1	145.1	27.0	25.8	6.7	6.4
2048	410	164.2	161.2	28.1	27.1	*	*
4096	670	174.4	165.8	29.0	27.7	*	*
8192	850	176.3	167.1	29.5	28.3	*	*
FT_256 (1 Client)							
128	233	104	99	26	25	7	7
512	337	117	111	26	25	7	7
4K	356	123	117	27	26	7	7
16K	361	122	116	27	26	7	7
32K	332	106	78	22	20	6	5
FT_2M (1 client)							
32K	234.9	92.5	70.1	21.8	19.2	5.7	5.2

* = Measurement not made. PERFORM3 could not synchronize the clients within it's required 2 seconds. PERFORM3 has problems with small WANs and large frame sizes.

Appendix A. Media Capacity limitations

The following table defines the media limitations at various frame sizes.

Table 42. Theoretical Media Capacity in Frames per Second

Media type	Frame Length							
	64	128	256	512	1024	1518	2048	4096
Ethernet	14880	8445	4528	2349	1197	812	-	-
16M Token Ring	28986	15038	7663	3868	1944	1312	974	488
4M Token Ring	7246	3759	1916	967	486	328	243	122
T1 (1.536MB) (1)	3016	1508	754	377	188	127	94	47
64Kb link (1)	125	63	31	16	8	5	4	2
Note (1): The total frames would be double on a fully utilized full duplex link.								

Table 43. Theoretical link capacity for DLS and SRB (Transactions per Second)

User Data Length	SRB Capacity				DLSw Capacity			
	1.536M	256K	64K	56K	1.536M	256K	64K	56K
100	980	163	41	36	1304	217	54	48
200	649	108	27	24	767	128	32	28
400	387	65	16	14	420	70	18	15
800	214	36	9	8	221	37	9	8
1600	113	19	5	4	113	19	5	4
1988	92	15	4	3	92	15	4	3
40/1400	128	21	5	5	127	21	5	5
40/1400+DR	126	21	5	5	125	21	5	5
Note (1):: The WAN speeds are full duplex.								
Note (2):: The capacities are calculated based on the ECHO response frame size which is larger than the request frame size.								

Table 44. Wandel & Goltermann DA-30 Achievable Maximum

Media type	Frame Length							
	52	64	256	512	1024	1518	2048	3960
16M Token Ring	6989	6347	4462	3124	1830	1259	944	500
Note: From LAN Bridge/Router IETF Test Application Documentation p.2-3								

There is a second limit which applies to the DA-30 on Token Ring. The test application cannot generate all possible frame rate and frame size combinations. For example, for 52-byte frames, it is not possible to generate any frame rates between 3903 and 5205. This means granularity of the test steps is not uniform.

Appendix B. References

- Bradner, Scott, "Ethernet Bridges and Routers", Data Communications, February 1992.
- Bradner, Scott, "Testing Multiprotocol Routers", Data Communications, February 1991.
- Tolly, Kevin, "Questioning Performance", Data Communications, April 1992.
- Tolly, Kevin, "Remote Token Ring Bridges," Data Communications, August-September 1991.
- Tolly, Kevin, "SDLC Testing the New SNA" Data Communications, May 1992.
- Tolly, Kevin, "SDLC Conversion, We Have A Winner" Data Communications, July 1992.
- Tolly, Kevin, "Local Token Ring Bridges," Data Communications, August 1992.
- Tolly, Kevin, "Lab test of bridges show real-world performance", Network World, Aug 10,1992, p.1.
- Tolly, Kevin, "IBM's 6611 in Action-at Last," Data Communications, September 21, 1992, p.31.
- RFC 1242 by Scott Bradner.
- TR16PERF PACKAGE on MKTTOOLS.
- 6611PERF PACKAGE on MKTTOOLS.
- The Tolly Group, 1995 Industry Benchmark: Data Link Switching Phase 2: SDLC Support, Executive Summary, No. 5250, March 1995.
- The Tolly Group, 1995 Industry Benchmark: Data Link Switching Phase 2: SDLC Support, Technology Spotlight IBM 2210, No. 5255, March 1995.
- The Tolly Group, 1995 Industry Benchmark: SNA over Frame Relay, Executive Summary, No. 5265, May 1995.
- The Tolly Group, 1995 Industry Benchmark: SAN over Frame Relay, Technology Spotlight IBM 2210, No. 5267, May 1995.

DSMLBR562W OBJECT EXCEEDS PAGE DEPTH ON PAGE 53.
DSMMOM395I '.EDFAWRK' LINE 920: .si dlssum inline
DSMMOM397I '.EDFAWRK' WAS IMBEDDED AT LINE 666 OF '2210DLS'
DSMMOM397I '2210DLS' WAS IMBEDDED AT LINE 547 OF '2210PERD'
DSMLBR529E 'KP' WOULD EXCEED MAXIMUM SIZE.
DSMMOM395I '.EDF#FBOT' LINE 130: .sp .5 c
DSMMOM397I '.EDF#FBOT' WAS IMBEDDED AT LINE 100 OF '.EDFEFIG'
DSMMOM397I '.EDFEFIG' WAS IMBEDDED AT LINE 668 OF '2210DLS'
DSMMOM397I '2210DLS' WAS IMBEDDED AT LINE 547 OF '2210PERD'
DSMBEG323I STARTING PASS 2 OF 2.
DSMLBR562W OBJECT EXCEEDS PAGE DEPTH ON PAGE 53.
DSMMOM395I '.EDFAWRK' LINE 920: .si dlssum inline
DSMMOM397I '.EDFAWRK' WAS IMBEDDED AT LINE 666 OF '2210DLS'
DSMMOM397I '2210DLS' WAS IMBEDDED AT LINE 547 OF '2210PERD'
DSMLBR529E 'KP' WOULD EXCEED MAXIMUM SIZE.
DSMMOM395I '.EDF#FBOT' LINE 130: .sp .5 c
DSMMOM397I '.EDF#FBOT' WAS IMBEDDED AT LINE 100 OF '.EDFEFIG'
DSMMOM397I '.EDFEFIG' WAS IMBEDDED AT LINE 668 OF '2210DLS'
DSMMOM397I '2210DLS' WAS IMBEDDED AT LINE 547 OF '2210PERD'
DSMAFP709E PAGE SEGMENT DLSSUM EXCEEDS TOP PAGE BOUNDARY ON PAG
E 54.
DSMAFP709E PAGE SEGMENT DLSSUM EXCEEDS RIGHT PAGE BOUNDARY ON P
AGE 54.