Token Ring network managers are faced with the difficult decision of staying with Token Ring or migrating to Ethernet. Making matters worse is that analysts, consultants, and vendors do not always agree on the answer. Some recommend abandonment of Token Ring as soon as possible and move to Ethernet. Others suggest that Token Ring is strategic and one should stay with it forever. Ultimately, one has to decide what to do. This article examines the technical and business factors that will help determine the future direction of the network.

First of all, take a look at a few of the more obvious facts about the Local Area Networking market. Regardless of how it is measured, the Ethernet market is much larger than the Token Ring market. This has resulted in increasing choices, decreasing prices, and rapid advancement of technology for the Ethernet user. Unfortunately, Token Ring technology has not advanced as quickly and prices remain much higher than for Ethernet technology. Also, fewer vendors are offering Token Ring solutions, as many view this to be a declining market.

Recently, there has been much press about new high-speed alternatives for Token Ring. Some argue that Token Ring customers have not needed higher speeds until recently, therefore these new technologies are arriving just in time. This is extolled as a revival of the Token Ring market.
and a reason for customers to stay with Token Ring. Others, however, say that this is too little and too late to stem the tide of customers migrating to Ethernet.

There is a business to run and one needs to make the best choice possible for the company — both in the short term and for the long term. Thus, one can examine the technical and business issues that should be considered. At the end, a checklist will be provided that will help weigh those factors that are most important in making this decision.

First, let’s examine the technical issues. What are the differences between Token Ring and Ethernet? Will an Ethernet network support all applications?

DIFFERENCES BETWEEN TOKEN RING AND ETHERNET
With the current state of LAN switching technology, many of the important differences between Ethernet and Token Ring have disappeared. Both Token Ring and Ethernet can provide a full duplex, dedicated link to the desktop from a LAN switch. This gives each user his own LAN segment with dedicated 10/100 or 4/16Mbps of bandwidth. There are no collisions and no one with which to share a token. In fact, for full duplex Token Ring, there is no token and no ring. In this environment, the only important differences are the speed, maximum frame size, source routing support, and IP multicast support.

Speed
The speed issue has recently become a topic of debate with the efforts of Token Ring vendors to establish a standard for 100Mbps and 1Gbps Token Ring. 10Mbps and 10/100Mbps Ethernet NICs, hubs, and switches are widely available today. Gigabit Ethernet is standardized and becoming widely available. Token Ring is widely available in 4 and 16Mbps versions.

The proposed High Speed Token Ring (HSTR) standards provide for 4/16/100Mbps Token Ring and 1Gbps in the future. There are no 100Mbps hubs planned for Token Ring because the proposed HSTR standards do not support shared media. At the time of this writing, 100Mbps HSTR NICs are just emerging and are priced at three to five times more than 10/100Mbps Ethernet NICs. Although there are stated goals to support both Token Ring and Ethernet over HSTR, initial offerings are Token Ring only. So, the only real difference in speed is 4/16Mbps vs. 10Mbps for client NICs. Server and backbone speeds for both Token Ring and Ethernet are the same.

Some vendors are providing support for Token Ring over Fast and Gigabit Ethernet links. This has the advantage of providing Token Ring frame support at or close to the price points of Ethernet. An important capability of these solutions is the ability to support both Token Ring and
Ethernet over the same link at the same time. This makes migration easier by allowing installation of a single high-speed backbone for Token Ring and Ethernet clients and servers.

**Maximum Frame Size**

The other performance-related difference is the maximum frame size. All speeds of Ethernet are limited to 1500 bytes as the maximum frame size. The maximum frame size for Token Ring can be set as low as 516 bytes and as high as 17,749 bytes. The typical value is 4399 bytes. On the surface, this appears to be a good thing. After all, the more data one can send per frame, the better the throughput, right?

As usual, things are not that simple. The benefit of large frames is most apparent on the server. Conventional wisdom states that the CPU in a server has to process each frame transmitted or received. The more bytes there are in each frame, the fewer frames are needed to send the same amount of data. This results in lower CPU utilization. This would be true if all NICs were created equal. CPU utilization depends a great deal on how efficiently data transfers occur across the bus. The NIC hardware, drivers, and operating system can impact performance and CPU utilization more significantly than frame size.

Well, if NICs are efficient, are large frames better? There is another tradeoff that needs to be considered. This has to do with the number of store and forward hops between the clients and servers. A store and forward hop can be a router, bridge, or switch in either the LAN or over the wide area network (WAN). Each store and forward hop must completely receive the frame before it forwards it on the next hop in the path. The larger the frame, the longer it takes to receive it and the longer it takes to transmit it. This can result in increased end-to-end latency that can negatively impact performance.

Without going into great detail about queuing theory and flow control, the net result is that larger frames work best over short, fast paths. Smaller frames work best over longer, slower paths. Typically, the network is a mix of short and long paths. For example, the LAN has short, fast paths and the WAN has longer, slower paths. Based on the author's experience, a maximum frame size of around 2000 bytes provides good performance for both the LAN and WAN. By the way, cut-through switching (in which the bridge or switch forwards the frame on the output link as it is being received on the input link) can help, but cut-through only occurs if the input and output link are running at the same speed. If they are different speeds, even a cut-through switch will use store and forward.

**Source Routing**

Source routing is a technique for bridging LANs that is not available on Ethernet. Ethernet only supports transparent bridging. There are three
advantages of source routing over transparent bridging: multiple parallel paths, duplicate MAC addresses, and network management.

Source routing allows traffic to be distributed over parallel bridge paths through the network. With Ethernet, parallel paths are allowed, but all traffic will take the same path. The other paths will be inactive until the active path fails. When the active path fails, the spanning tree protocol will automatically activate another path. There is an advantage to this approach. When a source routing path fails, the end systems have to re-discover a path. This may result in the failure of sessions (for example, SNA sessions). In Ethernet, a path change is transparent to the end system (this is why it is called transparent bridging). Therefore, sessions typically do not fail when the path changes in Ethernet. Pure transparent bridging can be used on Token Ring; however, this is not typical. Some networks use Source Route Transparent (SRT) bridging where some traffic will be bridged via source routing and other traffic, such as IPX, will be bridged using transparent bridging.

Duplicate MAC address support is a technique that was developed to get around a shortcoming of SNA. SNA did not implement an address resolution protocol on the LAN. As a result, SNA users had to configure the MAC address of their SNA gateway in their client. If the gateway failed, they would have to reconfigure a backup gateway or wait for the gateway to be repaired. Since source routing bridges or switches only look at the source routing information to determine the path, it is possible to put the same MAC address on two different ring numbers. This allowed the network manager to configure two identical SNA gateways with the same MAC address on two different Token Rings (with different ring numbers). Now, the SNA gateway would connect to the first gateway that responded to the client explorer frame (this is pretty much a random choice). If that gateway failed, the session would fail, but the client could immediately reconnect to the other gateway. This technique has been widely used in SNA to provide backup and load distribution between gateways.

Ethernet does not support source routing. All forwarding decisions in bridges and switches are made by looking only at the destination MAC address. As a result, a MAC address can only appear on a single Ethernet segment. Duplicate MAC addresses are simply not supported. One way to provide SNA gateway backup on Ethernet is to use a protocol in the gateway to activate a backup with the same MAC address if the primary fails or a protocol in the client to reconfigure it to a different gateway if the primary fails. One can also use a single source route/translational (SR/TLB) bridge between the Ethernet network and the Token Ring attached SNA gateways as shown in Exhibit 1. Another alternative is to change from pure SNA clients to the TN3270 or TN5250 protocol. TN3270/5250 runs over TCP/IP and uses TCP/IP for alternate path support.

Source routing is helpful for network management in that each frame contains the bridging path from source to destination. This is useful
when looking at traces since one can tell which ring number a frame originated on and where it is headed. On Ethernet, one must keep up with where MAC addresses are located. This can also be automated via a variety of tools and can include layer 3 addresses such as IP, IPX, or NetBIOS.

Source routing does have its share of headaches as well. Since the procedures for discovering a source route were never well standardized, there are a variety of problems that occur with different implementation of protocol drivers and protocol stacks. Recently, there was a situation where the client was configured to use source routing and the server was not using source routing. With this configuration, the server should not send or respond to source routed frames. However, when the client and server is on the same ring, the server would actually respond to a source route frame from the client. When the client and server were on different rings, it no longer worked. There are other cases where clients will send excessive explorers and flood the network when connections are lost to their servers. Ethernet is much simpler because it only supports transparent bridging. This is why some network managers have moved to transparent bridging on their Token Ring network.

IP Multicast
IP multicast is increasingly being used for distribution of live or scheduled multimedia information over the network. A server can send a single multicast packet of voice, video, or data to the network that multiple clients can receive. The network will duplicate this multicast cast packet as needed to get a copy to each client that has registered to receive it.
This technique greatly reduces the load on the server and the amount of traffic sent through the network.

Unfortunately, IP multicast is very difficult to do effectively on Token Ring networks. The reason has to do with the way that different multicast streams are identified at the MAC layer. Think of a multicast stream as a TV channel. On Ethernet, each channel uses a different MAC group address as the destination address of the frame. Ethernet NICs can support multiple group addresses at the same time. Therefore, an Ethernet NIC can tune in to channels 8 and 5 and ignore all other channels. It does this by only copying frames destined to the MAC group address for channels 8 and 5.

Unfortunately, most Token Ring NICs support only a single group address. Equally bad is that most of them do not support the universally administered group addresses used by IP multicast. Therefore, on Token Ring, all IP multicast data is typically sent to the broadcast MAC address or a functional address. If the functional address is being used, then a Token Ring NIC will either receive all of the channels or none of them, as illustrated in Exhibit 2. If the broadcast MAC address is being used, then all Token Ring NICs on the LAN will receive all of the channels if any one is tuned in to a single channel. These received multicast frames are sent to the CPU in the client or server regardless of whether there is any application running to process them. This can result in significant unnecessary utilization of the CPU.
WILL AN ETHERNET NETWORK SUPPORT ALL OF MY APPLICATIONS?

The short answer is yes. This author cannot think of any applications that only run over Token Ring. For years, SNA only ran over Token Ring, but SNA over Ethernet abounds today. One might have devices that only support Token Ring interfaces, such as 3174 control units. For these devices, source route translational bridging can be used to connect these Token Ring devices to an Ethernet network.

The only function that Ethernet cannot provide is duplicate MAC address support. If one relies on this feature of source routing on Token Ring, then it will be necessary to either migrate the SNA to TN3270/5250 or automate the gateway backup via other means. The other main difference between Token Ring and Ethernet is the maximum frame size. This may provide some performance advantage for Token Ring over Ethernet, but with the increasing performance of clients and servers, these differences will be less noticeable.

So, if one has decided that Ethernet can support the applications, what are the migration issues that need to be considered.

Migration Issues

The first migration issue is cabling. If one already has unshielded twisted pair (UTP) cabling for the Token Ring network, then one is in good shape. For category 5 UTP cable, one can run both 10Mbps and 100Mbps Ethernet; for category 3 cable, one can run 10Mbps Ethernet. What if one is currently using the IBM cabling system with Type 1 or 2 cable? This is a shielded twisted pair (STP) cable with 150-ohm impedance instead of the 100-ohm impedance for UTP. One cannot directly connect an Ethernet NIC or port to the IBM Type 1 or 2 STP cable.

There are a few choices in this situation. For IBM Type 2 cable, one can use the UTP category 3 telephone pairs in this cable for Ethernet. It will be necessary to wire these cables to a RJ45 jack in the office. For IBM Type 1 cable and no UTP cable, one can either rewire the building (no fun) or use baluns to convert the impedance from 150 ohms to 100-ohm. These baluns have an RJ45 female connector and an IBM cabling system connector. One will need one of these baluns at each end of the cable.

The second migration issue is interoperability during the migration. The length of the migration will determine how best to provide this. There are two basic approaches. One is to migrate as quickly as possible by replacing the current Token Ring NICs and installing an Ethernet switched network. The other is to move to Ethernet as devices are replaced. When a new PC comes in the door, it is installed on the Ethernet network. The existing PCs remain on the Token Ring network until they are replaced.

To migrate quickly, simply leave the current Token Ring backbone in place and install the new Ethernet backbone. Typically, one would use
existing routers to interconnect the Token Ring and Ethernet backbones. As clients and servers are upgraded with new NICs, they are connected to the Ethernet backbone. This will likely require changing the client or server’s network address, which can be done automatically with DHCP for TCP/IP. For IPX, the clients will automatically find their nearest server, but servers will have to be reconfigured manually.

To migrate gradually, a single high-speed backbone that can support both the Token Ring and Ethernet users is desirable. The choices for a high-speed backbone are ATM, Fast/Gigabit Ethernet, or HSTR at some point in the future. When using ATM as a backbone, it is easy to support both Token Ring and Ethernet over the same backbone. If Fast/Gigabit Ethernet is used for the Ethernet network, then look for a vendor that can support full Token Ring capability over this backbone. It will be a non-standard implementation, but it can provide an easy way to migrate to Ethernet without building separate Ethernet and Token Ring backbones. HSTR may be an option in the future; but at the time of this writing, it only supports Token Ring frames at 100Mbps. Even if it does support Ethernet frames and 1Gbps in the future, it will likely be much more expensive than a Fast/Gigabit Ethernet solution.

Next, one needs a way to interconnect the Token Ring and Ethernet network. The best solution is to use routing, either in a router or in a switch. Protocols that are routable such as IP and IPX should be routed, with the Ethernet and Token Ring networks configured as different subnets or networks. Nonroutable protocols such as SNA and NetBIOS can be translationally (SR/TLB) bridged. Typically, routers will support both routing and SR/TLB bridging between Token Ring and Ethernet. Routing will block broadcast and explorer traffic between the LANs and thereby reduce the impact of any broadcast storms.

Many customers are eliminating nonroutable protocols. NetBIOS can be run over TCP/IP very effectively and provides superior scaling to the native version. SNA traffic can be converted to TN3270/5250 and therefore also run over TCP/IP. This eliminates the need to have SNA session routing in the network. Even Novell is migrating Netware to run over TCP/IP. Migration to TCP/IP as the only networking layer 3 protocol is a good goal to set because it eliminates the complexity of managing multiple layer 3 protocols and allows the use of high-speed, layer 3 switching technologies that tend to be IP only.

For the routable protocols, parallel routers can be used between subnets and networks. The routing protocols will provide for automatic path selection and backup. For nonroutable protocols, parallel paths can only be used if there is the capability to run spanning tree end-to-end across both the Ethernet and Token Ring network. This can be a tricky function to implement, so it is usually best to provide a single path for bridging between the Token Ring and Ethernet network. Network management can be used to activate backup paths in the event of a failure.
One of the issues sometimes mentioned by Token Ring vendors about mixing Token Ring and Ethernet is the maximum frame size differences. Some will claim that this can cause a severe problem with either dropped frames or degraded performance. It is true that there could be some problems in this area. However, there are effective ways to handle this issue.

For TCP/IP, there are two mechanisms available to solve mismatches in frame sizes. Modern TCP protocol implementations will negotiate the frame size down to the smallest supported on either end of the connection. If a Token Ring user is connecting to a server on Ethernet, the maximum frame size will be set to 1500 bytes and all will be fine. If TCP is not being used and the Token Ring user sends a frame larger than 1500 bytes, the router can perform IP fragmentation and convert the large frame into multiple frames that are no larger than 1500 bytes.

For nonroutable protocols, the SR/TLB function can use the routing information field (RIF), which is part of source routing, to bring the frame size down to 1500 bytes. This will result in the Token Ring client only sending 1500 byte frames to an Ethernet server, while still being able to send larger frames to a Token Ring server. In most cases, these mechanisms will effectively resolve frame size differences.

To summarize, the main issues for migration are to choose a backbone technology that can support both Token Ring and Ethernet and the use of routing and translational bridging to support interoperability between the LANs. One should always be aware of possible issues with the different frame sizes, but in most cases this will happen automatically. If the application does not automatically adjust, one will need to configure the maximum frame size for the application on Token Ring to 1500 bytes.

BUSINESS ISSUES
Thus far, the technical differences between Token Ring and Ethernet and the issues involved in migration have been discussed. Understanding these issues will help in dealing with the business issues that usually revolve around satisfying a wide variety of demands from users and corporate management. How many times has one heard the following?

- The network is too slow, we are losing productivity.
- The network is critical; we lose lots of money every minute the network is down.
- We have a new application that we are rolling out. Can the network handle it?
- We keep getting a lot of dropouts when we play audio and video streams over the network.
- My new PC came with an Ethernet interface; why can’t I use it?
- The CFO says we are spending too much on the network, so he has cut our budget.
It always seems that everyone wants the network manager to do more with less, but the network manager has problems to deal with as well. It will be necessary to manage the network, define and deliver service levels, train employees so that they are effective in dealing with problems, and make the most cost-effective use of the budget available. When faced with all of these requirements and pressures, the typical reaction is to try to tweak the current network architecture to meet the needs with the least amount of change.

There is no doubt that simply upgrading the existing Token Ring network will provide the least amount of change. Migration to a new technology is difficult, time consuming, and will likely result in some problems during the migration. The most conservative approach is simply to enhance the existing Token Ring network.

On the other hand, the network manager may not be able to meet all of the requirements placed on him by simply upgrading the Token Ring network. For example, if there are definite needs for Ethernet connectivity, heavy requirements for IP multicast, or requirements for high-speed backbones and layer 3 switching today, one will at least need to provide an integrated Token Ring and Ethernet network. Most of the short-term requirements can likely be met by upgrading the Token Ring network or providing the integration of some Ethernet technology.

The real issue is the long-term viability of Token Ring. It is doubtful that Token Ring will ever increase in popularity or catch up with Ethernet in terms of technology or price. HSTR is unfortunately too late to attract the interest of many vendors other than traditional Token Ring NIC vendors. Since the number of Token Ring vendors is not likely to grow significantly, Token Ring customers will always have fewer choices than Ethernet customers. Over the long term, an Ethernet network clearly provides more choices, both in terms of vendors and technologies.

If one cannot, or does not want to migrate to Ethernet, then the best choice is to build the switched network so that one can easily support both Token Ring and Ethernet users. The short-term solution may be to only support Token Ring users. If one builds an infrastructure that can support both, one can add Ethernet users in the future if the requirements change. Therefore, choose vendors that can provide a single backbone for both Token Ring and Ethernet, whether it be ATM, Fast/Gigabit Ethernet, or even HSTR. Ideally, you should not have to pay more for a backbone infrastructure that can support both Ethernet and Token Ring than you would pay for one that only supports Ethernet.

**SUMMARY**

It is possible to migrate to Ethernet from Token Ring, and there are short-term and long-term advantages in doing so. One can build higher capacity LANs at lower cost with Ethernet than with Token Ring. There are a
few features and functions that one has to work around (e.g., duplicate MAC address support), but one gains better support for IP multicast. So, should one migrate?

This is a decision that only the network manager can make. If one needs to keep up with the latest networking capabilities and new applications, migration to Ethernet is a wise choice. If one has limited resources and no major needs to change, enhancing the existing Token Ring network may be the best choice. If one chooses to stay with Token Ring in the short-term, make sure that the backbone solution can support Ethernet users in the future. This will minimize headaches if one decides to migrate to Ethernet in the future.

Exhibit 3 summarizes a series of factors that can be used to determine which issues are the most important in your network. After ranking the items, sort them from high to low, and see which technology best satisfies the most important items. Enter an importance factor for each item (1 is low; 5 is medium; 10 is high).

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