Why is access to System/390 and AS/400 terminal applications using the Internet so important? There are three basic reasons.

1. These terminal applications represent a large percentage of the data and logic of a typical enterprise.
2. There is a huge installed base of users who are currently accessing these applications productively.
3. New devices and end systems are being enabled with technology to access these applications.

ENTERPRISE DATA AND LOGIC
For larger enterprises, 70 percent or more of their mission-critical data resides on mainframes. While System/390 and AS/400 terminal applications are typically referred to as legacy applications, they collectively represent a vast majority of the business infrastructure upon which our economy rests today. And with a solid foundation of business logic that represents a history of investment, users of these applications rely heavily on their ability to access them to perform daily business transactions.

USER PRODUCTIVITY AND CONFIDENCE
Most of these terminal applications emerged in the late 1970s and early 1980s during the evolution from batch to online processing. Brought about by the introduction of the computer terminal and System Network Architecture (SNA), online pro-

PAYOFF IDEA
Successfully integrating SNA host terminal applications into the Internet requires standardization that includes interoperability, security, manageability, and extensibility. This article introduces to Information Technology executives why it is important to provide Internet access and outlines key Internet standards activity for integration of host SNA terminal applications.
cessing gave rise to more direct access to enter, view, and alter information by the end user (see Exhibit 1). This empowered the individual and allowed productivity to soar. The ongoing reliability and availability of these terminal-oriented applications fostered confidence in the Information Technology (IT) professional and the end user to commit to completing ever-increasing volumes of transactions interactively.

NEWER PLATFORMS AND DEVICES
Since their introduction, personal computers have been used to emulate the terminal functions without requiring change to the host application. This emulation, along with new personal computing paradigms for down-sized solutions and client/server distributed platforms, has not displaced System/390 and AS/400 terminal applications. Rather, the technology that these approaches of the 1990s represented has propelled end user productivity to new heights. Greater end-user mobility has also contributed to this technology, which enables the use of much smaller yet powerful devices such as laptops and PDAs (see Exhibit 2).

With more power at their fingertips, the demand by users for access to System/390 and AS/400 terminal applications remains high as even newer and more innovative approaches are developed to manipulate and present the information that these applications maintain.

The most recent contributor to this demand has been the increased number of users served by the advancement of the Internet and World Wide Web. Viewed as the open global information highway, the Internet is expected to provide worldwide access between the information provider and the consumer. Electronic commerce (E-commerce) has quickly become the model for conducting business involving the Internet in the
next millennium. It then stands to reason that if one intends to participate in E-commerce, then System/390 and AS/400 terminal applications must be accessible to end users using the Internet. See Exhibit 3.

Basic to the Internet is use of Transmission Control Protocol/Internet Protocol (TCP/IP). Standards have been developed to enable access to
SNA terminal applications using TCP/IP. These standards are TN3270 and TN5250. Client and server implementations of TN3270 and TN5250 provide access without requiring change to the host application. See Exhibit 4. These standards are actively evolving to adopt additional Internet technologies associated with Web browsers and programming. The remainder of this article will address the TN3270 and TN5250 standards for using the Internet to access System/390 and AS/400 terminal applications.

HOW DOES STANDARDIZATION HELP?
The Internet consists of processors that are interconnected via transmission links. Some of the processors are designed to do a special task such as establishing a path or routing the information along to the next destination, while other processors provide services to end users such as security or information retrieval. Typically, the processor that the end user operates directly is called the client, and the processor that contains the application is called the server. To access a particular application, an end-user request may pass from the client through multiple processors before reaching the correct server. The manner in which these processors communicate is through the use of protocols.

Left to chance, it would be very unlikely that any of the independent implementations of hardware and software would operate well — if at all — with other implementations. This creates a multitude of business and technical challenges for IT professionals and their end users. Therefore, consumers expect developers of Internet products and services to follow specifications, known as standards produced by the Internet Engineering Task Force (IETF). The IETF is the organization that facilitates open participation in producing Internet standards and promotes interoperability among various Internet components from different sources. The benefit of greater interoperability among particular implementations is higher confidence in their use and the use of the Internet overall. More information on the IETF is available at the http://www.ietf.org Web site.

PROTOCOLS
A closer examination of the various components of TN3270 and TN5250 allows one to better understand the benefits of standardization. One begins with the protocol. Simply stated, the protocol is the manner in which two components establish and maintain communications. As observed in Exhibit 4, there are two network protocols involved to allow end users to access SNA applications via the Internet: TCP/IP and SNA (Systems Network Architecture). Any enterprise with 3270 or 5250 terminal applications will have SNA protocol. Also, any enterprise with access to the Internet will have TCP/IP. Enabling users to be connected to the Internet using TCP/IP and have access to SNA applications requires two key components, referred to as servers and clients (Exhibit 4).
EXHIBIT 4 — Internet Protocol to Access SNA Applications
Servers
A server has the important role of initiating, managing, and terminating the SNA flows required by the OS/390 and AS/400 applications business logic. This is depicted as “A” in Exhibit 5. A server can include the entire protocol stack or use the programming interface provided by an existing stack. The SNA resources assigned to the server are used to support requests from the end user. A server may reside on the same processor as the application or on a different processor.

The server passes the SNA datastream received from the terminal application to the end user by supporting the TCP/IP flows to and from the client. Requests and responses flow to and from the user on the TCP/IP connection maintained by “B” in Exhibit 5. A server may provide the TCP/IP stack or rely on the use of the programming interface of an existing stack. The role of “C” is to pass the datastream between “A” and “B.” Early implementations of TN3270 and TN5250 servers conveyed only the datastream and very little information to the client about the SNA connection. The latest specifications include many more options for passing additional information to the client about the SNA connection and resources.

Clients
The client maintains the graphical end-user interface (GUI) and connection to the server (see Exhibit 6). Component “D” is responsible for initiating, maintaining, and terminating the connection to the server using TCP/IP. Just like the server, it can include the TCP/IP stack or use the programming interface of an existing TCP/IP stack. Component “E” sends and receives the datastream with the SNA terminal application and provides the GUI to the end user. The latest specifications include more options that enable the client to provide the user with many more choices for presentation of the information.

Because multiple client and server implementations exist in the market and the client implementation can be obtained from a different source than the source for the server implementation, one can readily see how interoperability could be an issue without the benefit of standards. Keep in mind that standards evolve and do not always address every unique circumstance. Therefore, they allow for options that are left to the discretion of the implementers. Although a TN3270 or TN5350 client or server makes a claim of support for the standard, it is the set of options that should be examined closely against the requirements to determine the best solution for a business. Options for supporting such technologies as security, management, and programming should receive particular attention.

INTEROPERABILITY
The IETF charters working groups to address particular Internet problems or requirements. The TN3270E Enhancements Work Group was
EXHIBIT 5 — TN3270 and TN5250 Server
EXHIBIT 6 — TN3270 and TN5250 Client
such a work group chartered under the Applications Division. This work
group has produced a number of specifications for enhancing TN3270
and TN5250. In support of the implementation of these specifications,
the work group has conducted a number of interoperability tests.

Basic interoperability testing focused on:

• how well the server connected with the SNA application
• how well the server connected with the client
• how well the client connected with the server
• how well the client displayed the information

Results from the interoperability have been the consistent interpreta-
tion of the specifications, the increase in the number of new clients and
servers, and the solidification of the protocol on which to base additional
enhancements.

Enhancements
As end users access System/390 or AS/400 SNA terminal applications
from the Internet, certain characteristics, which existed in their prior ac-
cess, are expected. The work group has defined specifications to support
these characteristics that include:

1. Security (encryption, authentication, authorization). This specifica-
tion addresses the application level security based on the Transport
Layer Security (TLS) standard and Secure Sockets Layer (SSL).
2. Management (configuration, response time monitoring). Two MIB
specifications here address the configuration and response time
monitoring for service-level management.
3. Performance (service location, session balancing, caching). This
specification addresses the use of the Service Location Protocol (SLP)
standard to identify services dynamically and learn their current
workload factor.

Current efforts are under way by a number of vendors to implement
these new specifications. These capabilities will enable IT professionals
to deliver consistent levels of service to their end users when using the
Internet.

Programming
With the growing popularity of E-commerce, independent software ven-
dors (ISVs) want to deploy more Internet-ready applications. Most ISVs
traditionally rely on the ability to build their services on top of clients and
servers. Users want to integrate information from a variety of sources and
formats with the data available from SNA terminal applications. Satisfying
the need of the ISV and end user in this problem space requires new pro-
gramming capabilities extensible to the Internet user. This leads to the
use of object classes, object interfaces, and transform services. The sup-
port for Hypertext Markup Language (HTML), Java, and XML in browsers
requires new programming interfaces, which provide programmatic in-
teraction with the SNA terminal application.

SUMMARY
The use of the Internet to access SNA terminal applications is considered
to be rejuvenation as it opens up new markets and expands the reach of end
users. TN3270 and TN5250 specifications are designed to support the
needs of these applications. Interoperability and standardization have es-

established confidence in their use. Migration to these technologies by
the enterprise results in:

• no change to the terminal application
• reduced SNA networking complexities
• consistent user interface and tools
• E-commerce enabling

When selecting an implementation of a TN3270 or TN5250 client or
server, always request interoperability information for the implementa-
tion from the provider. This information should state how well this im-
plementation operates with similar implementations from other sources.
An implementation that has not been well tested with other implemen-
tations may be lacking in capability and leave requirements unsatisfied af-
after installation. If the provider is unwilling to produce such information,
one should ask oneself the question, "Do I really want my mission-criti-
cal applications to depend on this implementation?"

INTERNET INTEGRATION
The TN3270 and TN5250 standards established by the IETF paved the
way for the next generation of technologies for Internet integration of the
System/390 and AS/400 SNA terminal applications. Comparing the role of
the protocols to that of a typical package delivery service, the emphasis
is on preservation of the package or datastream (sometimes referred to
as the payload) from end to end. This gives the most consistency in be-
havior for presentation of information to the end user when compared to
the original terminal or emulator. See Exhibit 7. When the application
creates the datastream (1), it remains intact and unchanged as it travels
to GUI (6). Although use of the Internet is made to carry the datastream
to the end user, this does not support integration of the information with
other Internet applications.
The Web browser has introduced a new behavior that can enhance the presentation of the information to the end user. The use of a browser may require transformation of the data stream into another format — HTML and XML technologies use transformations. Java, on the other hand, does not require a transformation of the data stream. As an applet, it is designed to correctly process the original data stream. Typically, the transform occurs at point 3 in the flow in Exhibit 7. However, some designs may actually not perform the transform until point 6.

One can see that careful thought should be given to where the transform occurs. Performance and function can be significantly affected. The use of objects to assist in processing the data stream is advancing the use of transforms. This is the momentum behind such efforts as the Open Host Interface Objects (OHIO) specification to establish an industry standard. By placing object interfaces into point 3 or 6 greatly enhances the capabilities of vendors and users to integrate the information from SNA terminal applications with other Web and Internet bases while maintaining function and performance. All the excitement of E-commerce has brought a number of new players to the market, providing SNA terminal application integration into the Internet. How consistent these implementers are in developing and using transforms and objects can impact E-commerce deployment within an enterprise. One should know where and how the transform is achieved before committing one's business to a particular implementation.

LOOKING FORWARD
Many of today's business processes (e.g., inventory, finance, claims, manufacturing, shipping) lack integration with the Internet due to a previous inability to offer services to end users that they needed and were accustomed to using. Slow progress is partly attributed to insufficient security and manageability. Although still maturing, recent enhancements in the market have produced better solutions that enable enterprises to speed up Internet integration of their host terminal applications and enter into E-commerce.

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