ELECTRONIC DATA INTERCHANGE

Organizations are increasingly adopting electronic data interchange (EDI) for performing basic business transactions to become competitive and flexible in the global marketplace. To successfully reap the benefits of EDI, organizations must integrate their application systems with the EDI systems. This integration can be achieved by properly understanding the different subsystems involved in EDI. This article discusses the EDI standards, the hardware, the software, and the communication networks required for both domestic and international interchange of transactions. EDI translation software converts transactions into ANSI ASC X12 or EDIFACT format. Communication networks with the help of communication software transmit these standardized transactions to the trading partner's application system for appropriate response. Installation, maintenance, and control procedures are needed for proper operations of the EDI system.

Electronic data interchange is the process by which a business organization exchanges business transactions between

J. Webster (ed.), *Wiley Encyclopedia of Electrical and Electronics Engineering*.

application systems in electronically processable forms. In this process, an automated business application system originates the transaction, the value-added network transmits it to the receiver, and an automated business application system at the receiver adequately responds to the transaction. For example, at a store, the bar code scanner at the cash register can update the inventory for each item sold. If inventory falls below some predetermined number, the bar code scanner system triggers an ordering system. The ordering system creates an order and hands it over to the EDI system. The EDI translator translates the purchase order into a standardized transaction set according to ANSI ASC X12.850 standards and electronically sends the purchase order to a vendor's mailbox using an EDI value added network (VAN). Human intervention is not needed in any step of the whole process. It is clear from the above example, for EDI to be successful, integration must exist among various business application systems and the EDI software. The EDI system should support the seamless location, transfer, and integration of business information in a secure and reliable manner.

EDI uses computers to transmit business transactions and in the process eliminates paperwork significantly. With this paperless transfer of data one does not have to rekey the information at the receiving end. Therefore, errors, time, and costs incurred in the rekeying of data are saved. This automatic creation and transfer of business transactions enables organizations to improve accuracy of business data, better serve their customers, improve relationships with suppliers, and effectively compete in the global markets. For example, just-in-time (JIT) inventory control practices that have significantly cut inventory costs would be difficult to implement without EDI.

In addition to the above-mentioned direct benefits, EDI provides many indirect benefits. EDI standardizes business transactions for the whole industry as participants in EDI must agree in advance on what data are to be exchanged, in what order, and what format needs to be used. This standardization helps in streamlining the transaction process, as parties do not have to go back and forth asking for clarifications or missing data. The federal government as well as major companies expect their suppliers to use EDI. For example, the U.S. Department of Defense will not transact business with a vendor any other way except through EDI. So a vendor has no choice but to have EDI capabilities. This paper details EDI system components and processes needed to implement EDI.

EDI SYSTEMS AND PROCESSES

To automate transactions processing among different business partners, a successful EDI system has the integrated components shown in Fig. 1 (1,2).

STANDARDS

Every industry has a set of transactions. Different terms have specific meaning and usage in a specific industry. Standards are needed so that transactions are formatted in a structure that can be processed by the transaction processing systems of the industry. Standards provide the framework for formatting any specific transaction. ANSI ASC X12 and EDIFACT are the two predominant standards.

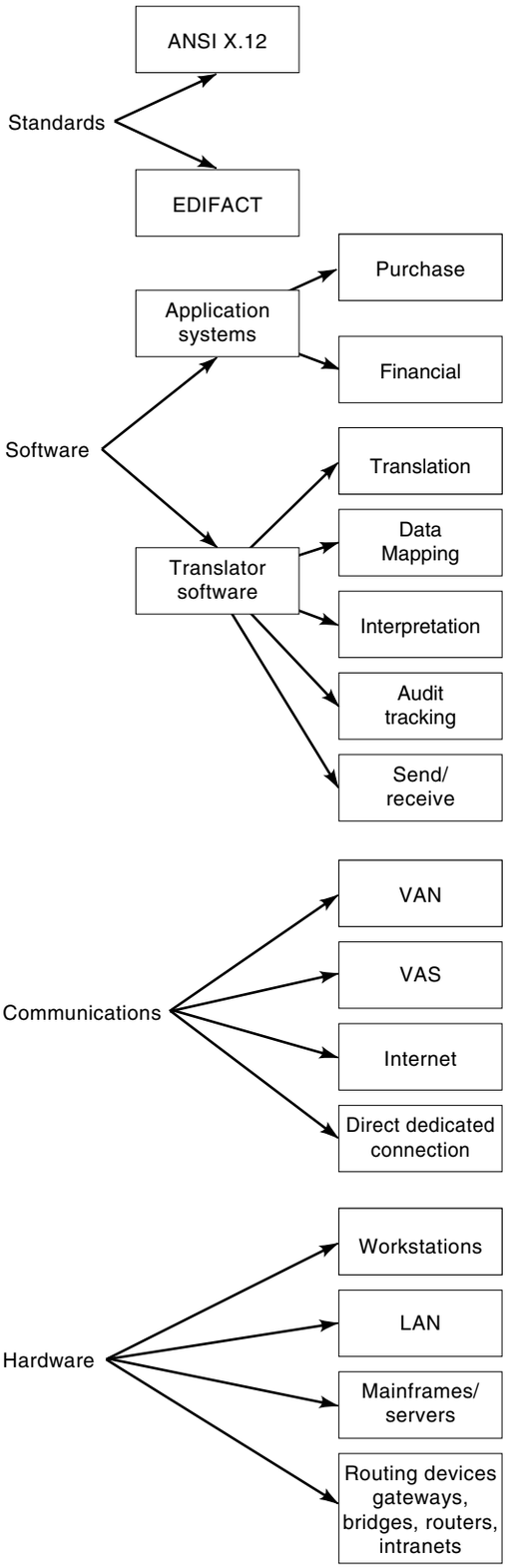

Figure 1. EDI system and processes.

ANSI ASC X12

The American National Standards Institute (ANSI) is the national body that coordinates the development of standards in all areas of business. ANSI created the Accredited Standards Committee (ASC) X12 and gave it charter to develop a set of standards for electronic exchange of business transactions. ANSI ASC X12 standards define the data structures and the rules for encoding business transactions. Following are the structures used in ANSI ASC X12 standards:

Data Element. This is the very basic or elementary unit of information. For example, item number, quantity, item description, and so on. The characteristics of each data element are defined. A group of simple data elements that represents a single named item is known as composite data element. For example, if a piece of metal has to undergo seven different machining processes, then 1c234de represents those seven machining processes.

Data Segments. A data segment consists of a group of related data elements. These logically related data elements are arranged in a predefined sequence to generate a data segment. For example, an address segment consists of a group of data elements, that is, company name, city, state, and zip code. A segment contains some data elements that are essential while other data elements may be optional. Some of the optional data elements may not be applicable for a business, therefore, they are omitted in the transaction. When a data element is omitted, the data element separator should explicitly indicate such an omission. For example, a purchase order can be sent as follows:

PO1100*EA*50.00**VC*P123**

*	Element separator
PO1	Purchase order 1
100	Quantity
EA	Each
**	Omitted data element
50.00	Price
VC	Vendor catalog
P123	Part number P123

Quantity: 100
Unit: Each
Description: Part No. 123
Unit Price: 50.00
Total: 5,000.00

Transaction Set. A transaction set consists of a group of related data segments that must be present to provide information for a viable business transaction. For example, transaction set X12 840 is request for quotation (RFQ). This transaction set X12 840 provides the information about different data segments and data elements that are required to make RFQ a meaningful transaction. Similarly, X12 850 is a purchase order and X12 855 is a purchase order acknowledgment. To create a format for a transaction, one has to define:

- Segments to be used
- Structure of each segment
- Data elements to be used in each segment
- Characteristics of each data element

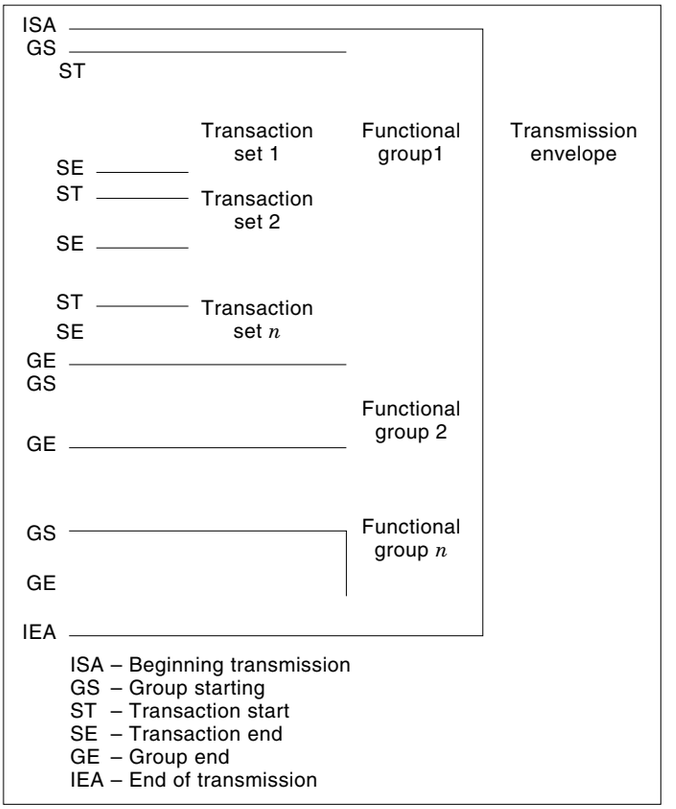

Figure 2. EDI envelope and group mapping.

Functional Group. A functional group consists of a group of similar transaction sets. For example, if there are three requests for quotation (RFQ) for three different items to be sent to same trading partner, the EDI software would create one interchange with one RFQ functional group. This RFQ functional group will contain three different transaction sets, one each for three different items. Some EDI translators allow several different functional groups to be included in one interchange. For example, if two responses for request for quotation (RFQ) and five purchase orders are being sent to the same trading partner, the EDI translation software will create one interchange that contains two functional groups, that is, one RFQ response functional group and one order functional group.

Envelope. An EDI envelope is a specialized segment that contains (a) routing information, that is, it provides addresses of both the sender and the receiver for electronic transmission. The address segment marks the beginning of the transmission, (b) the date and timings of the EDI interchange, (c) the unique control number used for tracking the transaction, (d) the authorization and security information, (5) the EDI standards and version of the interchage, and (6) number of functional groups in the interchange. Figure 2 explains the structure of EDI envelope, arrangement of functional groups, and transaction sets (1,2).

EDIFACT

For international trade, the United Nations rules for electronic data interchange for administration, commerce and transport (EDIFACT) provide a set of standards, directories, and guidelines that have been internationally agreed upon for electronic exchange of structured business transactions. EDIFACT is a global attempt to standardize such information exchanges so all computers involved are speaking the same language. This will create an open system that anyone can join at any point. EDIFACT is designed to be independent of software, hardware, or communication media, thus accomplishing universal connectivity. The International Organization for Standardization (ISO) adopted the EDIFACT syntax in 1987.

To achieve global open EDI one can use EDIFACT document syntax rules, X.400 message handling systems, and X.500 directory services. X.500 directory services can be used to store product information so that purchase managers can order electronically. These X.500 directory services are a powerful tool that allows EDI to take place between organizations without prior EDI agreements.

Both the ANSI ASC X12 and EDIFACT standards perform the same functions. ANSI ASC X12 is an older standard and provides many more functions than EDIFACT. The EDIFACT organization is trying to develop additional functions. The two standards have different syntax and therefore it is difficult to convert transactions from one system to the other. In January 1995, the ANSI ASC X12 development body decided to follow the syntax and standards of EDIFACT so that full compatibility is achieved. EDIFACT can be used for both domestic and international interchanges while ANSI ASC X12 is mainly for domestic interchanges. One can obtain a complete listing of both these standards from Ref. 3.

EDI SOFTWARE

An organization may have automated applications in the area of finance, marketing, accounting, production and operations, and human resource management. Data are entered into these application systems and transactions are generated which may have to be communicated to business partners. These business information systems call on EDI software to establish and maintain standards and hand-shaking rules for communicating among business partners. EDI software defines the methods, timings, and routines for receiving, transmitting, storing, and updating transactions among application systems (see Fig. 3). EDI software makes the exchange transparent, that is, hides the complexity of the underlying communication protocols from the end-user. A good integrated EDI software package provides the following functions:

- Application interface
- Translation
- Data communication

Application Interface Software

As the term indicates, the application interface software is the software bridge that facilitates the interface between the business application system and the EDI standards translation software. This software enables transparent flow of transactions among business partners. After the required data have been entered in the application software and the transaction is ready to be transmitted to the receiver, this software retrieves transaction data from the application database and places them into a flat file for subsequent conversion into EDI-formatted data prior to transmission to trading partners. Flat files are used to pass transaction data between an application system and the EDI translation software. System interface software is important for both outgoing and incoming transactions as it either reads or writes flat files of transaction data. For incoming transactions, this software retrieves data from a flat file and prepares them for acceptance by the application system. Some transaction software packages may not use a flat file because they exchange data directly with the application system database, thereby eliminating the need for interface software.

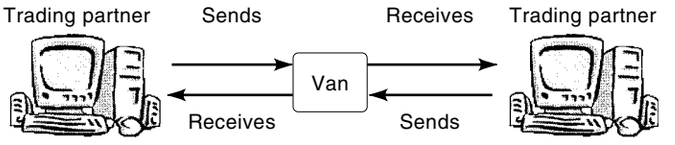

Figure 3. EDI process.

Standard Translation Software

A business organization transacts business with many trading partners. Some degree of flexibility is needed to support communication with the various trading partners because the need may exist to modify a trading partner's data to ensure compliance to the standards and to facilitate integration with the user's application system. EDI translation software allows for both the semantic and syntax translation of data elements. A summary of the characteristics of a standard translation software listed by the National Institute of Standards and Technology is as follows:

Transaction Set Mapping. Translation software translates data retrieved from an application database into a standardized EDI format before it is transmitted to trading partners. It also converts EDI formatted data, for example, in ANSI ASC X12 format, received from trading partners into a file format that the application system recognizes. Before the translator can translate data, it must know the location of data to be translated. Some translators require users to create a separate flat file formatted as ASCII text file. Such a flat file helps in the standardization of data from various files and different formats. Some translators have a utility called "transaction set mapper." The transaction set mapper cross-references the contents of flat file with an EDI standard set and subsequently translates the flat-file information into the desired transaction set. Mapping from/to the standards to/from the application formats is one of the key functions of translation software. The mapper reduces the amount of programming for application system interface. Data manipulators map internal data fields to applications according to an ANSI ASC X12 transaction set. This enables different trading partners to exchange transactions.

Character Set Conversion. If business applications of the trading partners use different character sets (ACSII and EBCDIC), the need may exist to convert one to the other. Sometimes EDI software may do the conversion or, if VAN is used, it will do the required character set conversion.

Code Conversion. Codes used in a vendor's application program might be different from the standard EDI codes. For example, the X12 ID Qualifier for serial number is SN while a user application might use the code SRNUM to identify a serial number. The EDI software converts the standard codes to and from the user's code to facilitate integration between the user's application and EDI software.

Automatic Compliance Correction. For both inbound and outbound data, EDI software verifies the identity of trading partners, the syntax of the data, and whether it complies with the EDI standards and version being used. To do this verification EDI software references its tables of EDI standards at the user's trading partner profiles. Some simple errors are automatically corrected by adjusting the data to make them comply with the standards.

Manual Compliance Correction. Some compliance verification errors may be so severe that EDI software cannot make automatic correction to them. In such circumstances, the software suspends the processing so that an end-user can review the transaction, correct the errors, and submit the transaction for reprocessing.

Duplicated Number Detection. Some EDI software tracks the use of business document numbers, such as purchase order numbers. If a number is duplicated, the software identifies the duplication and can take several different actions. It can either display or log error messages, or it can suspend processing of the transactions until the end-user can correct the duplication.

Functional Acknowledgment. Senders of transactions would like to know if the recipient received the information. The ANSI ASC X12 997 transaction set is known as functional acknowledgment. The recipient uses functional acknowledgment to send the sender an acknowledgment of EDI transaction. It verifies the acceptance or rejection of a transaction set and reports any syntactical errors. Generally EDI translators are so configured as to automatically return functional acknowledgment.

Document Type Sequencing. Control numbers are used to identify functional groups in an exchange. There may be several different kinds of document types within the multiple functional group. These document types are also identified using control numbers. Each trading partner may have a set of functional group and document control numbers sequentially. It is easy to find a missing document from transmission by viewing the lapses in document control numbers.

Multiple Functional Groups. Some EDI translators permit multiple functional groups in one interchange. For example, if three Invoices (ANSI ASC X12 810) and two request for quotation (RFQ) (ANSI ASC X12 840) responses are being sent to the same trading partner, the EDI software creates one interchange containing two functional groups, that is, one functional group for invoices and other for RFQ responses. If the software does not support multiple functional groups, then two interchanges would be needed, one for each functional group. The second interchange would cause increased overhead in terms of double transmission costs and greater storage requirements.

DATA COMMUNICATION SOFTWARE

The communication software establishes the communication link between the sender and the receiver. One can use a general purpose data communication software for operating the modem dialing and connecting to VANs. To achieve this job the communication software has to perform several tasks (1).

Protocol(s) Support. Communications software must support the required protocol(s). Some EDI software include asynchronous transmission; others provide bisynchronous transmission. These programs would provide seamless transmission if they were fully integrated with simple mail transfer protocol (SMTP) or X.435.

VAN Script Files. For communicating with the VAN, the sender initiates a session. This session is governed by a predefined set of commands called "VAN script," which are specific to the VAN's host computer. The functions of a VAN script are as follows: (a) dials into the VAN; (b) recognizes the login name and password for allowing access; (c) deposits EDI messages to be delivered to trading partners, and (d) retrieves EDI messages from the mailbox.

Unfortunately, there is not a standardized set of commands for communicating with VANs. Different VANs may have different VAN script. Therefore, when purchasing EDI software the user should make sure that it has the VAN script that enables the user to communicate with the available VAN services. VAN providers know this difficulty and therefore generally provide to the VAN subscribers the software required for communicating with the application systems. A software vendor that offers scripts for several different EDI VANs is a desired choice for purchasing EDI software.

Multiple VAN Support. Trading partners of an EDI user may subscribe to many different VANs. Therefore, the communications software must be flexible so that it can connect to many different VANs.

Direct Trading Partner. Some trading partners may use VAN services while others might not use VAN services. Those who are not using the VAN services have to be connected directly by the EDI software. For receiving messages from these direct trading partners a dedicated computer system is required, because there is no VAN to provide store and forward message capabilities.

Script Building Tool. In some cases, a trading partner may have to connect to a VAN or directly to a mainframe computer for which no communication script is available. EDI software that has capabilities of building script can help in such situations by creating custom scripts for connecting to other VANs or directly to mainframes.

Communication Audit Trails. This can be used for verification that a transaction was communicated among trading partners. An audit trail may include:

- Times and dates of communication
- Identifiers
- Acknowledgments
- Error encountered if any and others

Viewing Utility. Large amounts of information are generated in EDI processes, such as audit trails, configuration data, functional acknowledgments, and others. Manually viewing or editing all these data may be cumbersome. Viewing utilities help in viewing various aspects of communication data.

Installation, Maintenance and Support

Several of the following functions are essential to install and maintain EDI software. Automated installation routines make it easy to install EDI software and update periodically because EDI software has to keep pace with the changes in standards and versions. Tracing facilities in the software provide a trace or show the way the transaction is processed. It helps in debugging translator software. Logging function provides the ability to maintain a computerized log of all interchanges and therefore provides an audit trail. Need may exist to permanently store some interchanges among trading partners for long period of time. The Archiving function helps in this long-term storage of data, either in regular format or compressed format. Over a period of time a lot of data from interchanges may accumulate. Automated purging utilities provide the ability to automatically purge data based on some criteria such as, starting and ending dates, particular partner, specific item, and others. Due to power failure or other reasons, the EDI process may fail during transaction interchange. Data recovery and restart utilities automatically recover the data and retransmit transactions that were not completed due to earlier failure.

EDI COMMUNICATION NETWORK

EDI needs a communication network that will transmit, receive, and store EDI messages and transactions, so that the entire communication process is fully automated. These networks can be classified as: (a) value added networks (VAN) and value added services (VAS), (b) Internet, and (c) direct dedicated connections.

Value Added Network (VAN)

VAN is a store-and-forward mechanism for exchanging business transactions. VAN performs EDI requirements as VAN acts as the communication facilitator that provides the functions of transmitting, receiving and storing messages (see Fig. 4). The easiest way to start communicating with the trading partners is to subscribe to a VAN. A VAN operator provides the EDI communication expertise and equipment necessary for electronic communication. VAN providers also provide value added services (VAS) such as consulting and training in mapping of EDI transactions, coding VAN communication script, on-site EDI software and hardware installation, and others.

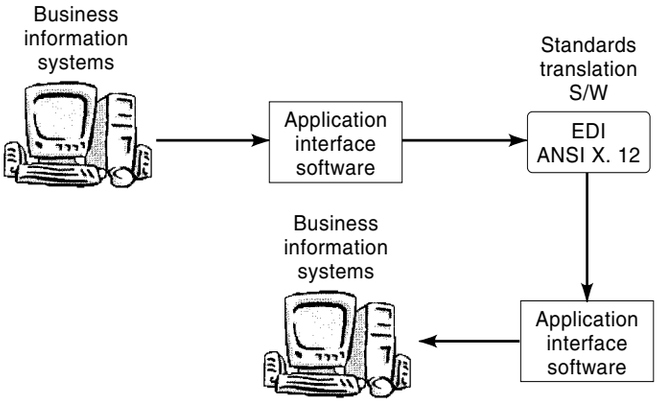

Figure 4. Commercial value added network.

VANs are the most widely used communication networks for EDI communication, because increased competition among the VANs providers has resulted in low prices for VAN services, and that has facilitated organizations to outsource the delivery of wide-range data and message services. In an increasingly competitive marketplace that demands efficiency and fast responses to customer needs, organizations have to focus on their core business. So, an organization may wonder, why struggle single-handedly trying to support national and international voice and data traffic when VAN service providers are ready to assume those responsibilities at very competitive prices? VAN services provide the most current technology, economies of scale, customer service, fault management, and others. VAN provides single communications access point, twenty-four-hour access and support, control reports on EDI traffic, and reliability of services. Advantages of VAN are as follows (1,2,4):

- VAN is generally available throughout the day, 24 hours a day.
- Any trading partner is just a call away to VAN.
- VAN provides the mailbox capability, that is, messages are routed, stored, and forwarded any time of the day.
- VAN capabilities are available irrespective of geographical location or time.
- VANs support different speeds and protocols.
- VANs provide reliable connectivity to trading partner.
- VANs provide security for transactions.

Users can schedule when the VAN script is executed. Execution of VAN script can be automated or manual. Automated execution is the preferred way, because a user can configure the communication software to call on VAN, for example, three times a day. In a manual system, the communications process will have to be started manually whenever desired. With manual control, the communications errors can be noted and corrected in real time.

There are several requirements that VAN must fulfill before it can be used (1,2,4):

1. VAN must support the protocol (asynchronous or bisynchronous) being used by the communication software. Some VANs may not support the X.25 protocol.

2. VAN must support the standards such an ANSI ASC X12, UN/EDIFACT, or industry specific TDCC, VICS, and so on.
3. No conflict should exist in the data segment and data element delimiters used by the trading partners and the VAN.
4. VAN should support the access method desired by the user, such as dial-up lines, leased lines, and so forth.
5. Data backup and recovery functions must be available.
6. Data security features should provide transmission status reports and usage accounting data.
7. Transmission timing should be short.
8. Additional value added services must be provided.

Support by VAN Service Providers. Support is essential for someone who has just bought EDI software. Users need guidance in installation, maintenance, and use of any new EDI software. Such user support can be provided both by the software and vendors. For example:

- User documentation, providing narrative text concerning the daily use of the EDI software
- Technical documentation
- Help success
- On-line tutorial
- Vendor services
- Training
- User group

Internet

The Internet provides the retailers and other businesses with the ability to communicate business documents electronically. The Internet provides a more convenient form of business communication. These on-line business transactions are more efficient and flexible. As no intermediary is involved, the cost of business transactions using the Internet is lower, compared to VAN-assisted electronic commerce. With the growth in Internet and related services, it has become possible for retailers to access a worldwide network of customers. VAN, as compared to the Internet's worldwide connectivity, has very limited connectivity to only a few thousand other paying subscribers. The Internet also provides interactive capabilities rather than just store-and-forward functions provided by VANs. These interactive functions provide browsing abilities to users and help retailers to market their products to a much larger audience. One major problem with the Internet is security, which is discussed in a later section.

Direct Dedicated Connections

There are many transmission and switching mechanisms that can make it feasible to have direct dedicated connection. Synchronous digital hierarchy, frame relays, and asynchronous transfer mode provide the potential for direct partner interface, mainly from LAN to LAN.

HARDWARE REQUIREMENTS

For operating the EDI software, communication software, and application systems, a business needs workstations, servers, and mainframe computers. For communicating with other organizations, LAN, WAN, Intranets, Internets, and other networks are needed. Routing devices such as gateways, bridges, routers, brouters, and others are needed for packet, message, or circuit switching. The detailed explanation of these hardware devices, network management devices, switching mechanisms, and communication protocols are beyond the scope of this article.

SECURITY

EDI demands that an organization become a part of a network. Once an organization becomes a part of a network, it faces challenges from unauthorized intruders and hackers. A list of control activities is provided to ensure that interchange of data takes place while maintaining the integrity of the computer systems.

Access Control. Access controls are required at initiation, transmission, and destination. These controls can be achieved by using password, user ID, storage lockout, and different levels of storage and function access.

Data Integrity. Authentication, acknowledgment protocol, computerized log, digital signatures, and edit checks can be used for detecting errors during the process of input or transmission. Authentication, integrity, confidentiality, and nonrepudiation can be achieved through public-key cryptosystems that employ digital signature, encryption, and key exchange technologies. Nonrepudiation can be accomplished through the use of certification authority. Upon user authentication, traditional access control or role-based access control methods can be employed to define access rights. For security many competing algorithms exist and may give rise to interoperability problems.

Digital certificates, electronic forms that encrypt and authenticate both ends of the same transaction, are crucial in enabling EDI over the Internet. They provide the level of security EDI users are accustomed to with existing VAN service providers. Digital certificates exist that are compatible with the standard ANSI ASC X12 data types. The Internet could prove to be a much simpler and cheaper transmission medium for EDI than VANs if adequate security is developed.

Transaction Completeness. To avoid loss or duplication of a transaction during transmission, one can use batch totaling, sequential numbering, and one-to-one checking against the control file.

Availability. Viruses, Trojan horses, programming errors, hardware and software errors may interrupt availability of EDI systems. One can use anti-virus packages to prevent viruses. By planning, developing, installing, and operating error-free software one can eliminate the problems of Trojan horses, viruses, and other software errors that lead to interruption of services. Fault-tolerant systems including off-site backup, redundant arrays of independent disks (RAID), disk mirroring, tandem computers, and other techniques help in avoiding interruption due to sabotage or natural causes.

SUMMARY

EDI is being used for accelerating the flow of business transactions among trading partners. Advances in computer and communication technologies have made it possible to create transactions in a few minutes and transmit them to trading partners in seconds. Standardization must exist among transaction formats for computerized communication to take place between application systems of different organizations. ANSI ASC X12 and EDIFACT are two dominant formats for domestic and international interchanges, respectively. The output of the senders' application system is sent to the receivers' application system with the help of application interface, standard translation software, and communication software. Understanding of the different components and their integration requirements helps in the successful implementation of EDI. Such a successful implementation reduces transaction costs, provides flexibility, and improves the competitive advantage.

ACKNOWLEDGMENT

This article is based on the fundamental concepts explained in *Guidelines for the Evaluation of Electronic Data Interchange Products* and *Electronic Data Interchange* (1,2). The framework of this article and many details are repeated from these documents.

BIBLIOGRAPHY

1. J. J. Garguilo and P. Markowitz, Guidelines for the Evaluation of Electronic Data Interchange Products [Online], *National Institute of Standards and Technology,* Available www: http://www.snad.ncls.gov/
2. Anonymous, Electronic Data Interchange [Online], *National Institute of EDI,* Available www: http://www.fie.com/web/era/introedi/index.html/
3. Data Interchange Standards Association, Inc, Alexandria, VA.
4. Anonymous, Your Introduction to Electronic Commerce [Online], Business Handbook, Available www: http://ch5.htm at net.gap.net/

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