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Advisory editors **CHRIS ARGYRIS**
AND WILLIAM H. STARBUCK

VOLUME VII

**THE BLACKWELL
ENCYCLOPEDIA
OF MANAGEMENT**
SECOND EDITION

**MANAGEMENT
INFORMATION
SYSTEMS**

Edited by
GORDON B. DAVIS



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THE BLACKWELL ENCYCLOPEDIA OF MANAGEMENT
MANAGEMENT INFORMATION SYSTEMS

THE BLACKWELL ENCYCLOPEDIA OF MANAGEMENT

SECOND EDITION

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Edited by
Gordon B. Davis
Carlson School of Management,
University of Minnesota



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Preface

Information and communications technology has changed rapidly since the first edition of the *Blackwell Encyclopedia of Management*. Each wave of new technologies enables innovations in organization systems for information processing and communication. New ways of performing the transactions and management and knowledge work activities of organizations are made possible. Organization systems are no longer simple and easily constructed or modified; they are complex, depend on technology, and require significant effort to construct, implement, and modify. Managers and other knowledge workers at all levels in an organization can do their work better if they understand information systems. They can rely on technical personnel to handle the technical issues, but they need to understand the systems if they are to use them effectively and efficiently, and if they are to be able to specify improvements and innovative changes.

Information systems are vital to products, services, and management processes in an organization. A new organization function has been established to plan, implement, and manage the information technology infrastructures and systems required by an organization. The business function is justified by the size of investments in information resources and its importance to organizations. An academic discipline has also emerged to teach and research the use of information technologies in organizations and the management of information resources.

A variety of names are applied to the new organization function and academic discipline. The term, Management Information Systems or MIS, is widely used; other often used terms are information systems and information management. The term IT or information technology may also be used because of the importance of information and communications technology in information systems.

The focus of the *Management Information Systems* volume in the *Blackwell Encyclopedia of Management* is on information systems in organizations and the management of information and information system resources. There are articles describing the concepts, processes, and tools employed in planning, building, and managing information systems and information resources. Those persons in an organization who deal with or use information systems and information resources should have a user level understanding of systems, applications, and databases. They frequently need to understand the information and communications technology employed in the systems. They do not need to be technologists, but they need a user level or managerial level understanding of the technology. The emphasis of the MIS volume is on the systems, applications, and processes that are employed in planning, managing, and delivering information resources to an organization. However, there are also user level and management level explanations of technical terms that are relevant to dialogue about existing systems and opportunities and requirements for new applications. In other words, technologies that are important only to technologists are not included; technologies that are important to organization systems are explained. An example of a technology that is included is RADIO FREQUENCY IDENTIFICATION (RFID), a new technology that is the basis for new systems for managing inventory and tracking customer purchases.

A useful starting point for a user of the *Management Information Systems* volume is the entry on MANAGEMENT INFORMATION SYSTEMS. It defines and describes the management information system for an organization and the scope of the organization function that manages it. Underlying

concepts are found in entries on INFORMATION CONCEPTS and SYSTEM CONCEPTS APPLIED TO INFORMATION SYSTEMS.

The articles and definitions in the volume have been written by academics and professional colleagues working in the field of information systems. They were instructed to make the descriptions technically correct but understandable to a reader who is not a specialist in the field. The writers come from universities and companies in a number of countries. I appreciate their work.

Gordon B. Davis

About the Editors

Editor in Chief

Cary Cooper is based at Lancaster University as Professor of Organizational Psychology. He is the author of over 80 books, is past editor of the *Journal of Organizational Behavior*, and Founding President of the British Academy of Management.

Advisory Editors

Chris Argyris is James Bryant Conant Professor of Education and Organizational Behavior at Harvard Business School.

William Haynes Starbuck is Professor of Management and Organizational Behavior at the Stern School of Business, New York University.

Volume Editor

Gordon B. Davis is the Honeywell Professor of Management Information Systems in the Carlson School of Management, University of Minnesota. He pioneered in the academic field of information systems, beginning in 1967 with the first formal degree program in the United States. He participated in and helped form most of the academic associations related to the field. He has served as advisor, co advisor, or committee member to over 100 doctoral students, lectured in 25 countries, held visiting professorial appointments in Europe and Asia, written 21 books, and published over 200 articles, monographs, and book chapters. His book *Management Information Systems: Conceptual Foundations, Structure, and Development* has been recognized as a classic text. He has received recognition as an ACM Fellow, AIS Fellow, and AIS LEO award (for lifetime achievement in the field of information systems). He has a doctorate from Stanford University and honorary doctorates from the University of Lyon, the University of Zurich, and the Stockholm School of Economics.

Contributors

Dennis A. Adams

Bauer College of Business, University of
Houston

Gediminas Adomavicius

Carlson School of Management, University of
Minnesota

Gove Allen

Freeman School of Business, Tulane
University

Soon Ang

Nanyang Technological University, Singapore

Priscilla Arling

Carlson School of Management, University of
Minnesota

David Bahn

Metropolitan State University of Minnesota

Nicholas L. Ball

Carlson School of Management, University of
Minnesota

Robert J. Benson

The Beta Group

Paul L. Bowen

Department of Commerce, University of
Queensland

Eric S. Boyles

Consultant, St. Paul, Minnesota

Susan A. Brown

Eller College of Management, University of
Arizona

Glenn J. Browne

Jerry S. Rawls College of Business
Administration,
Texas Tech University

William J. Caelli

Information Security Research Center,
Queensland University of Technology

Christopher L. Carr

Katz Graduate School of Business, University of
Pittsburgh

C. Janie Chang

San Jose University

Norman L. Chervany

Carlson School of Management, University of
Minnesota

Roger H. L. Chiang

University of Cincinnati

Alina M. Chircu

McCombs School of Business, University of
Texas at Austin

Mary Beth Chrissis

Software Engineering Institute, Carnegie
Mellon University

Claudio U. Ciborra

London School of Economics and Political
Science

Elayne Coakes

Westminster Business School, University of
Westminster

x List of Contributors

Jim Coakes

Westminster Business School, University of
Westminster

Rosann Collins

University of South Florida

Wendy L. Currie

Warwick Business School, University of
Warwick

Qizhi Dai

LeBow College of Business, Drexel University

Amit Das

Nanyang Technological University, Singapore

Michael J. Davern

The University of Melbourne

Gordon B. Davis

Carlson School of Management, University of
Minnesota

Roger Debreceeny

University of Hawaii

William H. DeLone

Kogod School of Business, American University

Gerardine DeSanctis

Fuqua School of Business, Duke University

Roberto Evaristo

University of Illinois, Chicago

Gordon C. Everest

Carlson School of Management, University of
Minnesota

H. Kevin Fulk

Bauer College of Business, University of
Houston

Mark A. Fuller

Washington State University

Stefano Grazioli

McIntire School of Commerce, University of
Virginia

Jungpil Hahn

Krannert Graduate School of Management,
Purdue University

Scott J. Hamilton

The Manufacturing Guild, St Paul, Minnesota

Joel R. Helgeson

Appiant, Inc., Roseville, Minnesota

Nancy K. Herther

Wilson Library, University of Minnesota

Loke Soo Hsu

University of Singapore

Blake Ives

Bauer College of Business, University of
Houston

Rodger Jamieson

University of New South Wales

Andrew P. Jansma

School of Business and Economics, Michigan
Technological University

Brian D. Janz

University of Memphis

Sirkka L. Jarvenpaa

McCombs School of Business, University of
Texas at Austin

Jesper M. Johansson

Microsoft Corporation

Julie E. Kendall

Rutgers University

Kenneth E. Kendall

Rutgers University

William R. King

Katz Graduate School of Business, University of
Pittsburgh

Barbara Klein

Management Studies, University of Michigan –
Dearborn

Christine Koh

Nanyang Technological University,
Singapore

Vlad Krotov

Bauer College of Business, University of
Houston

Frank F. Land

London School of Economics and Political
Science

Linda Levine

Software Engineering Institute, Carnegie
Mellon University

Moez Limayem

City University of Hong Kong

Donald J. McCubbrey

Daniels College of Business, University of
Denver

D. Harrison McKnight

Eli Broad College of Business, Michigan State
University

Ephraim R. McLean

Robinson College of Business, Georgia State
University

Salvatore T. March

Owen Graduate School of Management,
Vanderbilt University

Richard O. Mason

Southern Methodist University

Manjari Mehta

Bauer College of Business, University of
Houston

Tarun Mital

Bauer College of Business, University of
Houston

Eve Mittleton Kelly

London School of Economics and Political
Science

William D. Nance

San Jose State University

J. David Naumann

Carlson School of Management, University of
Minnesota

R. Ryan Nelson

McIntire School of Commerce, University of
Virginia

Boon Siong Neo

Nanyang Technological University,
Singapore

Kathryn Ritgerod Nickles

School of Law, Wake Forest University

Steve H. Nickles

Babcock Graduate School of Management,
Wake Forest University

Fred Niederman

John Cook School of Business, Saint Louis
University

T. William Olle

T. William Olle Associates, Surrey, England

Jinsoo Park

Korea University Business School, Seoul, South
Korea

Stacie Petter

Robinson College of Business, Georgia State
University

Theresa M. Quatrani

IBM Software Group, Philadelphia

Reagan M. Ramsower

Hankamer School of Business, Baylor
University

Sangkyu Rho

Seoul National University

Dzenan Ridjanovic

Laval University, Quebec

xii List of Contributors

Frederick J. Riggins

Carlson School of Management, University of Minnesota

Thomas M. Ruwart

Digital Technology Center, University of Minnesota

Sandy Shrum

Software Engineering Institute, Carnegie Mellon University

Sandra A. Slaughter

Tepper School of Business, Carnegie Mellon University

Randy Snyder

Consultant, Wisconsin

Christina Soh

Nanyang Technological University, Singapore

Mani R. Subramani

Carlson School of Management, University of Minnesota

Nellai Subramaniam

Bauer College of Business, University of Houston

Jonathan K. Trower

Hankamer School of Business, Baylor University

Viswanath Venkatesh

Walton College of Business, University of Arkansas

Douglas R. Vogel

City University of Hong Kong

Lester A. Wanninger, Jr.

Carlson School of Management, University of Minnesota

Hugh J. Watson

Terry College of Business, University of Georgia

Ron A. G. Weber

Faculty of Information Technology, Monash University

James C. Wetherbe

Jerry S. Rawls College of Business Administration, Texas Tech University

Charles A. Wood

Mendoza College of Business, Notre Dame University

hardware based products and services. Such standards often relate to specific industries such as the banking and finance sector, health care, and so on.

See also *biometrics*; *cryptography* (*crypto*); *identity theft*; *phishing*

automated teller machine

ATMs are used in consumer (retail) banking. Customers may withdraw cash or enter deposits from remote locations. ATMs are typically connected to a network that allows customers from different banks or holding different credit cards to use them (*see* ELECTRONIC FUNDS TRANSFER).

B

bar code

Gordon B. Davis

Bar codes such as the universal product code (UPC) are important to information processing because they provide a low cost, well defined method for identifying products, parts, equipment, etc. The bar code itself consists of sets of black and white bars of different widths. There is a human readable interpretation of the bar code at the bottom of the bar code space. The bar code can be read by a hand scanner or by a checkout counter scanner connected to a cash register. For sales purposes, a UPC is assigned to a product and placed on a small rectangular space on the product package. In the case of a retail store, the data scanned from the bar code are input to a computer that looks up the price and provides it to the cash register. The computer also collects data for inventory updating and sales analysis.

A bar code can be used internally without obtaining an assigned code. For commerce purposes, a company, Uniform Code Council (UCC), assigns a unique six digit manufacturer identification number in return for an annual fee. The UPC used for a product consists of the manufacturer number plus a five digit item number and a check digit (for error checking purposes). There are rules for coding special situations such as coupons, items to be weighed on checkout, etc.

The advantage of the UPC bar code is its simplicity and the existence of inexpensive devices for creating tags for products. Separating the product identification from its selling price allows a retail store to change the price being charged without changing the price on each individual item. It reduces the need for a checkout clerk to enter a product identification number and a prod

uct price. A disadvantage is the possibility of a person making an unauthorized UPC for an item that shows a different (lower priced) item code, applying it to the item, and going through checkout with a lower price being charged. An alternative to a bar code is a RADIO FREQUENCY IDENTIFICATION (RFID), which contains coded data that is transmitted to a reading device.

batch processing

A term applied to periodic processing of transactions that are assembled into batches. See PROCESSING METHODS FOR INFORMATION SYSTEMS.

biometrics

William J. Caelli

The term “biometrics” is defined in the US’s NCSS Instruction 4009 (revised May 2003), an IT assurance glossary of terms, as encompassing “automated methods of authenticating or verifying an individual based upon a physical or behavioral characteristic.”

The term relates to the original definition of three ways to verify a claim of identity that emerged in the 1970s. These are proof of identity claimed by:

- what you know, such as a password, personal identification number (PIN), etc.;
- what you possess, such as a smart card, mechanical/electronic token, etc.; and/or
- what you are, such as a fingerprint, eye retinal pattern, voiceprint, DNA pattern, etc.

The most common biometric, in a historical sense, is the usual fingerprint used in police and like investigations. For added security, two or all of these may be combined and products incorporating all three factors are now coming to the market. Examples include a smart card that can sense and read a fingerprint which holds it while the associated card reader requires a password to activate the card itself. Problems with the wide spread introduction of biometric systems for increased overall system security and user identity AUTHENTICATION have included user acceptance and cost.

However, there are other problems that need to be considered in relation to the use of biometric systems. These include the following factors.

Should a biometric system be compromised in some way, e.g. a user's fingerprint be duplicated, it is more or less impossible to overcome the problem in a direct fashion. This is not the case with, say, the token or password situation where these can be changed and reissued.

In particular, it has to be observed that a biometric subsystem employed as a security scheme in an information system is only as good as the systems that protect the "string of bits" that represent the user's biometric measurement. So, for example, if a fingerprint scanner system is used and verification of the print pattern is performed by, say, a central server system, then the bit pattern that represents that fingerprint must be itself authenticated and kept confidential on an end to end basis. This usually means that some form of cryptographic algorithm and protocol set must be used to perform such a service, and this brings with it the necessity to manage that cryptographic subsystem and its associated keys with a very high degree of trust. It can also be argued that since such biometric systems may be used to produce data in the form of audit trails that provide evidence in a court of law, such systems should themselves be evaluated for their own security robustness using accepted national and international standards, e.g., IS 15408, FIPS 140 (for associated cryptographic services and related key management schemes), and so on.

The price of biometric units has collapsed since 2000 and such units as fingerprint scanners can now be observed in such items as laptop computers, cell phones, personal digital assist

ants (PDAs), access controls for doors, and other devices.

blog (weblog)

A blog is the web page that publishes the online journal of an individual. Many blogs are updated frequently, even daily, with entries describing events, emotions, or questions in the life of the individual. Some blogs become the basis for a discussion about issues such as health, handling personal problems, opinions, etc. The style is personal and informal.

See also *bulletin boards*

broadband

see ELECTRONIC COMMUNICATIONS

bulletin boards

Gordon B. Davis and J. Davis Naumann

Computer bulletin boards can be a valuable source of information for organizations. Three different types of information sharing groups have evolved: (1) bulletin board systems; (2) commercial discussion groups; and (3) personal discussion groups. Bulletin board systems are independent systems created and operated by entrepreneurs or organizations. The largest bulletin board system is the Usenet. These news groups number in the tens of thousands and are globally distributed over the INTERNET. The Usenet evolved with no central organizational structure. It has been the source of controversy and even legislation because of the lack of control over its contents.

A second class of discussion groups and information services is provided by the major commercial online vendors. The services are marketed for a relatively low monthly fee and hourly charge. They are one of the primary sources of technical information provided by information industry vendors. Vendors assign staff to follow their bulletin boards, post replies, announce problem

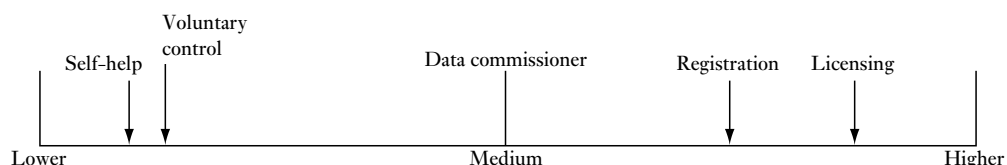


Figure 1 Regulation models: lower, medium, and higher refer to the level of government regulation in corporate privacy management (Milberg et al., 1995)

received and an investigation reveals a failure to adhere to data protection principles would a system be “deregistered.” Thus, this model provides more remedial than anticipatory enforcement of principles.

- 5 *The licensing model* creates a requirement that each databank containing personal data be licensed (usually upon payment of a fee) by a separate government institution. This institution would stipulate specific conditions for the collection, storage, and use of personal data. This model anticipates potential problems and heads them off, by requiring a *prior* approval for any use of data.

The US is usually described as intermingling the self help and voluntary control models. Germany is often viewed as a good example of the data commissioner model, the UK as the registration model, and Sweden as the licensing model. Some countries have no data protection laws at all (see Bennett, 1992; Madsen, 1992).

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processing methods for information systems

Gordon B. Davis

Processing methods are generally associated with transaction processing. Transaction processing is a basic organization activity. Without transaction processing, business transactions would not be completed. Without it, bills would not be paid, sales orders would not be

filled, manufacturing parts would not be ordered, and so on. Without it, data for management activities would not be available.

TRANSACTION PROCESSING CYCLE

The transaction processing cycle begins with a transaction that is recorded in some way. Although handwritten forms are still very common, transactions are often recorded directly to a computer by the use of an online terminal, desktop computer, or handheld device with communications capabilities. Recording of the transaction is generally the trigger to produce a transaction document or instructions that are displayed on a terminal, desktop computer, or handheld device. Data from the transaction are frequently required for the updating of master files; this updating may be performed concurrently with the processing of transaction documents or by a subsequent computer run.

The capturing of data on documents or by direct entry is a necessary first step preceding other activities in processing the transaction. For example, a sales order is manually prepared on a sales order form by a salesperson, a telephoned order is entered in a computer by a telephone salesperson, a cash withdrawal is entered in an automatic teller machine by the customer, and a reservation is entered by a travel agent using an online reservation terminal.

When a transaction is recorded manually, a copy of the document is usually used for data preparation. The transaction is keyed into a file using a terminal or data entry computer. The records of the transactions are used for processing. Many times, the documents involved are partially or completely coded. A bank check is precoded with the customer number and bank number; the amount of the check must be added. A turnaround document may be coded with much of the transaction data. An example is the part of the invoice returned with the payment; the turnaround portion may often be read with optical scanning.

Data validation is the testing of input data records to determine if they are correct and complete. This cannot be accomplished with complete assurance, but reasonable validation is usually possible. Validation tests applied against each data item or set of items may include tests for missing data, valid field size for each data

item, numerical data class test, range or reasonableness test, valid or invalid values test, and comparison with stored data. Identification numbers and processing codes are very sensitive to errors. They can be validated for size, range, and composition of characters. An additional, very effective, validation technique for codes is a check digit. It is a redundant digit derived by computations on the identification number and then made a permanent part of the number. During data preparation and input validation, the check digit derivation procedure is repeated. If the procedure performed during input results in a different check digit, there has been an error in recording or entering the identification number.

When input data items have been validated, the transactions are processed. Subsequently, two major activities occur during transaction processing: updating of machine readable stored data (master file) related to or affected by the transaction, and preparation of outputs such as transaction instructions, documents, and reports. In these activities, control information is also produced.

Transaction data output can be classified as to its purpose. There are three major reasons for producing transaction documents or other transaction outputs: (1) informational to report, confirm, or explain proposed or completed action; (2) action to direct a transaction to take place or be completed; and (3) investigational for background information or reference by the recipient. Action documents include shipping orders, purchase orders, manufacturing orders, checks, and customer statements. These documents instruct someone to do something. For example, a purchase order instructs a vendor to ship, a check instructs a bank to pay, etc. When action is taken, the completed action (or lack of completion) is reported back to the organizational unit initiating the action. A sales order confirmation verifies receipt of an order. Lists of checks not paid by banks represent a confirmation of completed action (if not on list, checks have been paid) and lack of completed action (by being listed as unpaid). A single document or different copies of it may serve both action and informational purposes. For example, one copy of the sales order confirmation may be sent to the customer to confirm the order; a second copy may

be used as an action document to initiate filling of the order.

Some transaction records are distributed to other departments in the organization to provide background information for recipients in the event that they need to respond to inquiries or need them for other reference. With online systems, a reference copy of the transaction can be stored in a computer file and may be retrieved via a terminal by anyone who is authorized and has need of the information. Transaction documents may also be used for managerial information or control scanning, as when a purchasing manager scans all purchase orders to spot unusual occurrences. In general, however, managerial information purposes are better met by reports or analyses that summarize transactions.

When transactions are processed, a transaction report is usually prepared for a period of time such as a day, a device such as terminal, or other basis for reference. The listing includes control totals for the number of transactions processed, total dollar amount of transactions, etc. The listing represents a batch of transactions received or input during a period of time. It provides a means of processing reference and error control.

METHODS FOR PROCESSING TRANSACTIONS

There are three different methods commonly used for processing transactions and updating master files: (1) periodic data preparation and periodic batch processing (usually termed batch processing); (2) online entry with subsequent batch processing; and (3) online entry with immediate processing (termed online processing). The choice of methods should reflect the underlying process being supported. If the underlying process is transaction oriented with immediate completion of the transaction desirable (as with order entry), online processing is indicated. If the process is periodic (as with payroll), batch processing is adequate.

Batch processing involves the accumulation of transactions until a sufficient number has been assembled to make processing efficient or until other considerations, such as a report cycle, initiate processing. The processing of batches can be daily, weekly, or monthly, depending on the volume of transactions and other considerations.

Batch processing of transactions can be very efficient in terms of data preparation and pro-

cessing of transactions. One major disadvantage of periodic batch processing is the delay in detecting and correcting errors. This is an especially serious problem for errors that can be found only when the transaction is compared against the master file. For example, if a transaction is coded with an apparently valid customer number for a nonexistent customer, the error will not be detected until processing is attempted against the customer file. The delay makes it difficult to trace the transaction back to the origination point and identify the correct customer.

With a batch system, the user prepares data input as a batch of transactions recorded over a period of time such as a day or week. A user responsible for processing data in a batch system must prepare input data in the exact format and with the exact codes required by the processing program, prepare control information used to insure that no records are lost or remain unprocessed, and check output received for errors (including checking against the control information prepared with input data). The user is also responsible for reviewing error reports, preparing corrections, and submitting corrections for processing.

When transactions are entered at an online terminal, the transaction is entered directly into the computer and validated immediately. The processing itself may be performed immediately or at a subsequent time as with periodic batch processing. One important advantage of online entry over periodic data preparation and input is that most of the validation may be performed while the transaction is being recorded. Many errors can therefore be corrected immediately while the person entering the transaction is available for correction. Often the user or customer originating the transaction is still available to make appropriate changes. In addition, the master files can be accessed for the detection of errors such as nonexistent master file records. In online entry with subsequent batch processing, the computer is used for direct data entry and validation, but valid transactions are stored for later periodic batch processing.

In *online entry with immediate processing*, the transaction is validated online and then processed immediately if valid. A response with the result of processing or a confirmation of

completion of processing is generally provided to the user at the input terminal. The advantages of this approach are the same as direct entry with subsequent processing (i.e., immediate validation with opportunity for immediate corrections by the person doing the input) plus the additional advantage of immediate processing with immediate results. The master files are always up to date. For instance, after an item is sold, the inventory master file reflects the actual state of the inventory for that item. The disadvantages of immediate processing are the somewhat higher cost of online processing versus periodic batch processing (requires greater computer power and often data communications) and the extra procedures required to produce adequate control information and to safeguard the files against accidental or deliberate destruction during online updating.

In online processing, the user has a terminal, microcomputer, or handheld device for the input of transactions and output of results. The input devices are connected by wired or wireless communication lines to a remote computer where processing actually takes place. Transactions are entered and processed one at a time as they occur (in real time). The user generally has to be identified to the system as an authorized user before transactions are accepted. System sign on and authorization usually uses a password protection scheme. Users may have different authorization levels which determine what types of transactions they may perform. For instance, a user may be authorized (via his or her password) to process certain update transactions (e.g., a sale) but not others (e.g., alteration of payroll data). The mode of operation is a dialogue. The dialogue may be extensive and provide tutorial and help information for entry of data, or it may be very limited and require the user to understand what data to enter and how they should be entered. A user responsible for processing data in an online system must enter transactions in the proper format based on a dialogue, a visual form, or instructions in a manual; respond to error messages (since the system should reject any invalid data) with corrected input; and review control information. At the end of a period of processing transactions, the user signs off, so that an unauthorized user may not subsequently enter data.

RETRIEVAL IN TRANSACTION PROCESSING

Many online systems use data retrieval software to support transaction processing. Even in applications where batch updating is appropriate, the capability to access related records during transaction preparation is often desired. For instance, a bank may install online terminals so that customers may inquire about the status of their accounts. A customer complaint department in a retail catalogue company may check the status of an order when a customer calls. In these examples, online inquiry into master files is required.

Inquiries associated with a transaction processing system tend to be fairly structured, so that they may be programmed to use a standard set of commands that can be mastered fairly easily. In some systems, commands can be assigned to special function keys on the keyboard so that the operator needs only to press a single key rather than type in a command. Terminals that are only to be used for inquiries, such as terminals for customer use on a bank floor, may be specially designed with only function keys.

INFORMATION PROCESSING CONTROLS

Control of transaction processing begins with the design of the document or screen for initially recording the transaction. If the document is manually prepared, it should be designed to minimize errors in completing it. This requires adequate space, unambiguous directions and labels, and a sequence of recording that is natural to the preparer. Boxes, lines, colors, labels, and menus of alternatives are some of the methods used to aid the preparer. One serious problem is how to make sure every transaction is recorded and entered into processing. Interruptions or carelessness may cause a transaction to not be recorded or the source document to be misplaced. To prevent or detect such errors and omissions, the transaction processing system may have one or more controls such as the following: (1) computer defined transaction number or prenumbered source document; (2) record anticipating a transaction (such as payment due); (3) document produced as a by product; or (4) comparison with related transaction controls.

The use of a terminal, desktop computer, or handheld device to enter the original transaction has the advantage that a machine readable record is produced at the same time as source documents needed for the transaction are prepared. If a source document is misplaced or lost, the computer record permits the tracking or reconstructing of the missing record. Accuracy and completeness considerations for source document design also apply to input screen design for the visual display terminal. Since online entry may also be performed without a source document (as with order entry by telephone), the machine record may be the only "document."

In the flow of control in batch processing, it is best to establish a control total of documents before the batch processing begins. The control total can be a record count, a financial total, or a "hash total" of numbers such as account numbers, which are not normally summed (hence the total is meaningless except for control purposes).

During the data preparation process, the control totals are checked to verify that no transactions are missing and that items used in control totals have been entered correctly. The control total is input with the data and checked by computer as part of data validation, processing, and output. The control totals appear on batch reports and on other control reports. The output (after adjusting for rejected transactions) should match the control total for the input batch. Computer programs and control personnel make control total comparisons during processing; users check controls on output against control totals for data they submitted for processing. This checking provides a simple but powerful control procedure to insure that all transactions in the document batch are processed.

In the case of online input from documents, there is no control total of transactions prior to entry. However, if there are reasonable control procedures to enforce entry of all transactions, control totals can be developed for logical batches of input (transactions that are logically grouped by some common feature). The logical batches provide a basis for listings for reference, follow up, comparison with physical evidence, and so on. For example, the log of all transactions entered is sorted, and logical batches of

transactions are prepared by terminal, by operator, by type of transactions, etc.

There are special control considerations with online processing. The files change continuously, and therefore any error can disrupt a file and create additional errors as subsequent transactions are processed. The straightforward preprocessing batch control totals cannot be used to check batches before updating. Some examples of controls illustrate how control in online processing is handled. Restart procedures tell input personnel which transactions were lost if a system goes down. A separate backup file copy and transaction log are used for making file correction.

PROCESSING REFERENCE CONTROL

The audit trail (or a processing reference trail) is the trail of references (document numbers, batch numbers, transaction references, etc.) which allows tracing of a transaction from the time it is recorded through to the reports in which it is aggregated with other transactions, or the reverse, tracing a total back to amounts on individual source documents. The processing trail is required for internal clerical, analytical, and management use because of the frequent need to examine the details behind a total or to trace what happened to a transaction. It is also needed by external auditors and is required by certain tax regulations for tax related records.

An audit trail should always be present. Its form may change in response to computer technology, but three requirements should be met:

- 1 Any transaction can be traced from the source document through processing to outputs and to totals in which it is aggregated. For example, each purchase of goods for inventory can be traced to inclusion in the inventory totals.
- 2 Any output or summary data can be traced back to the transactions or computations used to arrive at the output or summary figures. For example, the total amount owed by a customer can be traced to the sales and payments that were used to arrive at the balance due.
- 3 Any triggered transaction (a transaction automatically triggered by an event or condition) can be traced to the event or condition.

tion. An example is a purchase order triggered by a sale that reduced inventory below an order point.

programming languages

Gordon B. Davis

A computer program is a set of instructions that direct the computer to execute operations. Writing a set of instructions is termed "coding." The computer executes machine language instructions, but programs are not written in this form because they are expressed in some binary form that is difficult for human use. A symbolic assembly language was used in the early development of computers to allow programmers to code machine level instructions using mnemonic names for instructions and symbolic names for storage locations. The difficulty with symbolic assembly languages is that they require one symbolic instruction for each machine instruction. Most programming is now done in a higher level language. There are different types of high level languages, but a common characteristic is that the program is written in instructions that describe the procedures or problem solving steps to be performed. The high level instructions are converted to a machine level program by a computer program called a "compiler."

High level languages used in information processing can be categorized by their orientation. The classification below is useful in thinking about the orientation of languages, but often programming languages do not fit exactly into any one category.

- 1 Algebraic, formula processing languages.
- 2 Business data processing languages.
- 3 Specialized languages.
- 4 General purpose languages.
- 5 Fourth generation languages (4GL).
- 6 Screen oriented languages.
- 7 Object oriented languages.

Algebraic languages are oriented toward computational procedures for solving mathematical and statistical problems or problems that can be expressed in terms of formulas or numerical solution procedures. Algebraic languages have

good facilities for expressing formulas, for describing computational procedures, and for specifying common mathematical functions. Typically, they are less useful for complex input and output and manipulation of non numeric data. There are a large number of such languages, each one suited to a specialized environment. The most commonly used algebraic languages are FORTRAN (FORmula TRANslator) and BASIC (Beginners All purpose Symbolic Instruction Code). FORTRAN has developed through a number of versions and is supported by standards efforts. BASIC was developed as a language for student use but is now widely used as a simplified language. Since most languages have facilities for expressing formulas and mathematical functions, many newer object oriented languages with facilities for INTERNET applications are used for mathematical and statistical problems (*see* OBJECT ORIENTED PROGRAMS AND SYSTEMS).

Business data processing languages emphasize information processing procedures involving manipulation of non numeric data, large files, and high volume of input and output. They also have extensive formatting capabilities for reports. The processing procedures do not usually require extensive mathematical manipulation. COBOL (COMmon Business Oriented Language) has historically been the most widely used of these languages. As a historical note, a language often used with smaller business computers was RPG (Report Program Generator). In the development of business oriented data processing, existing languages have been expanded to include user screen design and screen object operations. Newer object oriented languages suited to applications involving microcomputers and Internet applications are often used for business data processing applications. Database packages include programming facilities for retrieval of data and formatting of reports. A standard language, SQL, is the most common query language. Many database packages have graphical user interfaces (*see* GRAPHICAL USER INTERFACE) for formulating queries, but the underlying instructions are generated in an SQL like language.

Specialized languages are used for situations requiring functions that are not common to algebraic or business processing. An example is

simulation languages, which are used to simulate operations involving queues. These can be quite complex and difficult without a specialized language. For example, a simulation of the operation of a job shop will involve many processing stations, many waiting lines of jobs to be processed, etc. Other specialized languages are used to write programs to control machine tools, do computations unique to engineering, etc.

General purpose languages are designed to support both algebraic and business data processing plus some common specialized functions. An example is ADA, a general purpose programming language. It is especially suited for the programming of large, long lived systems with a need for ongoing maintenance. It supports modern programming structured techniques and concurrent processing.

Fourth generation languages (4GL) are languages that produce programs based on high level specifications rather than detailed procedural code. Fourth generation languages are used by both professional programmers and experienced users to access data and build reports. Complete applications can be built using fourth generation languages. This is frequently the case in applications that depend upon database use.

Screen oriented languages are designed to assist in programming applications that are run by a user employing a graphical user interface to select operations from a menu, by a mouse operation to activate a screen object, or by keyboard entry.

Object oriented languages are designed to assist in programming with reusable objects rather than writing extensive procedures. Each element of an object oriented program is an object. Each object consists of data structures plus the operations, called methods, that can be performed on its data. Objects are activated by messages that come from other objects or are triggered by external events. Objects interact only by exchanging messages (which can include data). This characteristic of data and methods contained within an object is called "encapsulation," one of the main principles of the object oriented approach. The effect of encapsulation is that data can only be affected through the methods of the object con-

taining them. Another important characteristic of objects is inheritance. Once an object has been defined, a descendant object may be created that automatically inherits the data structures and methods of the original object. The two most widely used object oriented languages are C++ and Java, but there are many others. Each of these language systems provides complete development environments tailored to the needs of object oriented implementation.

The type of language or its orientation is useful in selecting the programming language that best fits the characteristics of an application. However, because most information processing functions can be programmed in almost any language, a programmer will often select a language that is known rather than the language that has the best functionality for the problem.

protocols

Gordon B. Davis

When two devices are communicating, there must be agreement as to the meaning of control information being sent with the data, and agreement as to how the control information and data will be packaged. This agreement is the protocol. There are a number of standard communication protocols. The most widely known communications protocol is the OSI (open systems interconnect) reference model developed by the ITU (International Transport Union). It has been standardized as the X.25 seven layer model. In this model, separate sets of rules (protocols) are defined for different communication conditions and needs.

There are other models or collections of protocols. These models are often called communications architectures. Examples include IBM's SNA (systems network architecture) and TCP/IP (transmission control protocol and Internet protocol, two key elements of the protocol architecture). Communication on networks using a single protocol architecture is simpler and more efficient than communication involving multiple architectures.

gateways, companies offer guest users access to the Internet, whereas employees have full access to internal resources once they are authenticated. This helps to balance the flexibility versus security issue.

There have been numerous concerns regarding the security of devices supporting Bluetooth. In a technical sense, someone may be able to download the contents of your PDA or your cell phone address book just by simply walking past you and making a wireless connection. In the case of infrared connections, the limits of range and need for line of sight makes security less of a concern. However, there is a new proposed use of IRDA called IRFM (infrared financial messaging), also known as "Point and Pay," which integrates unique security features to pay for transactions using a personal device.

wireless communications

see WIRELESS COMPUTING

worldwide web

Mark A. Fuller

In 1993, a new INTERNET function was introduced by the CERN physics laboratory in Switzerland termed the worldwide web. The worldwide web is a service that provides an Internet accessible network of hyperlinked documents. The documents are standardized in their underlying structure, facilitating the exchange of complex types of information. Until this time, most people had not found the Internet to be particularly useful. While some businesses and many universities used the basic functions of the Internet, i.e., message and file exchange, the ability to gather useful information from remote locations was still a reasonably complex task, beyond the skill and interest of many. The worldwide web (also known as the web or WWW) changed usage by making it possible to exchange information more easily and in richer forms.

Information on the worldwide web is organized into pages and accessed through software called a web browser. Each page may contain information in the form of text, images, sound files, or full motion video. The worldwide web has evolved into an interactive media as well. Programs running in the background of some web pages allow the user to respond to questions online, fill out forms, access remote databases, or interact with other types of programs. These interactive capabilities have the potential to change the way users run both their personal life (through applications involving activities such as online banking, shopping, or entertainment) and their work (through online systems that assist in business activities such as inventory control, product ordering, and communication).

Web pages typically contain hypertext links to other pages and resources. When links are activated, the user may be retrieving data from the same computer where the original page resides, or from a computer in a remote location thousands of miles away. Each page and computer combination has a unique address called a uniform resource locator (URL). This addressing system enables users to store the location of a resource for access in the future. Web documents are created in a particular language which browsers recognize and translate. The language, termed hypertext markup language (or HTML), is reasonably simple to learn, allowing even relative computer novices to create basic web pages in a short amount of time (*see* MARKUP LANGUAGES).

The earliest web browser, called Mosaic, was designed at the University of Illinois and incorporated the ability to interpret graphical images on the screen. Since that time, a variety of other browsers have been developed, including Netscape's Navigator and Microsoft's Internet Explorer. The web became a rapid success, changing Internet usage from primarily the governmental and educational sector to nearly 10 million users by 1994, just one year after its inception. As of 2003, the estimated number of users was nearly 600 million. In that year, these users accessed over 6 billion web pages and spent nearly \$100 billion dollars purchasing goods and services on the Internet's worldwide web.

X

XML (extensible markup language)

Roger Debreceeny

MARKUP LANGUAGES are used to define the content of files that are exchanged between different applications or different users. They are very important because they define the format and meaning of strings of characters or text within letters, documents, forms, and other business documents that are sent within an organization or between organizations. In the absence of a markup language, each message or document would need to describe how the strings of characters being exchanged should be interpreted. The markup language is a standard way to describe the content. Without a markup language, for example, a document containing a financial report would need significant descriptive information to explain the elements of the report and how the recipient should format the elements in the report.

There are many markup languages; the most significant are those accepted as standards. Some are limited in scope and use; others are broad and extensible. For example, HTML (hypertext markup language) is a standard markup language for INTERNET pages that interconnect with other pages. XML (extensible markup language) is one of the most important markup languages, because it is standard in its structure and yet can be extended to include new markup requirements and creation of new markup languages.

XML was developed in response to the need for a general purpose markup language that could be widely deployed on the Internet. The World Wide Web Consortium (W3C) created the extensible markup language version 1.0 (XML 1.0) as a foundation for the development of new Internet based standards and applications in electronic commerce (*see* E COM

MERCE), metadata management, and other application areas. XML is a metalanguage, designed to support the creation of new languages. XML is a subset of the standard generalized markup language (SGML), which is expressly designed for the Internet and the WORLDWIDE WEB.

A markup language is coded in plaintext. Defined components of the file are interpreted as markup ("tags") instead of content. The text "<title>" and "</title>" in the string <title> This is the title of this document </title> are the opening and closing tags or markup that provide semantic value to, in this case, a fragment of text.

Markup within a file may contain instructions for the application using and interpreting the plaintext file. The markup may alternatively provide semantic interpretation of the text contained within the markup. Semantic interpretation of the markup is defined by the markup language. SGML, XML, and HTML are examples of markup languages. In contrast with the predefined set of tags (tagset) defined in the HTML specification, XML has an extensible tagset. XML makes no semantic restriction on the tags that may be incorporated within a particular application. Indeed, HTML 4.0 is reproduced in XML as XHTML.

XML semantic content can be incorporated within both tags and/or attributes of tags. The XML code fragment shown below illustrates the use of both tags that are designed to impart semantic content to the text they encompass (e.g., "<paragraph>") and tag attributes that add semantic meaning to the encompassed content (e.g., "<display = 'Yes'>").

```
<?xml version = '1.0' ?>
<helloworldtext>
```

```

<title>
My First XML Document
</title>
<paragraph display= ``Yes``>
Hello World.
</paragraph>
</helloworldtext>

```

XML 1.0 has, by design, a highly limited set of features. XML provides no direct support for presentation of content on interactive displays or in print. It has no mechanism for transporting XML content on the Internet or any other network architecture. It provides no direct support for externally defining the semantic meaning of the extensible tagset within XML documents. For example, the semantic meaning of the markup such as “<title>” and “<paragraph>” shown in the code fragment above will be completely dependent on the application under development. In this case, the markup has semantic value within the English language. The tags (elements) could equally as well have been represented by the terms “<ax74t>” or “<xi3f5>.” Support for the prerequisites for any complete application such as presentation, transport, and semantic definitions are found either elsewhere in the suite of standards defined by the W3C and that make up the XML family, or in the wider body of Internet standards defined by organizations such as the Internet Engineering Task Force (IETF).

The suite of companion XML standards developed by the W3C is both broad and deep, covering presentation, namespaces, semantic structuring, information querying, and hyper linking. Support for transformation and presentation of XML documents is covered by the extensible stylesheet language family (XSL). XSL transformations (XSLT) provides a means for transforming XML documents from one form (“source tree”) to another (“result tree”). The content and structure of the transformed document will depend on the way in which the consuming application has utilized a template that is associated with an XML document. XSL 1.0 (previously XSL Formatting Objects (XSL FO)) provides a means for formatting a result tree in a particular display format, typically a print based layout.

The core XML specification makes no restriction on the naming of elements or attributes

and there is, consequently, no central registry of elements or attributes. It is highly likely, then, that application designers will each identically name elements or attributes. In designing an inventory application, for example, it will be common to have elements such as “<part_id>” or “<bin_location>.” The XML Namespaces specification provides a mechanism, based on standard Internet universal resource identifiers (URIs), to uniquely identify the authority for a given element or attribute. This will allow the consuming application to differentiate “<my:part_id>” from “<your:part_id>.”

The foundation of SGML, of which XML is a subset, was in the processing of textual documents for publication purposes. Whilst these documents typically have complex structures, they are of quite a different character to the semantic structures required for processing business or e commerce information. SGML provides a method for externally imposing a data structure upon one or more instance documents through the document type definition (DTD) mechanism. Whilst this mechanism is also supported in XML, it has been effectively replaced by the relatively recent XML Schema specification. XML Schema was created in response to a clear need for a more efficient and effective method for enforcing data structures over instance documents in a wide variety of application domains, notably in all aspects of e commerce. XML Schema provides a more data centric approach to specifying knowledge structures in instance documents. The specification provides a systematic approach to defining both simple and complex data structures that can be consistently enforced on a set of instance documents by an application. XML Schema defines a host of simple data types that are commonly found in database schema languages, including string, decimal, integer, negativeInteger, and positiveInteger. The specification provides a mechanism for deriving further specializations of the predefined simple types. For example, negativeInteger and positiveInteger are both specializations of the integer simple type.

XML Schema also supports the creation of complex types, such as a “purchaseOrder” or “customerAddress.” These complex

types incorporate sets of simple data types or complex types. The complex type can impose both ordering or sequence and cardinality on sets of simple and complex types. Data structures can be reused by associating different names with predefined simple or complex types. Specialization is also supported by allowing new types to be created that are extensions of existing types. Types may be associated with rich sets of attributes that may, in turn, be associated with enumerated lists.

XLink and XPath are components of the companion suite of XML standards that collectively provide a significantly enhanced set of hyperlinking functionality, as compared with HTML. XLink supports both simple and complex ("extended") hyperlink structures. The HTML hyperlink based on the anchor construct is functionally equivalent to the simple link in XLink. Extended links, however, allow designers to incorporate highly complex link structures in their applications ("linkbases"). Links in XLink at their simplest level join two resources such as content in XML instance documents together over an arc. The manner by which those links are established can be derived in complex ways. An extended link associates an arbitrary number of resources. XLink provides mechanisms for the developer to bind resources together by networks of links, associate human readable titles to a given hyperlink, set rules for traversal between resources, and define the resources that may be accessed by a given hyperlink.

XML instance documents will frequently have highly complex internal structures. Information that is of value to applications may be stored within some subsection of the instance document. XPath provides syntax for applications based on other standards such as XPointer and XSLT to address given components of an instance document. The choice of components may depend on some processing logic and selection criteria by the application using (consuming) the data. XPath provides a mechanism for applications to locate parts of XML documents. XPath sees documents as a tree of nodes that include text, attribute, and namespace nodes and then provides a mechanism for retrieving sets of nodes. A revised version of the XPath specification is also an important component of the architecture to query sets of XML instance

documents, along with the nascent XQuery. XQuery is designed to allow consuming applications to query documents that are of a primarily textual nature (semi structured) as well as sets of documents that correspond to a database in nature (structured). Both the revised XPath and XQuery are designed to interoperate with XML Schema.

A knowledge store defined in XML Schema is functionally equivalent to the semantic structure of an object oriented database (see OBJECT ORIENTED DATABASE MANAGEMENT SYSTEMS). In a RELATIONAL DATABASE, database structures are typically homogeneous, regular, and flat; the order of rows in tables is immaterial and missing information is typically represented by null values. In a database of XML instance documents, metadata are typically heterogeneous, with semantic structure being drawn from multiple XML schemas; ordering is intrinsically semantically significant; and missing information is represented by the absence of an element. XQuery is a strongly typed object query language that provides a wide array of functions, including math, sequences, Boolean, string manipulation, and regular expressions. Developers may also derive their own functions.

The World Wide Web Consortium has also developed several knowledge management (see KNOWLEDGE MANAGEMENT SYSTEMS) and ONTOLOGY specifications that are either based on XML or include XML documents within the resources described in the ontology. An early and important specification was the resource description framework (RDF). This framework provides a mechanism to describe any resource that can be encapsulated within a URI, including information that may be accessed on the Internet (such as websites, HTML documents, or a gateway to a Z39.59 library database), or animate or inanimate objects that are not reachable on the Internet. RDF ontological data describe both the location and properties of information resources. RDF/XML allows the exchange of structured information about these resources. OWL (web ontology language) is a new specification that provides a formal means for developers to provide a rich set of descriptives on web resources, including XML instance documents. OWL is in three versions, each of increasing functionality ("Lite," "DL," and "Full"). OWL can describe

resources in terms of XML Schema datatypes, equivalence, cardinality, versioning, and characteristics of the resource.

XML and the suite of companion specifications have provided a common language for the development of a wide range of knowledge interchange standards. XML is used as a common means to specify them. Some of the most important XML based standards have been in the broad sweep of e commerce. One of the most significant uses of XML in this segment is by RosettaNet, a consortium of more than 500 corporations primarily in the electronics sector. RosettaNet defines partner interface processes (PIPs) that provide the requisite information environment for the establishment, initiation, and completion of a wide range of business processes between trading partners. PIPs exist in seven “clusters” that include partner product and service review; product information; order management; inventory management; marketing information management; service and support; and manufacturing. The semantic content of PIP specifications is represented in document type definitions. Each business process includes a schema of the information transferred (e.g., in a quote request, the `GlobalPaymentMethodCode`, `contractIdentifier`, `ProprietaryDocumentIdentifier` and `estimatedAvailabilityDate`. `DatePeriod` are each defined) and provides a choreography as the business process proceeds from initiation to completion.

The extensible business reporting language (XBRL) is an important markup language (based on XML) for the exchange of business performance data. XBRL is being standardized by XBRL International, an international consortium of more than 200 organizations and corporations. Whilst the primary rationale for XBRL was to provide a means for representing the financial and non financial information typically found in a corporate quarterly or annual report, XBRL has been used in a variety of regulatory and other information exchange environments. Whilst the business processes established in RosettaNet are sufficiently structured and well defined to be incorporated directly into the RosettaNet technical specifications, financial reporting is more fluid and subject to variation at the international, regional, and entity level.

The XBRL specification establishes a framework for the establishment of reporting ontologies, known in the XBRL community as taxonomies, rather than attempting to predefine all reporting constructs. The taxonomies provide the metadata necessary to provide semantic value to facts reported by a reporting entity. XBRL is based upon three primary XML specifications: XML Schema, XML Namespaces, and XLink. Indeed, the XBRL community is arguably the most significant user of the XLink specification. XBRL taxonomies are, at their most essential, a simple XML Schema containing a flat list of the elements in the taxonomy. The elements described in the schema may take on the datatypes as defined XML Schema and the XBRL specification marks out several datatypes that have been defined especially for business reporting. The implementation of the monetary data type in the XBRL specification, for example, requires instance documents to report both the quantum and the reporting currency of any monetary item.

Most performance reporting applications require more than just a listing of elements within a particular knowledge domain. Descriptions of the taxonomy element and the nature of the mathematical and semantic relationship of one element of the taxonomy to another are all matters which application designers may wish to incorporate into the taxonomy. These elements of the XBRL ontology are bestowed in a set of so called “linkbases.” XBRL linkbases employ XLink to provide enhanced metadata and to impose a node structure on the elements defined in the XML Schema based taxonomy. The XBRL specification defines the role of presentation, references, calculation, label, and definition linkbases in linkbases. Traversal of the arcs within the linkbase is optional – in other words, an application consuming an XBRL instance document may not need to associate the predefined label of an element with the element tag and will not therefore need to process the label linkbase to retrieve the label. Other applications will need to report the name associated with a given taxonomy element and will traverse the arc to retrieve the label.

The XBRL specification is silent on many important elements that are necessary to construct a complete reporting environment, including registration of taxonomies, transmission,

354 XML (extensible markup language)

signing, or choreography. The XBRL consortium leaves these issues to the designers of particular reporting applications.

E commerce provided significant importance to the development of standard markup languages based on XML. ebXML (electronic business using extensible markup language) is an ambitious endeavor to construct a suite of XML based specifications designed to facilitate electronic business over the Internet. ebXML was originally developed by OASIS (Organization for the Advancement of Structured Information Standards) and the United Nations/ECE agency CEFAC, with technical development now primarily resident at OASIS. Taking a significantly more ambitious approach to electronic business than taken by RosettaNet, ebXML aims to bring two or more trading partners together in a wide range of business transactions. Aspects of this exchange process include registration of trading partners, description of products and services, catalogues of business processes, mechanisms for the discovery of trading partners and products and services, and the establishment, undertaking, and conclusion of trading relations between trading partners. Semantic structure of the various information

exchanges is enforced in XML Schema and DTD frameworks. These knowledge schemas control the format of, for example, a trading entity's collaboration protocol profile (CPP), which is a document that allows a trading entity to describe its "business processes" and "business service interface" requirements. These profiles are managed in a repository. Information is exchanged between the firm and the registry using a set of controlled terms. ebXML uses the extensible nature of the XML suite of specifications to enable a highly flexible set of interactions, ranging from an entity that may only want to discover potential trading partners, through to discovery not only of trading partners but also of the detailed products and services offered by those partners, and development of an agreement for the purchase and delivery of those products and services and completion of the requirements of that agreement.

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