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Electronic Document Management: Challenges and Opportunities for Information Systems Managers

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Abstract

Harnessing information technology to manage documents is one of the most important challenges facing IS managers in this decade. It is important because most of the valuable information in organizations is in the form of documents such as business forms, reports, letters, memos, policy statements, contracts, agreements, etc. Moreover, most of the important business processes in organizations are based on, or driven by, document flows. Electronic Document Management (EDM) promises major productivity and performance increases by applying new technology to documents and document processing.

The purposes of this paper are to show the value of new technology for managing documents, to illustrate the variety of ways this value can be realized, to develop some structure for understanding this rapidly evolving field, and to suggest some actions IS managers can take now to prepare for this revolution in information management. The paper argues that the IS Department, as the developers and managers of the technical infrastructure for EDM, will be in a position to lead this evolution as major change agents like they did in the EDP and MIS eras; but some specific actions will be needed to assume this leadership role.

This paper explores the scope and importance of EDM in more detail and illustrates how it expands our view of information management. It is designed to help structure the field by approaching it from three perspectives: technologies *that are making EDM possible, the application areas in which* business value *is being realized, and the* roles and responsibilities *of several departments that will be involved in developing EDM. The paper suggests what IS managers can do now to begin preparing for this major advancement in information management.*

Keywords: Document management, document processing, IS management

ISRL Categories: CA14, DA06, DA07, DB05, EF02, HA6-12, HA14

Introduction

For the most part, computer systems have handled facts organized into data records. Far more valuable and important to organizations are the concepts and ideas contained in documents. Reports drawn from the computerized database fill important roles in status assessment and control, but frequently they must be accompanied by a memo or text report that explains and interprets the computer report. Indeed, in one study, CEOs rated computer reports least valuable for decision making from among a set of communication mechanisms. Meetings, phone conversations, news items, written memos, and non-computerized reports rated much higher (McLeod and Jones, 1987). Technology applied to the handling of documents promises to improve these important forms of communication.

Until recently, however, technology for document processing has been mostly limited to better and faster ways to generate, print, and transport text documents. Now, several trends and developments suggest that we are on the verge of a major advance in computer-based information management. Electronic Document Management (EDM) is the application of technology to save paper, speed up communications, and increase the productivity of business processes. From a broader perspective, EDM is a major expansion in the domain of information management and a concomitant increase in the responsibilities of IS managers and executives.

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A recent Gartner Group Strategic Analysis Report forecasts that by 1995 document management functions will become the most important service on Local Area Networks after basic connectivity (Popkin and Cushman, 1993). The report argues that a strong business case can be made for investing in document management systems and the organizational leverage they provide. Ninety-eight percent of computer users employ word processing on their computers. Eighty to 90 percent of organizational information is in documents rather than structured databases. Dominant as they already are, these figures will increase.

More than a decade ago Swanson and Culnan (1978) recognized the importance of document-based computer systems for management planning and control. They cited early references to its importance, but noted that "the role of document-based information systems in management has been relatively neglected." As a result of their study, they suggested that "there is some reason to believe that document-based systems may at last find their way into contemporary MIS thinking."

Unfortunately, their view proved to be optimistic. Although there has been continual progress in applying technology to documents, the majority of computer-accessible information is still in data records, and the majority of document information is still on paper. But now a strong combination of business forces and major technology developments may finally make it possible to apply technology to documents in a productive way (Sprague, 1990).

Advances in handling information contained in documents are being driven by several forces in the business environment and are enabled by new technology developments. The business forces include the drive for increased quality on which to base global competitiveness and the need for increased productivity to conserve scarce resources. Technology developments enabling these advances include digital image processing, large capacity storage, hypertext, multi-media documents, high bandwidth communication channels, electronic printing, electronic mail and fax, and improved techniques for information and text retrieval. These technologies are proving valuable for applications such as workflow management, communication between and within organizations, training and education, records management, and internal reporting.

The objectives of this paper are threefold. The first objective is to establish a vision of the scope and potential impact of EDM in organizations and the implications of these developments for IS managers and executives. A second objective is to develop an understanding of the technologies that are enabling new ways of handling and processing documents and how these new technologies will be integrated into an expanded IS infrastructure. These rapidly evolving technologies make possible functions that were previously infeasible, so they will force us to think about information and documents differently. A third objective is to provide some structure to guide the journey toward the EDM vision.

The first section of the paper explores the scope and importance of EDM in more detail and illustrates how it expands our view of information management. The next three sections are designed to help structure this field by approaching it from three perspectives:

- **The technology**—What technology is needed? What is available?
- **The application areas**—What gets accomplished? What is the business value?
- **The roles and responsibilities**—How will we organize to manage EDM? What are the roles and responsibilities of the several departments that support documents?

The final section suggests what IS managers can do now to begin preparing for this major advancement in information management.

Scope and Impact of EDM

Definition and scope

A document can be described as a unit of "recorded information structured for human consumption" (Levien, 1989). It is recorded and stored, so a speech or conversation for which no transcript is prepared is not a document. This definition accommodates "documents" dating back to cuneform inscriptions on clay tablets; what has changed lately are the ways the information is represented and the ways the documents are processed. Information previously

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represented primarily by text is now also represented by graphical symbols, images, photographs, audio, video, and animation. Documents previously created and stored on paper are now digitally created, stored, transported, and displayed.

This definition also accommodates a wide variety of documents used in organizations. Examples include:

- Contracts and agreements
- Reports
- Manuals and handbooks
- Business forms
- Correspondence
- Memos
- New items and articles
- Drawings, blueprints, photographs
- E-mail and voicemail messages
- Video clips
- Script and visuals from presentations
- Computer printouts
- Transcripts from meetings

The application of technology for processing even the more traditional documents in this list is making a major change in what documents are and can accomplish in organizations. A definition more oriented to technology comes from BYTE magazine (Michalski, 1991): "A document is a snapshot of some set of information that can

- incorporate many complex information types;
- exist in multiple places across a network;
- depend on other documents for information;
- change on the fly (as subordinate documents are updated);
- have an intricate structure, or complex data types such as full- motion video and voice annotations; and
- be accessed and modified by many people simultaneously (if they have permission to do so)."

Another perspective suggests that a document is the "unit record" of conceptual information. A data record contains the attributes of an entity such as an employee in a personnel system or a part number in an inventory system; a document contains the information necessary to represent a concept or idea. Although most documents currently contain a cluster or set of these "concept nodes," future documents may be composed of a network or web of linked conceptual unit records. These "chunks" or "bundles" of information will have attributes that make them more useful and human than traditional data records. Context, tone, richness of representation media, and flexibility of structure will make the information in documents more consumable and accessible to humans. This perspective strengthens the understanding that document management is an expanded form of information management.

In spite of these broad definitions, the dominant connotation of a document is relatively structured and formal information (primarily text) printed on paper. Therefore, the scope of electronic document management must encompass the use of technology to handle paper documents or their electronic equivalent. Older technologies for document handling include micrographics, computer output microfilm (COM), and automated records center applications. A newer technology is digital image processing, which represents a page of a paper document with a digital image of that page.

Increasingly, however, EDM will emphasize *electronic documents* and their management. An electronic document uses a variety of symbols and media to represent a set of ideas and concepts. In addition to traditional letters and numbers (text), an electronic document may contain graphical symbols, photographs and other images, voice, video clips, and animation. This clustered set of symbols can be stored, retrieved, and presented electronically as a "compound document." For example, an internal report on a product improvement may present, on a computer screen, the text explaining the feature, a photograph, an engineering diagram, a voice notation from the product designer, and a video clip of the product in use. Figure 1 shows the conceptual structure of such a compound document. This is a richer, enhanced definition of what we have traditionally called a document. EDM requires us to expand our connotation of this old and comfortable word.

The use of the term EDM in this paper encompasses both of the interpretations given above. Thus, the scope and definition of EDM can be explained as follows.

- **Electronic**: the use of modern information technologies.

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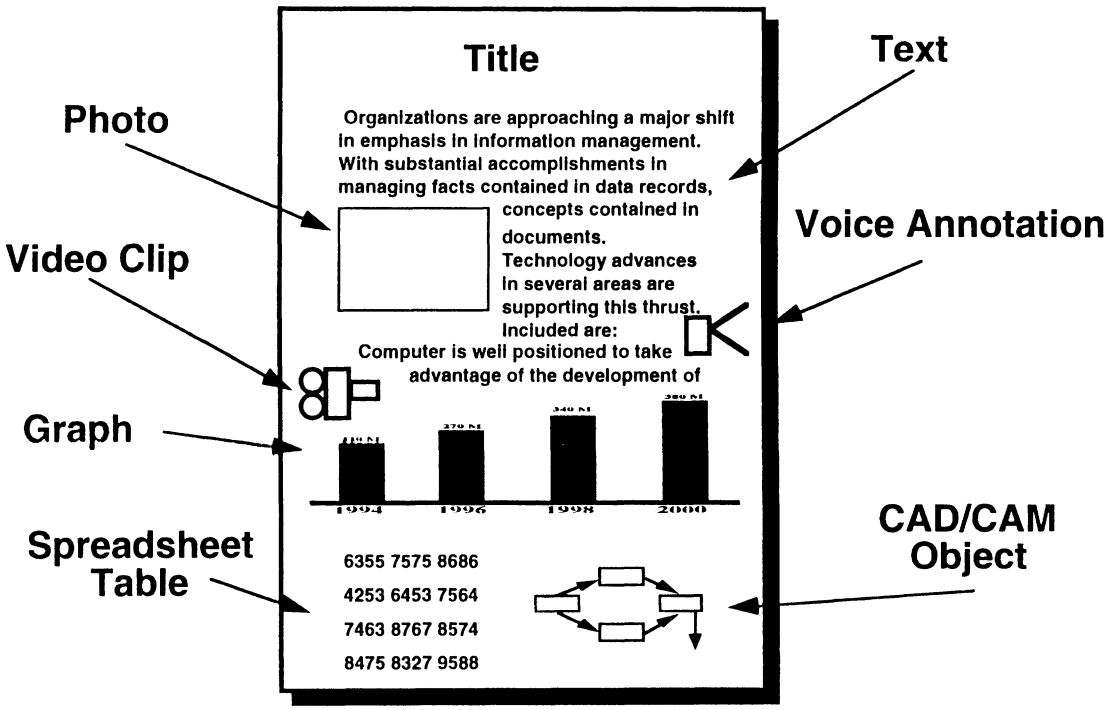

Figure 1. Structure of a Compound Document

- **Document**: a set of information pertaining to a topic, structured for human comprehension, represented by a variety of symbols, stored and handled as a unit.
- **Management**: creation, storage, organization, transmission, retrieval, manipulation, update, and eventual disposition of documents to fulfill an organizational purpose.

Business value from documents

Document management can generate business value in two ways. First, for some industries such as publishing companies, documents are a direct source of revenue as a product, or as support for a product. Second, for all organizations in all industries, electronic document management can improve the information management tasks that are needed to manage, control, and operate the organization.

In the first category, publishing companies produce books, magazines, newspapers, and other formal documents as products. Document processing facilities, procedures, and technologies are their "factory." Less obvious publishers are lawyers, insurance companies, consulting firms, and many government agencies for which the primary manifestation of their product or service is a document. Here again, electronic document management will improve the quality of their product or service and reduce the costs of producing it in the same way a modern factory does for a manufacturing firm. For some industries, documents are not the primary product, but they generate revenue by supporting the product. Examples include the owner's manual for an automobile or major appliance, the reference manual for a software product (often in electronic rather than paper form), and a pharmaceutical firm's application to the government for new drug.

In the second category, the value of document management to support organizational performance can be grouped in three general categories—as a mechanism for organizational communication (especially for concepts and ideas), as a vehicle for business process, and as a major component of organizational memory.

1. **Improved management and communication of concepts and ideas.** A major value

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of EDM derives from its ability to expand the scope of information management from facts in the form of data records and databases, to concepts and ideas that are generally captured, stored, and communicated in the form of documents. EDM technology can thus improve the efficiency and effectiveness of documents in their role as a primary mechanism for storing and communicating concepts and ideas within and between organizations (and their groups and individuals). This set of benefits directly supports the expected structure of future organizations that are likely to be flatter, heavily based on teams, geographically distributed, and more dependent on their ability to handle rich and varied information.

2. **Upgraded, ''reengineered'' basic business processes.** Most organizations have a substantial set of ''paperwork'' systems that have been resistant to computerization, at least partly because they are based on documents rather than (or in addition to) data records. Evolving EDM technologies will support more of these applications. Real benefit will result, not just from automating these processes, but from rethinking or reengineering them to take advantage of the advanced technology (Kind and Eppendahl, 1992). Several of these efforts suggest that the most effective reengineering approaches are document based or document driven (McDonnell and Somerville, 1991). In a recent project to reengineer one of six major business processes, Xerox identified 263 subprocesses with 2300 links connecting them. A full 2070 of the links, or 92 percent, were documents.

3. **Leveraging Organizational Memory.** Documents form an important part of organizational memory, and EDM can improve the ability of the organization to utilize it. In the short run, major value derives from merely storing paper documents in electronic form. In the long run, EDM will provide the means to access and analyze organizational memory to improve productivity and performance.

These general areas of use and value of documents illustrate why documents are so pervasive and fundamental to an organization. Table 1 shows some additional roles and purposes for documents, with an example of each.

In summary, the overall potential impact of applying technology to document management is significant. Because documents contain concepts and ideas, EDM promises to advance the management of conceptual information in organizations. Because most of the activities of information workers at managerial and professional levels deal with concepts and ideas, EDM promises improved support and productivity at these levels. Because documents are a major vehicle for exchanging information in business processes, EDM promises to make a major contribution to process redesign and improvement efforts. Finally, with documents forming a major part of organizational memory, EDM promises to support enhanced utilization of that resource.

Driving forces

In the short run, EDM will be useful in dealing with the ''paper problem.'' Many organizations are literally drowning in paper. A study by records managers estimates that there are 318 billion paper documents on file, with 92 billion new pages added each year. Computers print 775 billion pages each year. In 1990, these new documents required 3.1 million tons of paper (Allerding, 1992). Business forms are a large portion of this paperwork. A research firm estimates that U.S. companies spend more than $6 billion every year on preprinted forms and throw away more than $2 billion worth, and they spend from $94 to $120 billion per year to distribute, store, and process forms (Skapinker, 1991).

Although EDM technologies have already begun to have an impact on this problem, it is unlikely that merely replacing paper with an electronic equivalent will yield lasting productivity improvement. Major productivity improvements will require radical organizational change as decades-old processes designed around paper documents are abandoned. There is now widespread agreement that traditional work processes and practices must be redesigned or ''reengineered,'' taking advantage of new technological capabilities in order to reap true productivity increases (Davenport, 1993; Gleckman, 1993; Hammer, 1990).

However, the ''paperless organization'' is not a realistic idea in the foreseeable future. Paper has too many advantages and technology too many

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Table 1. Roles Documents Play

Roles	Examples
To record or to "document" contracts and agreements	Employment contracts, maintenance agreements, consulting contracts, purchase agreements, leases, mortgages, loans, etc.
To record policies, standards, and procedures	Procedure manuals, standards specifications, instruction handbooks, executive memos and letters that state corporate policy, etc.
To represent a view of reality at a point in time (reports and plans)	Status reports, problem analyses, operational reports, staff recommendations, budgets, strategic plans, etc.
To create an image or impression	Annual reports, marketing brochures, TV or radio commercials, etc.
To generate revenue as a product	A book for sale by a publisher, a report by a consulting firm to be sold to its client, a news item from a wire service, a reference from a bibliographic service, etc.
To support revenue by adding value to a product	A user's manual for a car or appliance or a software product, a warranty form, a catalog, a discount coupon for the next purchase, etc.
To act as a mechanism for communication and interaction among people and groups	Memos, letters, presentations, e-mail, messages, minutes of meetings, etc.
To act as a vehicle for organizational process	Orders, invoices, approval letters, most business forms, etc.
To provide a discipline for capture and articulation of concepts and ideas	Nearly all the kinds of documents that carry concepts and ideas

limitations to expect complete elimination of paper any time soon. It is likely, however, that the primary role of paper will change. Rather than serving mainly as the storage medium for documents, paper may act primarily as an interface medium. The official "original" document would exist in electronic form, to be printed when and where it is needed. The paper "copy" would be used and discarded (recycled), and printed again later if needed.

In the long run, continuous productivity improvement leads to an enterprise view of reengineering (Hammer, 1993). The ability to use technology to manage all organizational information, in documents as well as data records, would support or enable the changes in organizational structure that are forecast by organizational theorists. Galbraith (1979) suggests that organizations are literally information processing systems. Viewing organizations as sets of infor-

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mation processing units that need to interact and communicate illustrates the importance of the communication media.

While Galbraith stresses the role of information processing in reducing uncertainty, later work adds another major function—reducing ambiguity and equivocality (Daft and Lengel, 1986). This work led to a consideration of additional important attributes of information and communication media within organizations (Daft et al., 1987). EDM applies technology to enable traditional mechanisms such as documents to employ richer media and a richer structure, and therefore, to support organizational communication and information processing more effectively (Meier and Sprague, 1993).

In summary, the primary driving forces for EDM are the business need for productivity improvement in the short run and improved organizational effectiveness in the long run. But this organizational revolution will require a systems revolution driven by a paradigm shift in information management and the use of technology to implement it.

Opportunities and challenges

Managing this revolution will be one of the most important challenges facing IS executives in the rest of this decade. It will be important and challenging for several reasons.

- The short-term benefit potential from EDM applications is impressive. The well-publicized experience of USAA Insurance showed that a combination of imaging and workflow improvements can save millions of dollars a year while improving customer service (Elam and Sviokla, 1990; Plesums and Bartels, 1990). Before the new system was installed, storage space for active files required 39,000 square feet, and inactive files required 80,000 boxes in a warehouse. With the new system, total storage requirements for the equivalent on optical disks were reduced to about 100 square feet (Lasher, et al., 1991). In fact, there seem to be significant cost displacement opportunities from EDM applications, the likes of which have not been seen since the early days of data processing. IS managers may again have the luxury of clear cost-benefit justification for some systems projects.

- Technologies are evolving rapidly but unevenly in several separate but related areas. If these emerging technologies are adopted individually for specific applications without a plan for integrating them eventually, the result will be the separate "islands of automation" that characterized the early years of data processing. There has been some success in integrating dissimilar systems after they have been built (Hale, et al., 1989), but EDM applications promise to prove pervasive enough to cut across nearly all organizational activities.

- IS executives have the perspective to view EDM as more than just a set of incremental applications in office systems or records management. It is, rather, an expansion of the scope of information management. The corporate database has been viewed as the primary information resource for the organization. But the ideas, opinions, and judgments contained in memos and reports often drive the organization. News items, analysis, and other written reports from outside the organization influence the strategic thinking of managers and executives as much as, or more than, an analysis of the corporate database.

  The challenge is not to redirect efforts away from managing data toward managing documents, but to recognize that electronic document management is the next natural step in the evolution of information management. The information resources of an organization include data *and* documents, and the IS manager is in the best position to manage this expanded set of information in a coordinated way.

- Because EDM is an expanded domain of information management, and because the technology for implementing it is sophisticated and rapidly evolving, the responsibility for developing the technology infrastructure will likely accrue to the IS department. The IS executive is in the best position to serve as the chief architect of the EDM "revolution." But there are several well-established departments and functions for which document processing has been a primary mission in the past. These departments will have to work closely together, probably under IS leadership, even though they have had different objectives and perspectives.

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The "bottom line" is that organizations need improved productivity and enhanced performance. EDM promises to leverage new technologies to generate these productivity and performance improvements, but realizing these benefits will present major challenges and opportunities, especially for IS managers.

EDM from three perspectives

The previous discussion suggests that the topic of EDM is huge, pervasive, important, and technology-intensive, with significant potential value to organizations. It would be valuable to have some structure to begin working toward this potential. There are three perspectives that can be used to organize this effort.

- **Technology**—What are the technologies that will make EDM possible, and how can they be assimilated into the organization's IS infrastructure?
- **Benefits**—What are the application areas for which documents are mission-critical, and what is the plan for implementing them so that they are integrated?
- **Responsibilities**—What are the roles and responsibilities of the organization's departments and functions for which EDM will be strategic?

The next three sections of the paper explore these perspectives. Technology is discussed in the first section because it is proving to be the facilitating force. The second section explores a variety of application areas for which EDM is valuable, beginning with a case example that illustrates the variety of departments in which applications might evolve. The third section examines the roles and responsibilities of the several departments that must work together on a coordinated EDM effort.

Technologies for Document Management

Underlying infrastructure

The rapid developments in EDM are partly the result of advances in basic technology infrastructure. These underlying, enabling technologies improve the handling of information in any form, but several have attributes that support document processing and management. These enabling technologies can be organized into five major categories.

Stronger Desktop Workstations

Powerful desktop computers based on RISC technology are equipped with large, high-resolution color screens. These workstations permit the display of documents, a full page or two at a time, delivering (and capturing) non-text media such as voice, video, and animation (Herr and Rosebush, 1991).

Storage Media

High capacity storage media hold the large volume of bits required for multimedia documents. The capacity of magnetic media (hard disks and diskettes) in workstations and file servers has been increasing rapidly but is still barely adequate. Optical storage media such as CD/ROMs and laserdisks, perhaps in clusters called jukeboxes, provide orders of magnitude increases in storage capacity (Harvey, 1990). Holographic storage devices increase the amount of readily available storage capacity by several more orders of magnitude (Baran, 1991; Yam, 1993).

Networks

Networks will interconnect the workstations of most, if not all information workers, within and between organizations. These connections have increasingly high bandwidth to transmit the large volume of data contained in electronic documents and forms. Relevant technologies include FDDI, broadband ISDN, and Asynchronous Transfer Mode (ATM) (Sproull and Kiesler, 1991).

User-Friendly Software

The continued growth of graphic user interfaces (GUI) is enabling the multitude of people who handle paper documents, many of whom are not yet computer literate, to deal more easily with documents on computers (Seymour, 1989). Even for experienced computer users, however, interface software must continue to advance so users can move beyond managing hundreds of files to

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managing thousands of documents on the desktop workstation. Two examples are the information visualization project at Xerox PARC (Card, et al., 1991; Clarkson, 1992) and the Piles Interface at Apple (Mander et al., 1992).

Operating Systems

Client/server operating systems and network management systems are increasingly document oriented. In fact, new operating systems shift focus from the application to the document. They are also object oriented. This approach or paradigm is gaining popularity for improved software design and for the design of operating systems (Rymer, 1989). It is also the approach used for most of the work on compound documents.

Document management technologies

In addition to the underlying technology infrastructure, there is a set of technologies aimed directly at handling documents. Often called document "middleware," these technologies provide the functionality for the processing and management of documents, both electronic and paper. There are actually two sublayers in document middleware: functions for document processing and functions for document management. Summarized below is the set of document *processing* technologies, organized by the major steps in a document life cycle, and the document *management* functions, which together form the document technology infrastructure.

Capture and Creation

These are basically technologies to digitize information. For documents already on paper, hardware and software digitizes an image of a page and then electronically handles that image. Scanners capture the image, while algorithms convert it to digital form, frequently with compression to save storage space (Daniels, 1993; Datapro, 1991; Wallace, 1992). After a document page is scanned and digitized, it can be further analyzed to recognize the characters. Current software can capture full text in editable form in a variety of fonts, sizes, and formats. Extensions of these pattern recognition techniques can recognize voice, some images, and patterns in graphics, animation, and video (O'Gorman and Rangachar, 1992).

Other technologies for creation of documents include a wide variety of word processing and graphic software, joint (and group) authoring tools, and version control and access control software. Digital cameras, audio capture boards, and computer graphics systems that produce animation are used for digitizing non-text information.

Storage and Organization

Several technologies determine how documents are stored and organized. The primary developments are the compound document architecture, distributed storage management software, the integration of documents and databases, and hypertext.

Compound Document Architecture. Such an architecture is required for the different objects that make up a compound document to be handled together. In several implementations, the compound document consists of objects (e.g., a text object, a graphics object, a spreadsheet object, a digital photograph object) that may be stored on different devices, brought together logically through the use of pointers. Several vendors are working on different definitions of a compound document, although the Compound Document Architecture (CDA) from Digital Equipment claims over 200 compliant applications from 50 vendors (Travis, 1990; Williams, 1993.)

Distributed Storage. Documents are stored on local PC hard drives, servers (including large-capacity document servers), mainframes, and large repositories. A recent survey by the Gartner Group found that 80 percent of the documents stored in a PC networked environment are stored on the local hard drives, not on the server (Popkin and Cushman, 1993). This underscores the importance of distributed document management software to provide organization and access to this valuable resource.

Integrating Documents and Databases. Making documents an integral part of the information resources of an organization requires integration of document collections and databases. So far, most approaches have been to extend the database to accommodate documents, or vice versa. One approach is to define a BLOB (binary large object) as part of a tuple in a relational

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database (Shetler, 1990). A column is defined as a large binary object that can contain a document image or compound document in bit form. A document-centered approach is to reference a data record or entity in the document. This cross reference is used by the application to link the document with a data record. These early approaches are helpful in the short run, but eventually there needs to be an approach that integrates the data and document resources by their content, instead of just linking documents and data records (Gilbane, 1993a). Developing these approaches promises to present major challenges to researchers and practitioners. Organizing, cataloging, and retrieving concepts in documents is likely to require an entirely different architectural approach than those that have been used for facts in data records.

Hypertext. Software that implements a hypertext structure enables non-linear access to the logical structure of text within a document and multiple cross references between documents. *Hypermedia* technology provides the same functionality with multi-media or "compound" documents. Hypercard by Apple and Notecards by Xerox are examples of software to support hyperstructure (Bieber and Kimbrough, 1992; Conklin, 1987; Halasz, 1988).

Retrieval and Synthesis

Information retrieval selects documents from a collection according to the presence or absence of keywords assigned by an indexer. *Text retrieval* uses algorithms that eliminate the need for an assigned index. All content-bearing words are indexed (Lundeen, 1992). A further enhancement called *concept retrieval* uses thesauri and word co-occurence analysis to select documents that use similar, but different, words to represent a concept (Chen, et al., 1993). Queries can result in a list of selected documents ranked in order of likely relevance. An extension of this approach allows automatic synthesis or summarization of documents.

Transmission and Routing

E-mail systems are moving beyond simple text messaging to become the primary transport mechanism for electronic documents and forms (Butler-Cox Foundation, 1991). Object independence allows transmission of compound documents consisting of a variety of objects (text, graphic, image, audio, video). Other functionality required for business transport of electronic documents includes:

1. Authorization—assuring that the correct user is accessing the workstation and documents
2. Authentication—assuring that the "digital signature" of the user is valid
3. Encryption—coding and decoding documents for security
4. Filtering—automatically routing messages or documents according to their content

Other relevant technologies for routing include workflow management software, access control mechanisms, and intelligent documents. Documents that are "intelligent" or "smart" contain mechanisms to sense who should receive them and in what form. The document literally sends and displays itself to accomplish its purpose. "Active documents" by Interleaf is an example (Beal, 1991; Michalski, 1991; Weinberger, 1991).

Print and Display

Most documents will be printed at some time in their life cycle, so an important technology is the wide variety of digital printers and copiers on the network. These printers, along with text-handling software, page layout languages, and WYSIWYG displays (what you see is what you get) put high quality printed output within reach of nearly everyone. Laser printers significantly reduce the need for preprinted forms. Desktop printers permit distributed printing of richly formatted documents. Xerox's new production publisher operates on a network, accepts Postscript files, allows printed tab inserts, and offers a variety of covers and binding. The result is a new form of distributed printing and "print-on-demand" services that can print small or large runs of complex documents at remote sites under the direction of a workstation. Color copiers and printers also lead to an increased use of color in printed documents. More than just its attractiveness, color is providing a major increase in the communication power of documents (Shank and LaTarce, 1990; Vienzenu, 1988).

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This network of printers requires a set of software to manage the distributed printing. Print services on the network might include, for example, usage and activity reports, downtime and repair reports (perhaps with automatic diagnostics and repair calls), checks to be sure documents are being printed on the most appropriate printer, automated job tickets, and an accounting log. For documents that may not need to be printed, electronic display/delivery would take the place of printing, but the lack of a truly universal standard (other than ASCII) is slowing the growth of paperless publishing (Gilbane, 1993b).

Document Management Functions

The second sublayer of the document technology infrastructure consists of document management functions that cut across the phases of document processing. This set of functions is what enables documents to be managed as an information resource rather than as a collection of files. These document management functions include:

- Status Reporting—Who has a document? What is its recent activity?
- Access Control—Who "owns" it? Who can read it? Change it?
- Version Control—What is the current version? What previous versions are still needed?
- Retention Management—What are the legal retention requirements? Corporate policy requirements? How do we destroy paper and electronic versions?
- Disaster Recovery—How and where are backup copies kept? What are the recovery procedures?

This technology section can be summarized with the conceptual layered architectural diagram shown in Figure 2. The lower level is the basic infrastructure, and the middle layer (with two sublayers) is the document infrastructure required for EDM. The top layer is the application layer, which shows the four main areas of business value described earlier. A more detailed set of application areas is described in the next section.

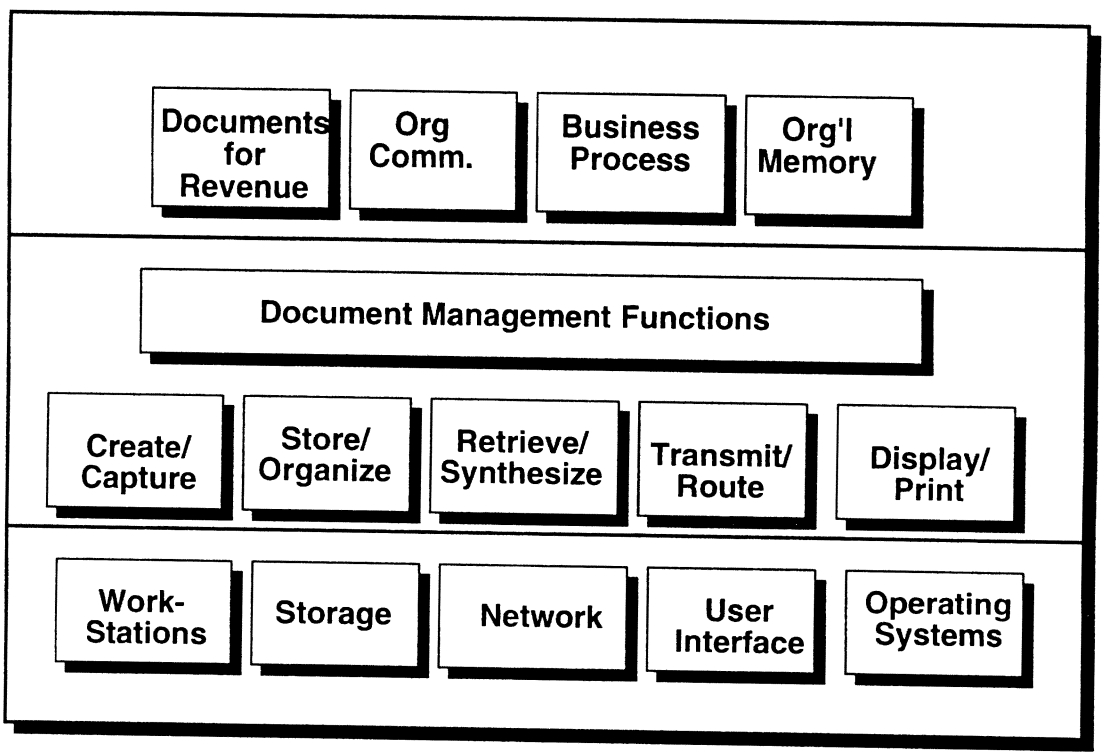

Figure 2. Technology Architecture for EDM

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Application Areas

The applications that generate value to the organization constitute the second perspective that helps organize EDM. The word "application" is used here in the broad sense of benefit, impact, usage, and value, rather than a specific program or system.

Case example

As technology and organizational processes evolve, EDM applications will be developed in several areas, and for several purposes. To illustrate the areas in which EDM can be applied, consider the case of a medium-sized manufacturing firm that discovered several EDM applications evolving in separate areas. These application areas, and the departments in which they evolved, are summarized in Table 2.

This case illustrates that the EDM approach and technology are turning up in several application areas. Generally, the departments that install them are not aware of the developments in the other areas. These "first generation" EDM applications generate business value by improving customer service, revising business processes, speeding the distribution of documents, reducing storage costs, or improving access to documents. They are different enough in structure, purpose, and users that they are separately developed, but they use similar technologies and approaches. Imaging, for example, is a technology used in several of the applications. A document server with multi-media storage and a strong search engine is needed for several. And the concept of "just in time" (printing, learning, forms processing) pervades the design philosophy in all areas. Without some planning in the development of these applications and their extensions, however, incompatibilities will limit the effectiveness of the applications in all areas.

Document management application areas

A taxonomy of application areas will assist the planning for integration of applications over time. This section describes some of the application areas that are particularly susceptible to EDM. They are generic functions in organizations that:

- Depend on the document as the primary mechanism for getting the work done,
- Are susceptible to emerging document technologies, and
- Have proven business value resulting from the application of EDM technologies and approaches.

EDM applications that generate value in supporting the organization can be organized into seven generic categories.

1. Improving the publishing process
2. Supporting organizational processes
3. Supporting communication among people and groups
4. Improving access to external information
5. Creating and maintaining documentation
6. Maintaining corporate records
7. Promoting training and education

Improving the Publication Process. Technology is enabling a major restructure of the process of publishing and distributing paper documents. For those organizations that produce documents as a product or as support for a product, this change is reengineering their document production processes. The stages of the traditional process, designed primarily for high-volume and high-quality documents, are shown in Figure 3. The document is created, generally with the use of electronic tools, and a photographic plate is made for an offset printing press. The offset press requires long print runs to amortize the extensive set-up costs. Thus, a large quantity of documents is produced and stored in a warehouse, then shipped to its destination when required.

This process has several inefficiencies. The offset presses are large, expensive, and use toxic chemicals. The infrequent long print runs require storage of documents that can become obsolete between runs. And transportation is an inordinately large part of the total cost of the process. In fact, R & R Donnelly, the country's largest publisher, estimates that 60 percent of the total cost of delivering these documents is in storage and transportation.

Figure 4 shows the steps in the revised publishing/distribution process using newer technologies. Documents are stored electronically, shipped over a network, and printed when and

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Table 2. Case Example

Department	Application
Records Management	An imaging system for archival storage and access to legal and tax documents. Replaced an aging microfilm system. Implemented on a network to eliminate physical shipment of paper documents among several offices in different cities.
Manufacturing	An extended version of a CAD/CAM system to use imaging to manage the blueprints and engineering diagrams.
Human Resource Management	An imaging system to support the hiring process. Candidates' resumes are scanned into the system when they apply, then circulated in image form among the many people involved in the hiring process.
Systems and Procedures	A plan to improve the process of printing and distributing the procedure manuals to secretaries and administrative assistants. Currently—Manuals printed centrally and mailed to all users; revised yearly with interim modification sheets. Phase I—Print manuals over the network on high speed remote printers at each major site (distributed printing). Phase II—Allow secretaries and administrative assistants to print sections of the manual on their local printer as needed (print on demand). Phase III—Add retrieval and reference capability so users can access relevant parts of the manual online as needed.
Customer Services	A new system for publishing and distributing owner's manuals, repair manuals, product descriptions, and products specifications. In the past these have always been printed on paper and mailed to customers, distributors, and sales personnel. Recently they began distributing them on CD/ROM.
Administrative Services	Development of a work flow system utilizing electronic forms for such tasks as office supply orders from stores, check requisitions, internal office equipment orders, telephone change requests, etc. A new version of the system will include some features such as authorization, encryption, and signature verification that will also permit the use of electronic forms for larger and more important processes.

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Table 2. Continued

Department	Application
Training and Education	A plan to evolve the process of teaching administrative assistants and secretaries. Currently a classroom course, based heavily on the procedures manual, which uses multi-media presentation materials to explain the steps in these procedures and show the forms that must be used. Phase I—Convert the multi-media course to a computer-based training course for use on a work station instead of in the classroom. Phase II—Structure the software so each procedure module can be accessed as needed rather than as part of an entire course. Phase III—Use real forms instead of just sample forms as part of the course material. These forms can be filled in on the work station and sent over e-mail so that the system becomes a real workflow system that actually performs the tasks. Access to reference material and training/education are additional built-in features.

where they are needed. The major benefits result from the reduction of obsolescence (revisions are made frequently to the electronically stored version), elimination of warehouse costs, and reduction or elimination of delivery time.

Supporting Organizational Processes. Documents are the vehicle or mechanism through which most processes in organizations are accomplished. Typical examples include processing a claim in an insurance company, hiring a new employee, or making a large expenditure. The documents are primarily forms, which flow through the organization carrying information, and accumulate input and approval from a sequence of people. These "workflow systems" are still heavily based on the physical circulation of paper forms in most organizations.

The use of technology to support these processes generates significant value in reduced physical space for the handling of forms, faster routing of forms (especially over geographical distances) and managing/tracking of forms flow and overall workload. Two new trends in organizations are increasing the importance of these workflow systems: quality improvement processes and process reengineering, both of which tend to be heavily dependent on documents.

In addition to transaction-oriented business processes that can be improved with EDM, many organizations are finding that documents are important to management processes such as reporting, control, decision making, and problem solving (Stanat, 1988). Several executive information systems (EIS) now supply documents to supplement the more traditional data-based reports. Organizations with a custom-developed EIS are also adding so-called "soft" information in the form of documents (Watson, et al, 1993).

Supporting Communication Among People and Groups. The purpose of applications in this area is to facilitate communication among people, and groups of people, in organizations. In the broadest sense, all EDM applications support this function, but included in this study are specific systems to support the transfer of information among people across time and space. Communication *can* take place without documents, of course. The conversation in the hall, a phone call, a video conference, a presentation—all are communication events that

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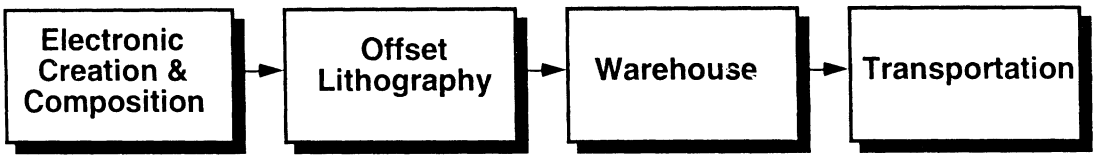

Figure 3. Traditional Publishing Process

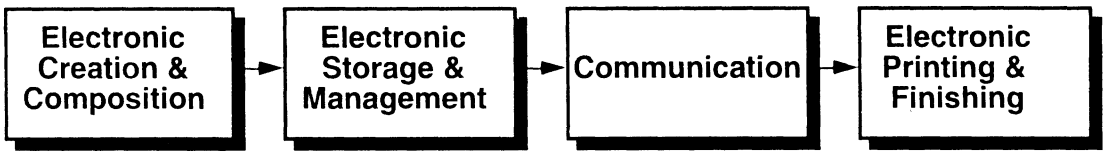

Figure 4. Reengineered Publishing Process

do not necessarily require a document. However, if the concepts, ideas, and information are to be communicated over time, they must be captured in a document. If they are to be communicated over distance, without voice or video connection, they must be captured in a document. Even when communication takes place between people at the same time and in the same place, a document might be used to improve the articulation or formation of the concepts. The primary value of EDM applications in this category derives from the richer communication offered by multimedia or compound documents and the reduced time needed for the electronic distribution of documents. An additional value results from the sharing of documents among a group of people simultaneously, coupled with the rapid feedback and interaction that ensues. The popularity of Lotus NOTES to support a variety of organizational communication illustrates this set of benefits.

Improving Access to External Information. The purpose of applications in this area is to provide better access to external information resources. Two general kinds of external resources are time-critical information (news) and reference material. The documents include news wire items, newspapers, periodicals, magazines, electronic bulletin board items, books, video tapes, research reports, proceedings of conferences, etc. Traditionally performed by a library, these applications are increasingly computer-based with online card catalogs, direct user access to online text databases (e.g., DIALOG, NEXUS), circulation of full text research papers, etc.

A major emerging document reference and access service is the wide area information system (WAIS) (Kahle and Medlar, 1991). It consists of a consortium of universities, government agencies, research institutes, and other organizations that share access to the full text of a document collection through a client/server network. Other document collections are available on the Internet. FTP, Gopher, and Archie allow access and transfer of text files from servers across the network. The World Wide Web is a multimedia, hypertext collection of documents managed by the Center for European Nuclear Research (CERN) in Switzerland. To access and explore the WWW collection, the National Center for Supercomputing Applications (NCSA) has developed Mosaic. NCSA Mosaic is a distributed hypermedia system designed for information discovery and retrieval on the global Internet. Mosaic provides a unified interface to various protocols, data formats, and information archives using powerful methods for discovering, using, and sharing information.

Creating and Maintaining Documentation. Another cluster of applications in EDM involves the creation, maintenance, and distribution of documentation. The purpose of these applications is to maintain documents that contain policies, procedures, reference material, product descriptions, etc. They differ from records management applications, which capture and store documents for archival purposes, accessing them infrequently and usually by request from an internal user. Documentation applications, on the other hand, maintain the "current version"

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of documents, which must be updated and accessed frequently by a wide variety of requesters. Documents tend to be reports, manuals, drawings, and reference material; they have been mainly text in the past, but are increasingly multimedia. Examples include:

- Internal standards and procedures manuals.
- Engineering blueprints and diagrams, possibly created with a CAD/CAM system.
- Systems documentation (MIS) and operating manuals.
- Product documentation manuals and other product information, both for internal users and customers.

Access to documentation can be provided in several ways. For internal users, online access through a workstation is most common. For external users, access to documentation improves customer service by providing answers to customer queries or solving problems with the right reference material.

When access is provided to reference material, not online, but through periodic distribution, these applications become "electronic publishing." When the reference material goes beyond basic status reports or reference material, it may become an "information product" of value to customers or as a marketing tool usable by dealers or distributors.

The benefits of EDM for these applications are (1) quicker access to the documents, (2) more efficiency in the search process, (3) simultaneous access by several people to the most current version of the document, and (4) reduced cost of printing and distributing documents.

Maintaining Corporate Records. Organizations must maintain official documents and records concerning their obligations, agreements, and financial performance, primarily to satisfy legal requirements. Traditionally the responsibility of the Records Management Department, this application area involves storage and retrieval of contracts, financial records, internal reports, and other important corporate documents. These are "documents" in the traditional sense, mainly text and mainly on paper. The role of EDM applications in this area is to manage this set of official corporate records by providing archival storage and occasional retrieval. The methodologies, approaches, and technologies have evolved from a tradition of library operations (from an earlier emphasis on automated records center applications, micrographics (film and fiche), and computer output microfilm (COM)) to an emphasis today on digital image processing. For records management and documentation applications, a government initiative is becoming important. CALS (Computer-aided Acquisition and Logistic Support) has been defined as a requirement for documentation by the U. S. government (Carter et al., 1989). Starting with the Defense Department, it has been adopted by many other government agencies (Zurier, 1992). Eventually, it is likely that any organization with government business will need to be CALS compliant.

For large records management applications, the savings from image processing in storage space and ease of retrieval alone are impressive. Other sources of value from the application of technology to records management include:

- Reduced misfiling of important documents
- Quicker and more accurate retrieval
- Better access and sharing over geographic distances
- Better version control
- Improved retention management

Promoting Training and Education. The purpose of the applications in this area is to teach or train people in an organization. The documents are curricular training materials or reference materials, and the use of multi-media documents, perhaps with hyperstructure, are proving to be extremely effective. A primary characteristic of these applications is the continuous, sequential interaction between the user and the information through the learning process over time, rather than a specific search and retrieval event to obtain a document.

Training and education applications are good early examples of the use of multi-media documents and hypertext. As mentioned earlier, hypertext is the most promising approach to structuring conceptual information. The body of knowledge to be learned or understood consists of "concept nodes," which are linked or cross-referenced to form a "web" of ideas and concepts. An excellent example is the intermedia research project at Brown University (Yankelovich, et al., 1988).

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Converging Application Areas

These categories of applications illustrate the benefit and value of EDM. The good news is that there are many opportunities in many different areas. But these applications use many common approaches and technologies, and, as the earlier case example illustrates, it will be desirable for them to converge eventually. If they have been developed separately, without a plan to integrate them, it will be very difficult to reap the potential benefits.

Roles and Responsibilities

Because of the pervasiveness of documents, most organizational units will find it important to use technology for document management. There are, however, several departments that have had primary responsibility for one or more functions in document management. It is these "document support" departments that will find it especially important to work together and coordinate their efforts. It will become their responsibility to develop the infrastructure needed to enable electronic document management. Thus, the third perspective for structuring EDM is identifying and defining the roles and responsibilities of these document support departments so they can accommodate the document processing needs of all other departments in the organization. The primary document support departments are:

- **The IS Department**—The technology is advanced enough and pervasive enough that the IS function will probably be given the responsibility for building the technical infrastructure of the organization to embrace it. The challenge is that the fundamental structure and processing of conceptual information in documents is quite different from that of facts in data records. Moreover, the principles and techniques of document storage, classification, indexing, retrieval, and retention are foreign to most IS professionals.
- **Records Management**—With its tradition in library science, Records Management has strong experience in document management practices, with particular emphasis on archiving and retention management. Therefore, technology has been viewed mainly in terms of its ability to meet specific needs in traditional areas such as storage and retrieval.
- **Office Management**—Most office work is computerized to some extent, but internal and external correspondence and reports still generate large amounts of redundant and hard-to-access paper files. In the future, these files will need increased cross-referencing among departments and integration with the IS databases.
- **Library**—External sources of information are increasingly available in electronic form, with search and retrieval capability from large document collections.
- **Reprographics and Printing**—Computer-based technology is becoming dominant. New high-speed printers and copiers are digital (not light-lens) and contain more computer power than many mainframes. As a result, offset printing presses may be an endangered species. Add a full line of networked Postscript printers to supply distributed printing and print-on-demand services, and central reprographics departments face an uncertain future.
- **Training and Education**—Increasingly based on multi-media documents and courseware, training is done "just in time" at the desktop as well as in more traditional classroom settings.

The result of these developments is that all the groups above will be facing significant changes in their traditional work and responsibilities. In addition, new ways of handling documents will affect the work practices of almost everyone in an organization. IS managers, as developers and managers of the technical infrastructure for EDM, will be in a position to lead this evolution and become the organization's major change agents, as they have been in the EDP and MIS eras. However, assuming this leadership role will require the IS Department to take some specific steps, such as those described below.

Conclusion

The previous sections of this paper have argued that EDM is a potentially significant development in organizations, but that it will create some major changes in the ways organizations process information and conduct business. The tech-

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nology is new, powerful, and rapidly evolving, but that rapid rate of change will make it difficult to build a compatible technical infrastructure to support document management.

This effort is justified, however, because there are applications in several business areas that can benefit from EDM tools and techniques. Because these early applications are springing up in diverse areas, there is a danger that they will evolve separately, although they benefit from being integrated. Therefore, planning will be important to build an integrated document technology infrastructure. In this process, several departments or organizational units with a history of document management will need to work together, even though they have different history, background, and perspectives.

The IS department has the opportunity to play a leadership role in coordinating the efforts of these user departments and document support departments in order to evolve the infrastructure and applications needed to support EDM. Playing this leadership role may be more difficult than it has been in the past. In this era of distributed systems and distributed responsibility for systems initiative, IS managers will need to educate a variety of user departments and document handling departments, convincing them to cooperate in the development of an EDM strategy and technology infrastructure. Here are some steps that IS managers can take now to prepare for these developments.

Form a "Document Council." Form a council consisting of representatives from each of the document support departments identified above that have been charged with managing some part of the document processing cycle in the past. Their first assignment would be to identify mission-critical documents and work back to applications and departments that depend on them. An initial set of applications will undoubtedly evolve from the members of the group. They have probably been responsible for producing and managing these documents in the past.

There will also be important applications that have been developed directly by the user departments, so the group should develop a way to find important applications of which they are not aware. Mechanisms for doing this include examining the areas and examples mentioned earlier in this article, finding examples in journals and trade publications, and distributing surveys and questionnaires in the organization. The work of this group and the technology tracking group described below should proceed in parallel, with periodic joint meetings for coordination and status reporting.

Form a Document Technology Group. Assign the task of tracking and forecasting the emerging document technologies to a small group with technical proficiency in several areas. If there is an advanced technology group, this assignment would probably fit into its charter. The assignment should cover both the infrastructure technologies as well as document technologies.

Prioritize Applications. The application group, perhaps in consultation with people who have been using the documents, should then prioritize the applications by business value and technical feasibility. There might be a difference in long and short-range perspectives, so both should be considered. The prioritization should also include consideration of fit or linkage between applications, especially when two or more applications can use the same technology or approach.

Develop an EDM Plan. As a result of their regular joint meetings, the document council and the document technology group can jointly develop a plan for adding the necessary technology to the infrastructure and developing the applications. These applications might not be developed by the IS department, or even by the departments represented in the group, but their development and approximate time schedule should be included in the plan. As it is refined and developed over time, this plan becomes an integrated EDM architecture and a plan for implementing it.

Revise Responsibilities. By this time, it may become clear that some of the roles and responsibilities of some departments may need to be revised. The council can develop recommendations to management concerning these changes. By performing this step last, any shifts in responsibilities will result from discussions based on the evolution of the applications and technologies, measured by business value. This will reduce the

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probability of a "turf war" that could result from the changes in the way documents are managed.

The benefits of EDM will evolve as the technology and our ability to use it evolve over the next several years. It is not too early, however, for IS managers to begin the planning processes to build the technology infrastructure for document management and to harness these new technologies to improve the performance of their organizations.

Acknowledgements

The concepts and ideas in this paper evolved over the past several years from a review of literature in several contributing disciplines and technologies and an analysis of more recent literature that is "converging" into EDM (Sprague, 1990). These reviews led to a series of interviews with over 100 managers, executives, and professionals concerned with the development of this topic. The interviews, conducted over the past two years, sought information and opinion on the opportunities, importance, and "philosophy" of EDM, as well as examples of current and potential applications. The categories of business value, the conceptual technology architecture, the application areas, and the suggested action plan evolved from these interviews. Early versions of the paper were reviewed by CIOs who were members of the Dooley Group and the Xerox Executive Advisory Forum. Their contributions and suggestions are acknowledged and appreciated.

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