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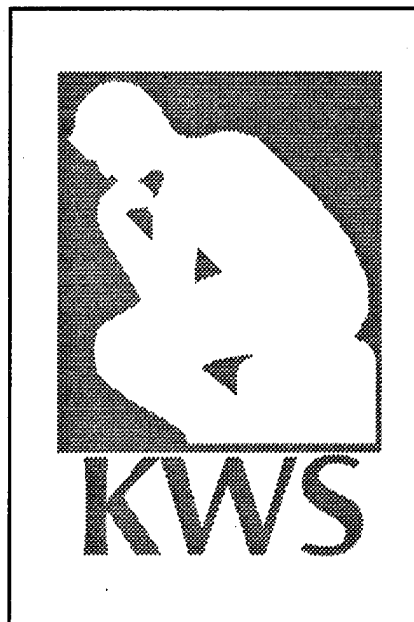
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September 1995

Document Management for the Knowledge Worker System

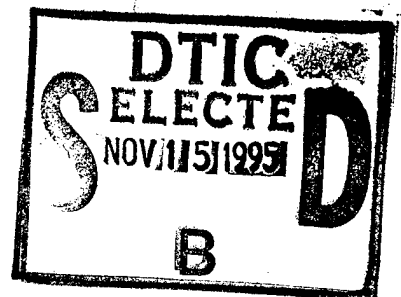
by
Sandra Kappes, Wayne J. Schmidt, and Duane D. Sears

"Knowledge workers" are personnel who perform business processes that involve the use of information resources to generate a product that is itself some form of manipulated information. The U.S. Army Corps of Engineers' Construction Engineering Research Laboratories (USACERL) is conducting research and development on a performance support environment for knowledge workers called the Knowledge Worker System (KWS) that enables workgroups to define the tasks, information resources, institutional knowledge, and computer applications required to perform their business processes. KWS provides the capability for knowledge workers to define associations ("attachments") between a task and the information resources required to execute their tasks. Attachments allow knowledge workers to access documents while executing a task, and can be associated with any electronically stored information resource from anywhere within the KWS process model.

This research: (1) developed a strategy for providing KWS users with improved attachment management capabilities and (2) developed methods to implement this strategy through a series of modifications to KWS Version 2.0, now available to KWS users.



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Foreword

This study was conducted for the Directorate of Military Programs, Headquarters, U.S. Army Corps of Engineers (HQUSACE) under Project 4A162784AT41, "Military Facilities Engineering Technology"; Work Unit FF-AT5, "Knowledge Worker Information Management." The technical monitor was John Sheehey, CEMP-MC.

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1 Introduction

Background

In both the government and industry, a large number of personnel are classified as "knowledge workers." Knowledge workers perform business processes that involve the use of information resources to generate a product that is not necessarily a tangible item such as a piece of machinery, but is itself some form of manipulated information. For example, to develop a government contract document, a knowledge worker requires access to a variety of information resources, including government contracting regulations, required forms, vendor information, previous contracts, information on funds status, and so on. The knowledge worker uses this collected information to generate the final product—the contract document.

Because information is the primary input to knowledge work, the quality of a knowledge worker's product depends on the ability to access and use the relevant documents containing this information. Managing and ensuring access to documents has always been a difficult task. The "Information Age" has simplified document creation and, as a result, the sheer number of documents has increased considerably. Because of this, managing documents—especially in electronic form—has become increasingly difficult.

The U.S. Army Construction Engineering Research Laboratories (USACERL) is conducting research and development on a performance support environment for knowledge workers called the Knowledge Worker System (KWS), which enables a workgroup to define the tasks, information resources, institutional knowledge, and computer applications required to perform their business processes. This information is stored in KWS, making it available to support task execution.

KWS provides online access to information resources by associating specific business processes or tasks with the information and/or documents required to support those tasks. For example, the task "Write Technical Report" requires the use of several information resources as well as the actual report document being generated. These resources might include instructions for required report format, content guidelines, referenced documents, author notes, and a word-processing template for technical

reports. Access to these resources is then provided to all knowledge workers involved in executing the defined task.

KWS associations can be made to any electronically stored information resource. These associations are implemented in KWS through "attachment links." The associated electronic documents are referred to as "attachments." Users can access the attachments relevant to a specific task from anywhere in a KWS process model (Figure 1).

Attachments may be defined during the initial development of a KWS business process model or on an *ad hoc* basis as required by the user. Attachments can exist in a variety of formats and can be generated by multiple sources. As the size and complexity of the KWS model increases, the number, format, and sources of attachments also increases, making it essential that KWS effectively manage the creation and use of attachments to ensure that the knowledge worker can easily access needed information. This step in ongoing KWS research investigated the effective management of attachments within KWS and developed and implemented a strategy to provide state-of-the art capabilities for attachment management within KWS.

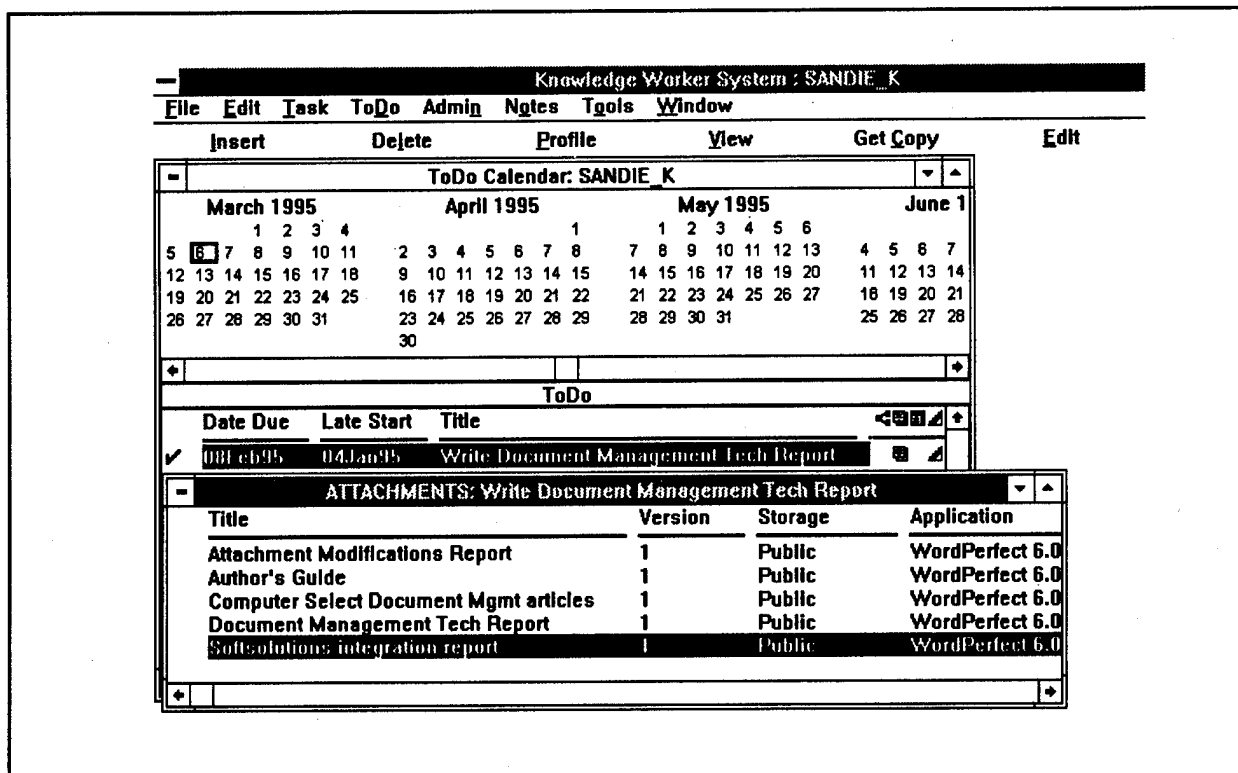


Figure 1. KWS Attachments links menu.

Objectives

The objectives of this research were to: (1) develop a strategy to provide KWS users with improved attachment management capabilities and (2) develop methods to implement this strategy through a series of modifications to KWS.

Approach

The basic document management requirements of knowledge workers were identified and commercially available document management services were reviewed to determine state-of-the-art document management capabilities. These results were used to develop a three-step strategy for improving KWS attachment management:

1. Existing KWS document management capabilities were evaluated and required capabilities not currently supported were identified. This information was used to develop specifications for modifying KWS to meet the basic requirements to provide knowledge workers with more effective ways to access the required information to do their jobs.
2. To provide users with additional document management capabilities in a relatively short time period, a method for integrating KWS with external, off-the-shelf applications was identified and demonstrated.
3. Advanced document management requirements of knowledge workers were identified and potential mechanisms for including these capabilities in future versions of KWS were described.

Mode of Technology Transfer

The findings of this research will be incorporated into current and future USACERL work units addressing the development of the Knowledge Worker System. The USACERL point of contact for obtaining KWS information or software is:

Wayne Schmidt
U.S. Army Construction Engineering Research Laboratories (USACERL)
PO Box 9005
Champaign, IL 61826-9005
tel. 217/352-6511, X7221, or (outside Illinois) 1-800-USACERL

2 Knowledge Worker Document Management Requirements

Document Management

“Document management” is a term that refers to the storage, retrieval, tracking, and administration of documents within an organization. The term originated with the use of manual file cabinets to store paper-based documents in alphabetized categories based on the documents’ contents. Since the widespread use of computer technologies, document management now also applies to electronic documents and paper-based documents converted to electronic form. Electronic documents exist in a variety of formats including word-processing files, spreadsheets, graphics, video, audio, bit-mapped images, and compound documents incorporating multiple formats. Now, instead of manual file cabinets, automated tools for document management are required to provide users with services to access electronic documents.

The Knowledge Worker System provides electronic access to information resources through associations of specific business processes with the documents required to support that task. As the size and complexity of the KWS business process model increase, the number of attached documents also increases. KWS must provide document management services to effectively manage attached documents to ensure that the knowledge worker can easily access and use the needed information to support KWS processes.

Basic Knowledge Worker Document Management Requirements

The following sections describe the basic document access requirements of knowledge workers and the document management services that KWS requires to provide simple access to and manipulation of documents. The services required include support for document creation, storage, retrieval, tracking, and administration within an organization. By providing these services, KWS can effectively provide knowledge workers with the information required to support their processes. (Additional services to provide more advanced support will be discussed in Chapter 6.)

Document Creation and Editing via Commercial Applications.

Knowledge workers use a variety of commercial applications to create and edit documents, including word-processing, spreadsheet, graphics, and electronic forms software. KWS users need to be able to access their preferred commercial applications to create and edit documents from within KWS. Document management services must be provided that support these commercial applications.

Document Storage and Retrieval.

After documents are created, services are required that eliminate the burden on knowledge workers to determine specific locations where the documents should be stored. This is analogous to deciding, in a traditional office, in which file and file cabinet to physically store a paper document. It should not be the responsibility of the knowledge worker to do this; document management services should be provided that determine this location based on specific information about the document, e.g., the individual creating the document, the content of the document, and the business process it supports.

Knowledge workers should also not be required to know the cryptic DOS file naming structures (e.g., "SERVER\VOLUME: DIRECTORY\FILENAME") to retrieve documents. Instead, knowledge workers should be able to retrieve documents using meaningful names that describe the content of the document.

Enterprise Document Storage Architecture

A storage architecture can ensure knowledge workers access to documents from anywhere in a given organization. One or more knowledge workers may need to share documents at one storage site or across multiple storage sites. A properly designed architecture will define where to store documents and will ensure quick access to them. In traditional terminology, this architecture would define which "file cabinet" a document should be stored in. In computer-based terminology, this "file cabinet" is a "file server," accessible via the computer network. The enterprise document storage architecture would define the locations of the various file servers in an organization. Using this architecture, documents would be stored on the appropriate file server that would enable access to them by anyone requiring it.

Multiple Storage Media

Knowledge workers also require support for storing documents to a number of different storage media. Besides file servers on local area networks (LANs), documents can be

stored to hard disks, Bernoulli disks, floppy disks, CD-ROM, jukeboxes, and so on. These media serve different purposes for document storage. For example, storing to floppy disks allows knowledge workers to remove a document from the network to edit it on a laptop computer away from the office. Jukeboxes are a cost effective solution for archiving files while still maintaining the capability to access them in a reasonable time period. Storage management routines may vary and would be determined based on the organization's specific document storage requirements.

Backup and Archival

The information stored in KWS attachments is a vital organizational resource. Mechanisms are required that ensure the safety of this information. The capability to back up documents to appropriate media is required and should be performed on a regular basis.

As the number of attachments in KWS grows, so do the number of documents. Because of storage limitations on any individual file server, management strategies are required that migrate files to secondary storage media. These strategies would be based on criteria such as period of time since last use. Since archived documents may be required at a later time, services are also required to allow knowledge workers to retrieve them on an "as needed" basis.

Shared Document Access

The collaborative nature of KWS may precipitate the use of a single document by more than one knowledge worker. Because of this, mechanisms are needed to maintain the document's integrity. For instance, unless document management services prevent modifications to the same document at the same time, the document will not accurately reflect the changes made by simultaneous edits. This document sharing capability would allow only one knowledge worker to edit a document at a time while still allowing other knowledge workers to read the document.

Document Import From Multiple Sources

Many documents used by knowledge workers are generated from external sources and originate in either paper or electronic format. KWS requires the capability to import electronic documents in a variety of formats, including word-processing files, spreadsheets, graphics, video, audio, bit-mapped images, and compound documents incorporating multiple formats. To provide quick access to paper documents within KWS, some mechanism must provide an interface between KWS and electronic scanning technologies capable of converting paper documents to electronic form. Once

converted, the knowledge worker may wish to either view or edit the file. Viewing the file requires an interface to technologies that allow the knowledge worker to display the electronic image of the document generated during the conversion process; editing requires an interface to optical character recognition (OCR) technologies capable of converting the electronic image of the document into a word-processing file format.

Document Viewing

Knowledge workers need the capability to view documents in multiple formats without having to launch the application used to create it. For example, a knowledge worker might need to access a Standing Operating Procedure (SOP) relevant to the task being performed only for reference—not to edit it. Without this capability, the knowledge worker would be limited to viewing only those documents created in application software for which they have legal copies. This would unnecessarily limit enterprise-wide access to documents generated across organizations in multiple formats.

Document Versioning

Versioning provides the capability to track changes made to the working version of a document. Multiple revisions of the working document can be maintained to allow one or more users to modify the original document. Once the revisions are reviewed and approved, the revisions can be reconciled to produce a single final document. Versioning also provides the capability to track multiple versions of the final document generated by incremental content revisions. For example, during the execution of a government contract, multiple versions of the contract may be generated. The initial document is the first version created by the knowledge worker. During the course of contract execution, modifications to this initial document may be required to add to or modify the contractor's tasks. Throughout the process, it is necessary to maintain the initial document as well as the revised document. Versioning provides this capability and allows tracking the history of the contract.

Security

An essential aspect of document management is to maintain all documents secure from unauthorized access. Each document varies in the type of security required based on its content. For example, there are legal requirements to maintain high levels of security on pre-award contract documents until the contract is awarded. After that time, the document must be made available to anyone requesting it. Some documents may require different levels of security. For example, some members of a workgroup may be authorized to modify a document while others may only be allowed to view it.

Document management services must also provide mechanisms for assigning a variety of access rights to each document based on its information content.

Document Management Strategy for KWS

Since both KWS and document management are rapidly developing technologies, an open-ended approach was developed to incorporate document management into KWS. This three-step strategy is meant to provide KWS users with better document management capabilities through a series of modifications to KWS and to allow access to more advanced document management technologies as they become available.

The first step was to identify the immediate document management capabilities required to support basic document management in KWS and to implement them through modification of KWS. This step is described in more detail in the following chapter.

The second step involved identifying a mechanism for quickly providing state-of-the-art document management capabilities in KWS by integrating KWS with commercial DMSs. The feasibility of this mechanism was demonstrated through a prototype integration with a single commercial DMS. (This step is described in more detail in Chapter 5.)

The third step was to define advanced document management capabilities required by knowledge workers and to provide recommendations for providing them in future versions of KWS. These recommendations address emerging document management technologies and are described in Chapter 6.

3 Review of Document Management Systems

Some commercially available document management systems (DMSs) can already provide users with state-of-the-art capabilities for document management. Attachment management in KWS adds a layer of complexity to managing an organization's documents due to the need to maintain the task/document associations. However, many of the capabilities available in commercial DMSs can be directly applied to KWS. A review of commercially available DMSs was conducted to identify the capabilities they support. No attempt was made to compare the capabilities or strengths of individual systems. Rather, this review concentrated on the overall capabilities and the benefits such systems provide to users. This review will serve as input into determining how document management can be improved in KWS.

DMSs automate document management on computer networks. (Standalone DMSs do exist for use on individual workstations but were not considered because they do not support file sharing throughout an organization.) These systems make it possible for workgroups to locate and share documents without having to know the DOS filename or physical location of the document. A DMS can also provide system administration functions by establishing criteria used to determine storage location or document archival actions. In addition, security criteria can be assigned to limit unauthorized access to documents. Essentially, DMSs provide a means of organized access and effective administration of an organization's documents.

A DMS works by storing critical information required to access the document in a document "profile." The profile includes such information as the document type, author, creation date, access rights, and so on. A good DMS allows for customizing the document profile to meet the particular needs of an individual organization. This profile information is stored in a data base used to retrieve the document without specifying the DOS filename and storage location. Through profiling, a DMS provides quick access to the user's documents by allowing the use of meaningful document names and searches by multiple criteria defined in the profile. Informative file descriptions can be specified in the document profile, thus eliminating the user's need to know the cryptic "SERVER\VOLUME:DIRECTORY\FILENAME" DOS file-naming structure. For example, the user can retrieve a file by specifying a descriptive title such as "Knowledge Worker Document Management Strategy" instead of (the less intuitive) "S:\ ATTACH\KAPPES\WPFILES\STRATRPT.WP6."

In addition to locating documents from the information stored in the document profile, a DMS can also index document text allowing users to perform full text searches to find documents. The user simply needs to input a word or phrase for the DMS to find and list all of the documents containing that input. However, the additional time and overhead required for generating and storing the indexes for this capability must be considered before providing it to users.

Most organizations deal with documents in multiple formats, ranging from ASCII text documents to spreadsheet or graphical documents. A DMS provides support to allow users to either edit documents in any format or to view and print them without having to load the application software that created them. A DMS can also provide mechanisms for converting paper documents to electronic form via integration with scanning and OCR technologies.

Other features provided by a DMS include the ability to copy a document and save it with a new profile, to generate multiple versions of a single document, and to track changes made to a document. A DMS can also provide the capability to temporarily check out documents from the network. The "check out" procedure copies the document to a removable media and locks access to the original document on the network so the document can be edited at another location such as a laptop computer away from the office and then checked back into the DMS. If another user tries to access a checked out document, the DMS will indicate that it has been checked out, who checked it out, the expected return date, and any other relevant information.

As workgroups produce more information, the storage requirements for documents increase. A DMS provides administrative capabilities to manage these increasing storage requirements. As the number of files grows, an organization will not be able to store them on one file server. It is therefore important to develop management strategies for migrating files to secondary storage media. These strategies can be implemented via the DMS to determine where a document is stored, how long it is stored, and when it should be archived to another location. For example, a document can be tagged for archival based on the period of time since its last use. An important feature is that, even though the document is moved off-line, the profile information is retained so users can still retrieve the document when necessary.

A DMS can also support enterprise-wide access to documents by allowing document sharing across multiple servers on the LAN or on servers at remote locations. This capability allows large organizations spread across various physical locations to deal with documents residing at multiple locations as a single corporate information resource.

Although DMSs support many capabilities, it was also found that they are an evolving technology. Because of this, considerable effort is required to install and update a DMS and incompatibilities exist between the various systems. Standards are being developed to address these issues and should soon be available. In addition, the evolving nature of this technology is an indication that more capabilities will be provided as the technology matures.

4 Basic Document Management in KWS

Introduction

The requirement for effective document management is not unique to KWS. However, KWS is unique in the way that it provides direct associations between the document and the task being performed. Therefore, document management within KWS also refers to the maintenance of the associations between a task and a document as defined in the attachment link. Because of this additional requirement, document management within KWS is also referred to as "attachment management."

Review of KWS Version 1.7 Attachment Management

The basic requirements for attachment management in KWS include those described in Chapter 2 for simple access and manipulation of attachments within a workgroup. In addition, there is a requirement for attachment maintenance to manage the task/document associations. KWS Version 1.7 was reviewed to identify the attachment management functions already provided and to determine if it provided the capabilities required. After this review, the modifications to KWS required to improve attachment management were developed and implemented in KWS Version 2.0.

Attachment Creation

Within KWS Version 1.7, attachment links can only be made to documents previously created outside of the KWS environment. For example, if a KWS user is performing a task that requires the creation and editing of a word-processing document, the user must open the word-processing application, create the file, edit it, and save it to a user-generated filename. The user must then create an attachment link within KWS to that attachment document. Since KWS does not support the capability to automatically create and link attachment documents within KWS, the user must execute the steps required to ensure the attachment link is made. In many cases, the user may forget to link the attachment or avoid the extra work and use the document entirely outside the KWS environment. As a result, important task/information associations supporting the tasks performed by the individual are not captured as part of the business process, already reducing the benefits normally gained by KWS.

Attachment Modification

Attachments are modified through the "attachment modify" option in KWS. The software application used to launch the attachment is defined when the attachment link is made by specifying the DOS command line required to execute the application. KWS uses this definition to launch the specified application with the associated filename. One problem with this is that the command line is specific to the individual user creating the attachment link. For example, if an attachment link is defined for a document created in WordPerfect, the user must specify the command line used to execute WordPerfect on the individual workstation, e.g., "C:\WPWIN\ WPWIN.EXE." This command may work for some users, but it will not work for those with WordPerfect installed in a different drive or directory.

File Storage Management

Attachment links in KWS are generated by the user who must specify where the document is located when creating a link. Once the link is made, the attachment remains in the location specified. This approach can result in attachment files being stored in various locations throughout the organization. Lack of storage management routines can result in: (1) users being unable to share documents, (2) administrators being unable to back up and archive KWS attachments, and (3) accidental corruption of the attachment link.

The ability to effectively share documents in a workgroup depends on the users' abilities to access attachments. If an attachment is stored to a local hard drive instead of a shared file server, no one can access it except from that workstation. Guidance on efficient directory structures for storing KWS attachments can be given to users to decrease this problem, but automated management routines are required to enforce them. These automated routines could determine where files are stored based on whether the document is to be accessed by other members of the workgroup or by only one individual.

When documents are spread out in various locations with no discernable directory structure, maintenance functions for backing up and archiving files are unnecessarily complex if not impossible. Storage management routines should enforce storage of attachments to centralized storage locations dedicated completely to KWS attachments. This will simplify maintenance functions for backing up files since the system administrator will know the exact locations that contain KWS attachment documents.

Attachment links to documents stored in random locations are very vulnerable to accidental corruption, which may occur when the attached file is either deleted,

renamed, or moved using DOS file commands from outside of the KWS environment. If the user tries to access an attachment with a corrupted link, KWS will be unable to find it since the original filename has been changed. Centralized storage management routines within KWS can prohibit or at least limit file access via external DOS file commands, thereby avoiding accidental corruption. If corruption does occur, recovery could then be possible through backup mechanisms.

Security Features

No mechanism is provided for limiting unauthorized access to attachments within KWS Version 1.7. Without these security features, attachments are not protected from modification by unauthorized users. This weakness forces users who want limited attachment access to store documents on a local workstation or to floppy disks that can be shared only by selected individuals, a method unacceptable in a workgroup environment. A capability to store attachments on a shared file server and to designate specific access rights to selected members of the workgroup is a better solution. Access rights assignment in KWS would limit access to attachments, thereby assuring users that their attached documents are secure from unauthorized access. For example, certain individuals may need access to edit a document while others may only need to look at it. In some cases, KWS need only indicate that there is an attachment and provide no access rights to it at all. If an attachment were stored on a user's local workstation, and the user tried to access it from another workstation, KWS' attempt to retrieve the document would fail. Instead of attempting to access the document, KWS would indicate to the user that they do not have access rights to the document. To gain access to the document, the user could then request authorization from the attachment's owner.

Attachment Viewing

Document viewing allows users to view documents without having to launch the application used to create it. KWS Version 1.7 allows for viewing text files only so that users must have a copy of certain applications used to create attachment documents before they can view them. Even if a user has the application, it is important to note that it may be improper to allow a user to view an attachment by launching an application since the objective is to "view only," not to retrieve or edit the file. Allowing the application launch subjects the attachment to unauthorized modifications.

Attachment Tracking

KWS Version 1.7 does not provide any features for tracking the history of attachment documents. It is important to keep a history of when the attachment was created, who created it, who edited it last, and when it was last changed. This information can be used for several purposes. First, it provides the user with a quick overview of who is responsible for the document and how current it is. Next, KWS can use this information to facilitate security and archival mechanisms. For example, KWS could enable document archival based on the period of time since the last edit. In addition, access rights to attachment links could be restricted to the attachment creator providing security against unauthorized modifications.

Attachment Versioning

Versioning provides the capability to save variations of a single document as separate files that can be used to track revisions to a document. KWS can provide this function, but not in an efficient manner. The user must select a "Get Copy" option in KWS, which copies the document to a user-specified location. The user is then responsible for creating an attachment link to the new document and specifying in the Attachment Title that it is a version of the original document. This time-consuming method precludes the possibility for KWS to provide mechanisms for ensuring that the versions are maintained as a single entity for other document management functions, i.e., archival.

Tracking Attachment Links

KWS allows a single document to be attached to multiple tasks causing a unique management requirement. The number of links associated with an attachment file are maintained by KWS, but are not displayed to the user. This information could be useful in understanding the impact of the process on the attachment document. For example, if the attachment were linked to a series of tasks in a review process, the user would be able to easily view the actions that will be performed on the attachment. KWS should also use this information for determining if documents should be deleted after all attachment links have been removed. This could lead to a large number of useless attachment documents being stored on the user's local workstation or shared file server. Although this deletion should not be automatic; the user has the option to move the document to another location when all links are removed.

Automatic Document Attachment

Documents can be created within KWS as the result of executing external software applications. For example, a report can be generated by a query to a mainframe data base system or a document generated from an electronic forms package. KWS provides this capability through the "Do It" function. For instance, the task "Generate Funding Authorization Report" could have a "Do It" linked to it that executes a computer application for logging onto a mainframe data base, generating the report, and storing the report to the user's workstation. On completion of this "Do It," KWS should automatically attach the generated report to the task. KWS Version 1.7 does not support automatic document attachment.

Exporting Attachments

On occasion, a knowledge worker may require access to a copy of an attachment outside of the KWS environment. KWS does provide users this capability through the Get Copy option. This option will save a copy of an attachment file to a KWS user-specified location and filename. For example, a user might need this option to convert an attachment file into another application or file format, e.g., to convert a PowerPoint attachment file to a Freelance format. The user would not be able to do this by making another version of the attachment and changing the Application value since Freelance would require the user to convert the attachment to its format via the Freelance Import option. However, the user could use Get Copy to save the file to their hard disk, import it into Freelance, save the file and then import it back into KWS.

Get Copy provides a valuable function to KWS users; however it could lead to problems if the user's intent was similar to the "check out" capability described in Chapter 2. Once the user removes the document from the KWS environment, the only way to return it is to create another attachment link to it. However, if the document were edited outside of KWS and returned via a new link, there could be confusion as to what to do with the original file. Should it be removed, or should it be considered a version? Also, if the original attachment in KWS were not protected from update while the copy was out of KWS, there is no way to indicate if changes were made.

KWS Attachment Management Modifications

After reviewing the existing capabilities for attachment management in KWS Version 1.7 and those required by knowledge workers, a set of modifications to KWS that could be implemented in a short time period were defined. These modifications were then implemented in KWS Version 2.0.

KWS's capacity to support attachment management was expanded by adding Attachment Profiling, storage management routines, and new options for creating, editing, viewing, and versioning attachments. Essentially, these features resulted in the modification of the KWS data base to support the additional attributes required in the attachment profile and modification of the KWS software to support the added functionalities.

Storage Management Routines

When attachments are created within KWS, the attachment is now given a KWS-generated document name and stored in a location reserved specifically for KWS attachment documents. This location is based on the Storage Type assigned to the attachment by the user (described in more detail later in this chapter). The user is only required to designate this value and is not responsible for determining the actual physical location where the document is to be stored. KWS then uses the Storage Type value and information specific to the user's organization to determine the physical location to store the document.

Automated management routines for attachment backup were not included in this modification. However, this process has been simplified by the centralized storage mechanisms enforced by KWS. Routine network and workstation backups can now be performed on storage locations established for the organization during KWS installation. Archival routines were also not included, but will be addressed in future modifications.

Viewing Attachments

The capability to display a selected attachment without launching the associated application has been added to KWS through an external interface between KWS and commercially available file viewing software. A file viewer is a software package that displays the contents of a file as it would normally be displayed in the application that created it. A variety of commercially available file viewers will allow users to view common file formats such as text files, word-processing documents, data base files, and graphic files. For instance, a file created in WordPerfect can be viewed on the computer screen without requiring a copy of WordPerfect. KWS will not require a user to have a file viewing package, and if the user does not specify a file viewer, the View option will not be available.

The Attachment Profile

KWS was modified to include the capability to “profile” attachments. The Attachment Profile is used in KWS to describe each attachment linked to a task (Figure 2). When an attachment is created within KWS, the profile information is stored in the KWS data base and is used to search for and retrieve the file. The attributes associated with an attachment that were considered essential to meet KWS’s basic attachment management requirements were:

- Attachment Title
- Application
- Storage Type
- Access Rights
- Version
- Attached By
- Date Attached
- Last Edit By
- Last Edit Date
- Link.

Attachment Title. The Attachment Title is a descriptive name given to the attachment document that is not the actual DOS filename. For an individual task, the Attachment Title should be unique. However, the Attachment Title does not have to be unique across all tasks since the combination of the task/attachment title will provide uniqueness.

The screenshot shows a dialog box titled "Attachment Profile". It contains several input fields and buttons. The "Title" field is set to "Document Management Tech Report" and the "Version" field is set to "1". The "Application" field is set to "WordPerfect 6.0a" and the "Storage Type" field is set to "Public". Below these fields is a "History" section with the following information: "Attached By: SANDIE_K", "Date Attached: 02Feb95", "Last Edited By: SANDIE_K", and "Last Edit Date: 24Mar95". To the right of the history section are three buttons: "Access Rights...", "Links...", and "OK" and "Cancel" buttons.

Attachment Profile	
Title:	Document Management Tech Report
Version:	1
Application:	WordPerfect 6.0a
Storage Type:	Public
History	
Attached By:	SANDIE_K
Date Attached:	02Feb95
Last Edited By:	SANDIE_K
Last Edit Date:	24Mar95
Access Rights...	
Links...	
OK	Cancel

Figure 2. KWS Attachment Profile.

Application. Application identifies the computer program used to *create and launch* the attachment file. The user selects the Application value from a list of available applications. This list is generated when KWS is initially installed on the user's workstation. The list contains information about the name of the application and the command line used to execute the software. It can be easily modified by the user as software packages are removed or added to the user's environment. This modification allows a user to define the command line that executes the application separately from the attachment's profile. This eliminates the problem that occurs where one user is unable to access an attachment because of an incompatibility in the command line.

When attaching an existing document, KWS will try to identify the associated application from the filename extension and display it as the Application value; otherwise, the value is left blank and the user must select it from the application list. If the application is not on the list, the user must add it to the application list and then set the value. The Attachment Profile can be saved with the Application value as blank, but the user will not be able to modify the attachment since KWS will be unable to launch the associated application. However, even if the Application value is blank, the user is still able to view the attachment document since the originating application is no longer necessary for viewing.

The Application value also provides KWS user's with the capability to create a document within KWS and have it automatically linked as an attachment. To do this, the user completes the Attachment Profile for the attachment to be created. The application is then launched using the defined application command line retrieved from the Application List and the KWS-generated filename. The user then follows normal procedures for creating and saving the document within the selected application.

Storage Type. The Storage Type value is used to indicate the storage location type of the attachment. The available values for Storage Type are "Public," "Private," or "Removable." Attachments with Storage Type Public are stored on the KWS shared file server on the LAN, storage type Private are stored in the \KWS \ATTACH directory on the user's KWS workstation, and Removable are stored on user-designated removable media such as floppy or Bernoulli disks. The directories for Public and Private attachments are defined by the KWS system administrator during the KWS installation process. When an attachment file is designated as "Removable," the user is prompted to: (1) specify the drive and directory of the removable media for storing the file and (2) enter a description used to physically identify the media. KWS will then store this information and use it to assist the user in subsequent retrievals of the attachment. For example, if the attachment file "*McClendon MADOC contract*" is stored to the user's Bernoulli disk labeled *MADOC contracts #1* in drive d:, KWS will

display a message to the user requesting that they *“Insert Bernoulli disk titled MADOC contracts #1 in drive d:\”* to retrieve the attachment file *“McClendon MADOC contract.”*

Access Rights. The Access Rights value indicates who has authorization to access the attachment. Current options are View Profile, Read/Copy, and Read/Copy/Edit. View Profile allows users to view the attachment profile, but not to access the attachment. Read/Copy allows users to view the attachment profile and read or to make copies of the original attachment. Read/Copy/Edit allows users full rights to view, copy, or edit the attachment as well as to view the Attachment Profile.

KWS automatically gives the attachment's creator Read/Copy/Edit access rights to the attachment. In addition, only the attachment creator is allowed to edit or delete an attachment profile. This ensures that unauthorized users do not alter an attachment profile. The attachment creator can change the defaults as desired by selecting values from the available options.

KWS provides default values for Access Rights to other users based on the value of Storage Type. The default value given for Public attachments is Read/Copy access rights to all users. The default value for Private attachments is View Profile access rights to all users. Allowing access to a Private attachment would result in a retrieval failure since Private attachments are stored to the attachment creator's local workstation. Even if users are not able to access the document, by giving them View Profile access, they are able to determine who owns the attachment so they can be contacted if access is desired.

KWS also allows users to designate an attachment as *“Sensitive.”* By doing this, KWS imposes restrictions to allow only the attachment creator to view the attachment profile and access the attachment file. In addition, the Storage Type value is forced to Removable. Forcing sensitive attachments to be stored on a removable media ensures that users do not inadvertently mark a file sensitive while keeping the Storage Type value Public, or make the storage type Private while causing the attachment to be stored on a nonsecurable media such as their local workstation or shared file server. If an attachment is Sensitive, KWS does not display the attachment link to unauthorized users. This provides additional security since, if other users do not know that the attachment exists, they would be unlikely to try to obtain access by other methods. These modifications did not address security for sensitive attachments stored on nonremovable media since these functions must be provided via network security protocols or file encryption mechanisms and were beyond the scope of basic attachment management.

Version. This value contains the version number of the attachment file. KWS provides the capability for users to quickly create new versions of a document through the Version option. When a new version is created, a copy of the attachment is made, the highest version number of the selected attachment is incremented by one and assigned to the new version of the attachment. The version creator will then be the owner of the new version which will be reflected in the "Attached By" field value. All other profile information remains the same and the user is no longer allowed to edit the "Attachment Title." This restriction is imposed to maintain the relationship between the original document and its revisions. Allowing a name change would essentially change the attachment to a copy of the original—not a revision. Future modifications should include management capabilities that treat an attachment and its versions as a single entity. For example, deleting an attachment with versions should remove all instances of the attachment. The current versioning structure will support additional modifications to KWS to allow for more sophisticated management.

Attached By. This value contains the KWS ID of the user who created the link to the attachment file. This value is used by KWS to determine who has subsequent rights to modify the attachment's profile. Only the attachment creator or System Administrator will be able to modify an attachment profile. If a user other than the one who created the link establishes another link to the attachment file from another task, the original creator will still maintain ownership of the link and will be the only one able to modify the attachment's profile. If another user makes a copy of the attachment file and links it to another task, a new attachment profile is created and the KWS ID of the user copying the attachment becomes the value of the Attached By field.

The following attributes were added to KWS to provide simple history tracking mechanisms:

Date Attached. This is the date the attachment was created.

Last Edit By. Contains the KWS ID of the user who last edited the attachment file.

Last Edit Date. Contains the date the attachment file was last edited.

Links. This value contains the number of links associated with an attachment file. From within the Attachment Profile, a KWS user can display a list of the titles of all tasks currently linked to the attachment file. As stated previously, this information is useful for understanding the impact of the process on the attachment document. KWS was also modified to use the link value for determining if documents should be deleted after all attachment links have been removed. This deletion is not automatic. The user is given the option to move the document to another storage location when

all links are removed if desired. This will eliminate the problem of managing non-KWS documents being stored in KWS-only designated storage location.

Modifications were also made to the methods used by KWS Version 1.7 to manipulate attachment links. Users need the capability to:

1. Link multiple attachments to a single task
2. Link multiple tasks to a single attachment
3. Make a copy of an attachment and link it to a new task
4. Move a link between an attachment and a task to another task (Figure 3).

KWS was found acceptable in its capability to support the first requirement, but changes were required to improve support for the rest. The ability of users to perform these functions have also been impacted by the addition of the Access Rights described previously. Essentially, the attachment creator owns the link between the attachment and the task. The effect of this ownership limits other users from deleting or moving links they do not own.

Linking multiple tasks to a single attachment was provided in KWS Version 1.7 through the Copy function. However, this was an improper implementation since it appeared to the user that they had made a copy of the attachment that could be modified without affecting the original attachment. In actuality, the user had created another link to the same attachment and any modifications made from either task were made to that same attachment. To correct this problem, the Copy function was modified to allow the user to create a new copy of the attachment file and link it with the desired task (Requirement 3). Any relationship with the previous link is now removed. All profile information remains the same as the original attachment file except for the Attached By and Date Attached values, which are updated by KWS. The user can then change profile information for the new attachment if desired.

The function of linking attachments to multiple tasks previously provided by Copy is now performed by the Link option. Link creates a new link between an existing attachment and the selected task. Any modifications performed on the attachment for any of the linked tasks are reflected in all linked instances of the attachment. All previous links and profile information remain the same. KWS was found acceptable in it's ability to move attachment links to other tasks (requirement 4). Move creates a link with a new task and deletes the link from the original task. The new Access Rights allow only the attachment creator to move a task.

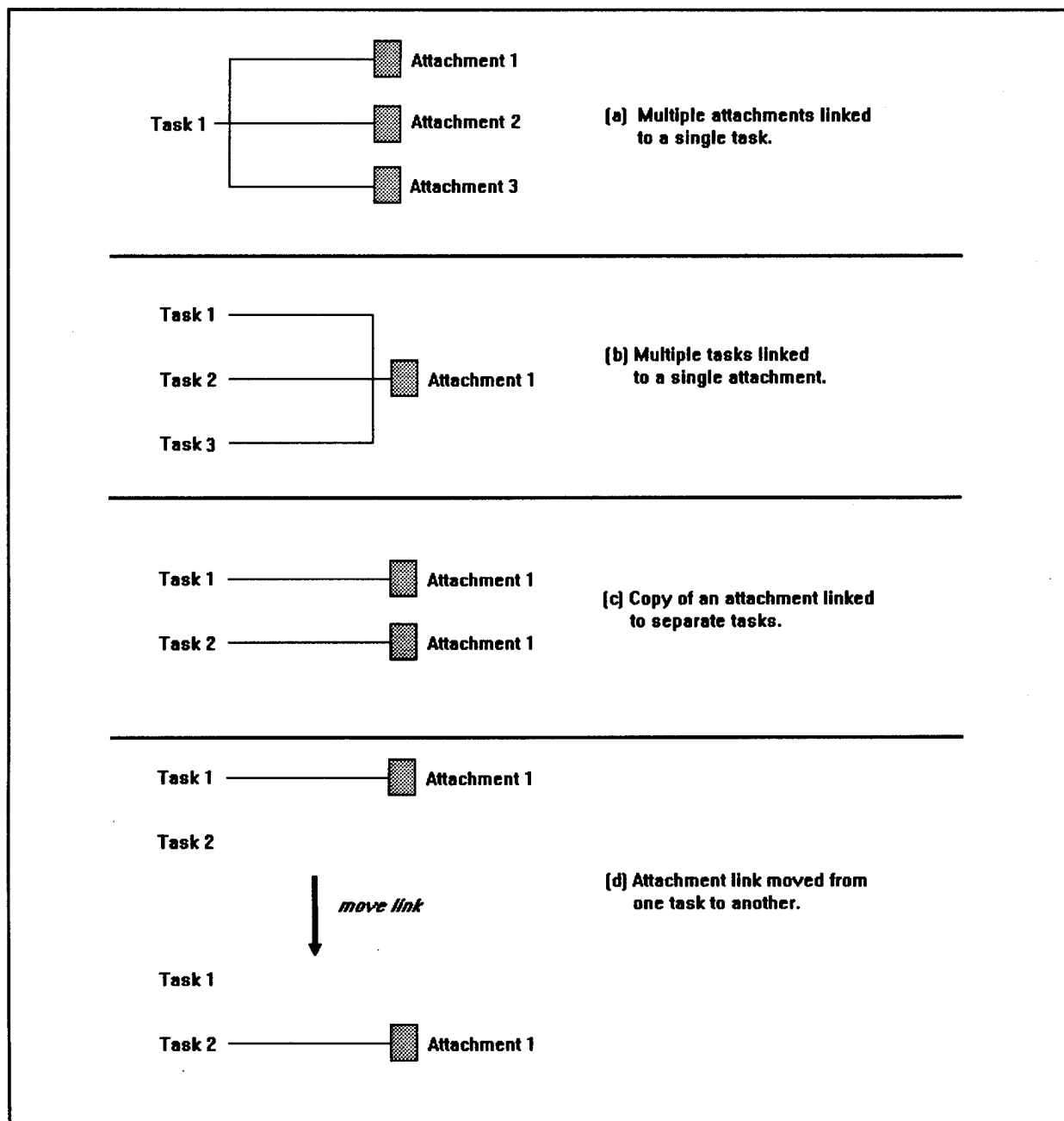


Figure 3. KWS manipulation of attachment links.

Automatic Document Attachment

The capability to enable Do Its to automatically attach documents created as a result of their execution has been developed. Because of the complexity of "Do It" development, this capability is not a user-accessible attachment management function within KWS, but is available to "Do It" developers. Essentially, this capability allows "Do It" developers to create the attachment link by adding an attachment record to the KWS data base with the appropriate Profile information assigned.

5 Integrating KWS With External Document Management Systems

The DMS review discussed in Chapter 3 clearly shows that technology exists for meeting most of the document management needs of KWS. These systems provide state-of-the-art document management capabilities that have been the result of many years of research and development. The second step of the KWS document management strategy is to investigate how KWS could incorporate these existing technologies.

This research has dealt with determining whether the existing DMSs support integration with external applications and, if so, developing a mechanism for integrating KWS with an external DMS. A literature review was conducted to identify potential DMSs for integration with KWS. The systems identified were then evaluated to determine if they could provide the capabilities required by KWS and a system was selected for integration. An external interface capability in KWS was required to be able to integrate the selected system with KWS. A mechanism for providing this interface was developed and the selected system was integrated with KWS.

The KWS DMS Integration Architecture

One requirement in developing the KWS DMS integration was that it appear transparent to the user. Consequently, the interface should provide users with state-of-the-art document management via the external application, but appear as if it were provided by KWS. The mechanism chosen to support this requirement was the development of a client/server relationship between KWS and the DMS.

A client/server relationship is an architecture where the local workstation (the client) requests services from a supplying machine (the server) such as a LAN File Server. The client provides the user interface while the server responds to data requests from the client. The services provided by the server depend on the application environment, but are typically centered around multi-user data base access. This multi-user access is an essential role of the server, meaning that the server is used for more than just a remote file server. The server is responsible for all data manipulation, and for passing only the answer back to the client.

The KWS DMS client/server relationship was defined with KWS acting as the client and the DMS as the server. All KWS attachment management functions were provided by making requests from KWS to the DMS. This architecture provided KWS users with transparent access to the capabilities of the DMS, thereby meeting the integration requirements.

Selecting a DMS for Integration With KWS

To be considered for integration with KWS, the DMS had to meet three criteria:

1. The DMS must support the required client/server architecture described in the previous section.
2. The DMS must offer a capability for integrating with the KWS application.
3. The DMS must be reasonably priced so that a KWS/DMS integration could be an affordable product for implementation at user sites.

The three products that met these criteria were *PC DOCS Open*, *SoftSolutions*, and Saros Corporation's *Mezzanine*. All of the three products meeting the criteria were good candidates for the KWS/DMS integration. *SoftSolutions* was selected because it seemed to provide the best capability for integrating with the KWS application through the *SoftSolution's* "Software Developer's Kit" (SDK). This SDK enables application developers to write software routines to access the *SoftSolutions'* DMS data base. This capability also supports the required client/server architecture.

The selected system was not required to provide the "best" set of user capabilities. This was not a criterion since the objective of this research was to investigate the feasibility of integrating KWS with commercially available DMSs, not to identify a single integration to meet all user requirements. In addition, because of the rapidly evolving nature of DMS products at the time of this research, it would have been difficult to identify the criteria required to establish the "best" set of user capabilities. Even if this had been a requirement, the three packages investigated were found to offer essentially the same capabilities.

The Integration Process

The integration process consisted of three parts:

1. Establishing a method by which KWS can communicate with the DMS to request services

2. Disabling the DM functions internal to KWS and replacing them with requests to the DMS
3. Establishing a method for maintaining integrity of shared data.

For KWS to communicate with the DMS, a mechanism within KWS is required by which KWS can call the DMS functions. In addition, the DMS must provide a mechanism to allow these function calls. *SoftSolutions* provided this capability through its SDK. The KWS source code was modified to use the SDK to enable the required communication between the applications.

Since this integration will result in DMS functions being provided by *SoftSolutions*, the existing document management capabilities within KWS were disabled. At the time of this research, there was no established way to disable or replace these functions in KWS. Modifications were made directly to the KWS source code to permit a rerouting of this functionality. Additional modifications were made to the KWS interface to change the way KWS displayed attachment information.

The process of maintaining integrity of shared data between applications is called data synchronization. Because KWS is using the DMS to manage attachments, the two applications need to agree on common keys to reference attachment records and to maintain some data about attachments. This common (shared) data must at all times be synchronized so that each application "knows" the same facts about an attachment.

For this integration, not all information about an attachment needed to be stored in both applications. At a minimum, it is required that KWS needs to store information on the reference for each attachment in the DMS. This information can then be used by KWS to request the document from the DMS. For performance reasons, it is recommended that any document information stored in the DMS that is to be displayed in the KWS interface, should also be stored within KWS. This includes basic information about the document such as access rights, author, title, and version number. It was not necessary in this integration to store any additional information from KWS in the DMS data base.

The additional requirement of KWS to manage attachment links may appear to add a layer of complexity to data synchronization in the KWS DMS integration. However, attachment link management does not affect this integration. In the existing KWS architecture, functions for managing and tracking attachment links are already provided. Any retrieval of information related to attachment links can already be provided through queries to the KWS data base. These queries would provide the information required to request the document from the DMS. Retrieval of the actual documents would be performed through requests to the DMS.

The Integration Environment

KWS is written in C and compiled using the Microsoft Visual C++ programming environment. The integration to *SoftSolutions* was accomplished by making modifications directly to the KWS attachment module using the *SoftSolutions* SDK. The *SoftSolutions* SDK includes two integration libraries—the application programmers interface (API) and the integrations DLL. Functions from both of these libraries were used to complete this project. The *SoftSolutions* SDK is a C-based interface available for both DOS and Windows environments.

The integration of KWS and *SoftSolutions* required changing the functions of the KWS attachment menu options to invoke the services of the DMS instead of the built-in functions already provided by KWS, which retained the functions required to display the attachment profile and create, delete, and modify attachment links. All document-related functions were replaced with *SoftSolutions*' functions. These included attachment editing, versioning, viewing, storage management, and security and access restrictions that had previously been performed by KWS. Only a portion of the document management functions available in *SoftSolutions* were made accessible via the KWS interface. Some functions, such as full text searching, were not included in this integration, but could be made available in future revisions.

Four new fields were added to the attachment data base record in KWS: (1) The *SoftSolutions* document number, (2) the version number, (3) the security group code, and (4) the application name. These modifications to the KWS attachment table represent the minimum data base restructuring needed to complete this project. Additional fields could be added to display more information about the attachment to the user.

The KWS Attachment options are the same as those provided in KWS Version 2.0. The following sections describe how these options are impacted by the integration with *SoftSolutions*.

Insert

To insert an attachment, KWS displays an attachment profile dialog box prompting the user for information about the attachment. Within the attachment profile, the user can specify the attachment title, the application used to create/edit the attachment, the security group code, the author (not necessarily the same as the creator), and the document type. Other profile options are managed by *SoftSolutions* and will be discussed later.

Once the profile has been completed, the user is given the option of importing an existing document as the new attachment or creating a new document. If the Import option is chosen, the user is asked to specify the DOS filename of the document being imported. The user is next given the option of editing the new attachment. If this option is chosen, the attachment's application is launched and the attachment file is loaded for editing. If the Create option is chosen, the new attachment's application is launched with an empty file ready for editing. In either case, *SoftSolutions* generates a Document Number for the new attachment and stores it in the appropriate location. Also, after files are added to *SoftSolutions*, an indexer window appears briefly as *SoftSolutions* adds the profile information to its index tables.

Delete

Choosing this function will cause the selected attachment(s), and all of their versions, to be deleted from *SoftSolutions*. The appropriate profile information is then removed from the *SoftSolutions* index tables. The user is asked by *SoftSolutions* to verify the decision to delete before the deletion occurs. KWS is then responsible for deleting attachment link information to the deleted document from the KWS data base.

View/Print

The *SoftSolutions* 4.0 Document Suite comes with a file previewer that works with most types of file formats. The previewer is defined for each application and is specified in the *SoftSolutions* application setup screen. Any previewer can be used, but the *SoftSolutions*' previewer is specified by default. Most file previewers provide the ability to print and view documents. The *SoftSolutions* file previewer provides viewer and printer support for most text, spreadsheet, bitmap, drawing, and data base file formats.

The *SoftSolutions* file previewer is a separate executable program that is launched by *SoftSolutions*. Only the latest version of the document can be previewed. Earlier versions must be accessed via the Edit option.

Get Copy

This options allows the user to save a copy of the attachment file to a specified location. The user must have security rights to at least view the document to use this function. If more than one version of the document exists, the user is prompted to specify the desired version.

Profile

The profile option allows the user to view and modify profile information. If the user has "edit" access to the attachment, then any of the information specified in creating the attachment can be modified. All other users are able to view the profile information (even if the profile is private), but cannot make any modifications.

As stated previously, the KWS interface provides the Attachment Profile display. However, information is stored in the *SoftSolutions'* data base that is not contained in the KWS data base. The user can access this information from within KWS through an "Additional Information" option on the KWS Attachment Profile display. Selecting this option result in the display of a *SoftSolutions'* screen that contains an activity list showing all operations that have been performed on any versions of the specified attachment. The activities list is ordered by date, the most recent operation appearing first in the list. Users with "view/copy" and "edit" access to the attachment will be able to access this screen; however, all other users will be limited to viewing only the profile dialog box.

Edit

The ability to edit an attachment is available only to those users that have "edit" access to the specified attachment. When an edit function is invoked, a call is made to *SoftSolutions* to execute the application specified in the attachment profile and to pass the filename associated with the chosen attachment to this application. When editing has been completed and the application has been closed by the user, control returns to KWS. If the attachment being edited has more than one version, the user is asked to specify the version to be opened.

SoftSolutions will dynamically map and un-map network drives if necessary to provide access to the selected document. The system administrator is responsible for specifying the appropriate mapping parameters during *SoftSolutions* installation.

Version

This option is only available to users with "edit" access to the specified attachment. When this option is chosen by an authorized user, the *SoftSolutions* version screen is displayed. When versions are added to existing documents, a comment can be entered for each version. The user has the option to view the existing version comments or create a new version. When a new version is created, the profile information is re-indexed and the version count is incremented by one.

Security

Security for attachments is provided entirely by *SoftSolutions*. The server software comes with three predefined security classes: public, semi-private, and private. Public access has no restrictions. Private access will allow viewing of the profile dialog box only. Semi-private access will not allow any "edit" access but does allow the attachment to be copied, previewed, and printed. Additional security groups can be defined by the system administrator.

Document security can be used to control the storage location of documents in *SoftSolutions*. Thus, a system administrator could declare that all private documents be stored on the user's local drive (if one exists). Sensitive material can be forced onto removable media as well using this capability. Each individual user's environment can be customized so that "sensitive" material is stored in an appropriate location.

Lessons Learned

Additional effort is required to develop this integration into a fieldable product. However, this prototype integration demonstrated the feasibility of integrating KWS with a commercially available DMS. The lessons learned while completing this integration can be used to "fine tune" the integration process.

First of all, the KWS code needs to be modified to simplify the integration process. For this prototype, the KWS source code had to be extensively modified to disable the existing DMS functions. To simplify integration, the KWS source code needs to be modified to separate attachment link routines from document management routines. Essentially, this separation was demonstrated by this integration, but further refinement is required before modifications should be made to the working version of KWS. This separation would also enable the integration of KWS with any system providing DMS services. This includes the basic DMS services provided by KWS (as described in Chapter 4) or those provided by commercially available systems.

Better tools are required for developing the routines necessary to communicate between the KWS attachment link routines and the DMS routines. This function was provided by the *SoftSolutions*' SDK for the prototype integration. However, at the time of this research, the *SoftSolution*'s SDK was not well documented, making the integration process more difficult than it should have been. A standard set of tools is required to initiate requests to any DMS. These standards would eliminate the need to deal with integrating KWS with multiple DMSs. Since this initial integration, an Open Document Management API has been developed to provide a standardized, high-

level interface between applications and DMSs. The use of this ODMA API should be investigated for providing the capabilities required for further KWS/DMS integration efforts.

The DMS capabilities provided through a KWS/DMS integration are limited only by the existing capabilities of commercial software. The time and cost of providing these capabilities via the integration was significantly lower than that of modifying KWS code to include them. In addition, integrating KWS with a commercial DMS also supports the Department of Defense, Directorate of Defense Information Management, Corporate Information Management (CIM) Initiative for use of Off-the-Shelf software, which requires DOD organizations to use existing commercial software when possible instead of developing software in house.

6 Advanced Document Management in KWS

In addition to the basic requirements for accessing information resources, knowledge workers require capabilities to enhance information utilization. Information utilization is the actual process conducted by knowledge workers to generate a product from the information resources they access. Advanced document management in KWS involves the integration of a wide range of technologies to not only store, retrieve, track, and administer documents, but also to promote electronic document sharing, distribution, review, and creation through collaboration among workgroups. By providing advanced features to enhance information utilization within KWS, the quality of knowledge worker products can be improved.

Activities that involve knowledge worker information utilization were analyzed to determine the capabilities required by knowledge workers. Next, potential mechanisms for supporting these capabilities through modification to KWS or integration with existing and/or emerging technologies were identified. The following sections describe these requirements and supporting mechanisms.

Support for Workgroup Information Manipulation

Knowledge worker information manipulation is often a workgroup activity requiring the support of several technologies. For example, one knowledge worker may gather the data for a task while another is responsible for generating a report from the analysis of the data. Once the report is generated, that knowledge worker may distribute the report to several knowledge workers who must review it and provide feedback. After incorporating review comments, the report could then be routed back to the review group for final approval and then be distributed electronically throughout the organization. To support this process, KWS users require several advanced document management capabilities. These include the capability to: (1) pass completed attachments to the next KWS task in the process, (2) allow several knowledge workers to author and review a document at the same time, and (3) electronically distribute documents to the appropriate members of the organization. These capabilities could be provided through technologies supporting workflow, group authoring and document review, and electronic document distribution.

Workflow

Workflow is a capability that allows an organization to create and monitor the flow of documents from one place to another. Commercially available systems can provide automated workflow to track each document throughout the system. These systems track documents based on a predefined set of linked transactions that governs the document's route from person to person in the organization. As each person completes an assigned action on the document, the document is passed to the next person in the workflow. Insurance claim processing is a classic example of a workflow application. There is a predefined set of actions that occur on the insurance claim document from its point of receipt in the claims office to the time it is processed and the final action is taken on the claim. This type of process, one that is easily defined as a step-by-step set of actions, can be readily supported by commercial workflow applications.

KWS differs from workflow systems in that it is "task" instead of "document" centered. Instead of routing documents within a workgroup, KWS schedules tasks with attached documents. Unlike workflow applications, KWS is concerned with the status of a task, not a document. (Where a document is the end product of a task, completion of the task would indicate completion of the document.) In addition, KWS differs from workflow systems in its assumption that most knowledge worker tasks are not easily defined in a step-by-step fashion. Therefore, the workflow paradigm would impose an inappropriate definition structure on knowledge worker business process models. However, some knowledge worker tasks can be defined in a step-by-step fashion and KWS should support such a structure.

KWS requires additional features to provide the capability to define portions of a task hierarchy step by step. This capability would allow knowledge workers to automatically pass attached documents to the next task on indicating the completion of a task. Preliminary functionality to support work flow will be provided in the next KWS version through modifications to the KWS data base and task status routines. KWS already provides the capability to define tasks in sequential order via the predecessor, successor functions. An additional attribute will be included in the attachment profile to indicate whether the attachment is an end product of the task being performed. When the task is marked as completed, the KWS task management routines will determine if the task had a successor and if so, its associated end products will be linked to the successor. Additionally, a "ready to start" status value will be included in the task status attribute to indicate to the user that a successor task can be started once the task's predecessor was completed.* For example, if the task "Write Technical Report" with the end product "Technical Report" is marked as complete within KWS,

* KWS currently supports task status values of "Not Started," "Started," "Finished," and "Overcome by Events."

its successor task "Review Technical Report" will be given the status "Ready to Start" and the document containing the technical report will be automatically attached to it. In the enterprise-wide case where the successor task was assigned to a KWS user at another location, KWS will also manage the process of moving the attachment to the file server at the appropriate location so it will be available when needed.

Group Authoring and Document Review

Knowledge workers require the capability to simultaneously edit and review documents. Workgroup conferencing software is being investigated as a potential technology that could be used within KWS to support this requirement. This emerging technology provides a platform for group discussion and decisionmaking. It enables information to be simultaneously transmitted to multiple personal computers via a LAN or modem connections where it can be discussed and modified. This allows the capability for conducting virtual meetings that do not require the attendees to physically reside at the meeting location. Also called "whiteboard software," this technology allows one or more users to simultaneously annotate graphics files and scanned images. These annotations are useful for the knowledge worker responsible for incorporating reviewer notes into the revised document. In addition, this software supports application sharing, which enables participants to run third-party software at the same time. This capability could be used to enable group authoring of documents by knowledge workers at a single location or multiple sites.

Electronic Document Distribution

Knowledge workers frequently need to disseminate information generated by the execution of a task to non-KWS users. This dissemination is commonly done by printing a hard copy of the document and routing it to the appropriate individuals. Features could be provided in KWS that would enable users to select a mechanism such as electronic mail or FAX to automatically distribute an attached document to the appropriate individuals.

Access to Enterprise Information Resources

Information utilization is often supported by referential documents defining procedures, regulations, and so on required to execute a task. Knowledge workers typically need access to a core set of referential documents relevant to the specific missions of their individual organization. In KWS, this set is established as the process model is developed. It is not likely that every possible association between each task and the relevant reference would be established within KWS. This is

because of the dynamic nature of the KWS process models. KWS models are continually changing as new tasks are added to the model and there is a continual requirement to identify new associations. Because of this, knowledge workers require *ad hoc* access to these references from anywhere in a task hierarchy to assist in identifying new associations to support task execution. Also, it is not always necessary to create an attachment link to a reference each time it is accessed. Therefore, knowledge workers require the flexibility to review references on an as-needed basis without having to create an attachment link.

Reference Document Library

Enterprise reference documents used within KWS should be organized in a central location. By accumulating all such documents in this central location, a reference document library would be established for the organization. This structure would ensure that KWS users know where to locate reference documents and that the documents could be accessed by anyone in the organization. In addition, this structure would reduce inefficiencies caused by storing multiple copies of the same document. These inefficiencies include increased requirements for storage capacity and additional efforts required to manage document updates. For example, if two KWS tasks require access to the same reference document, a link from each task should be established to the one copy of the document. Without access to a library of resources to select from, KWS users may be unaware that a document is already stored in the KWS environment. Thus, it is very likely that two copies of the document would be imported into KWS with each task linked to a different copy.

Modifications to the existing document management routines and centralized file storage structure of KWS could support creation of an organization's reference document library. Additional attributes could be included in the attachment profile to indicate that a document is a reference and to list the contexts in which it is used. For example, a document defining the development of a Government contract could be defined as a reference for the context "Contract Development." Additional document management search routines could then be developed to provide KWS users assistance in locating references in the library.

Task Inheritance of Referential Document Attachment Links

Many attachment links from tasks to references in KWS may actually be relevant for multiple if not all tasks in a particular hierarchy. It is possible to create multiple links to the reference document from each task in the hierarchy, but this would be unnecessarily complicated. Instead, a mechanism could be provided within KWS to enable a child task to inherit attachment links from its parent task. Rather than

manually creating a link between each task and the reference document, one link could be created at the appropriate level of the hierarchy and all sublevel tasks would automatically be associated with the document.

Document Search and Retrieval

Even when knowledge workers are provided with quick access to the set of information resources relevant for their tasks, it may not be enough for them to simply retrieve the references. Instead, they may need assistance in identifying a subset of available references, viewing a specific section of a reference, or viewing all relevant sections of a reference. For example, a KWS process "Generate Government Contract" would have several tasks in the process hierarchy that require associations with Government contracting regulations. Depending on the requirements of the specific contract, only a subset of these references may be required by specific task. From this subset, a task may always require an association with a particular paragraph within a reference while another task may require the capability to access specific portions of the regulation based on the requirements of the particular contract (e.g., all portions related to Automated Data Processing [ADP] services).

Full Text Query

The requirements for accessing a subset or portions of all relevant documents could be provided through full text query capabilities. Full text query is a technology that allows searching for a specific word or phrase within a document or set of documents. In the previous example, a knowledge worker could enter the phrase "ADP" and a list of documents containing this phrase would be provided to the user. The user could then search each of these documents individually to view all sections containing a reference to ADP.

Bookmarks

The ability to link a task to a specific portion of a document could be achieved through the use of bookmarks. Bookmarks are used to mark a location in a document so that the user can return to that location quickly. Capabilities for placing "electronic" bookmarks in a document are provided in many commercially available word-processing and spreadsheet packages. This can meet knowledge workers' requirements for bookmarking within documents they create. In addition, bookmarking is a common feature available in electronic publishing software used to create and distribute corporate information repositories.

Global Access to External Information Resources

In addition to the core set of information resources, knowledge workers may require access to a variety of external information resources from anywhere within the KWS task hierarchy. For example, the World Wide Web is a quickly expanding resource of information in a variety of subjects. The World Wide Web was created as a way to enable physicists to collaborate more effectively over the Internet. It has since expanded to support collaboration around the world among a multitude of workgroups. As the World Wide Web continues to grow, the benefits to knowledge workers for accessing the information on it also grows. KWS users need a way to easily access and share information on the World Wide Web with members of their workgroups residing at remote sites around the world. Access to other external information resources such as online library catalogs, documents published on CD-ROM, and so on are also required.

World Wide Web Access

KWS can integrate with external software from individual tasks via "Do Its," or globally from all tasks via the "Tools" option. Essentially, the "Tools" option allows a user to launch external software by selecting it from the set of tools listed. Several commercially software packages enable users to easily log onto the Internet and browse through its information resources (e.g., Mosaic). By providing access to these packages via the tools option, KWS can provide users with access to the World Wide Web from anywhere within the KWS task hierarchy.

Online Document Repositories Access

An increasing number of document collections are becoming available on electronic media such as CD-ROM. For example, "Computer Select" is a commercial CD-ROM library containing articles from a number of computer trade journals. Through the Computer Select interface, a user can identify and retrieve relevant documents using full text query. Access to Computer Select or other online document services could be provided in the same manner as World Wide Web access via the KWS tools option.

7 Summary and Recommendation

Knowledge workers require access to a variety of information resources that support their business processes. KWS provides the capability for knowledge workers to define associations between a task and the information resources required to support execution of the task. These associations, called attachments, allow knowledge workers to access documents while executing a task. Attachments can be made to any electronically stored information resource from anywhere within the KWS process model. As the size and complexity of the KWS model increases, the complexity of managing the documents involved also increases. An effective mechanism for managing the creation and use of attachments is required to ensure that the knowledge worker is able to easily access their required information resources.

This research: (1) developed a strategy for providing KWS users with improved attachment management capabilities and (2) developed methods to implement this strategy through a series of modifications to KWS. This was done through a three-step approach that provides KWS users with increasing attachment management support:

1. Identifying immediate needs of KWS users to improve attachment management.
2. Modifying KWS Version 1.7 to support these needs.
3. Investigating the capability to provide state-of-the-art support through integration with external commercially available DMSs, investigating the advanced needs of knowledge workers to support manipulation of information resources after retrieval, and identifying potential mechanisms for providing the required capabilities.

This research contributed to the development of improvements subsequently incorporated into KWS Version 2.0, now available to KWS users. This study demonstrated the feasibility of providing state-of-the-art capabilities via integration of KWS with a commercially available DMS. Also, several potential mechanisms were identified for meeting the advanced needs of knowledge workers in support of information manipulation.

Continued research and development is required to fully implement the document management capabilities described in this report. The following activities are recommended to achieve this end:

1. Modify the existing KWS code to simplify integration with external software applications to support document management.
2. Complete development of the KWS capability for integrating with external DMSs through ODMA APIs.
3. Modify the KWS code to support the identified advanced document management features.

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