

A Framework for implementing digital information for life long Electronic Archives in Construction Engineering

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Abstract

Digital Storage management systems have become more affordable over the last few years and software applications have emerged to help business managers implement them. Digital information is designed to derive its value from best practice information and business processes using electronic media. Storage and archiving however, has become paramount importance in knowledge platforms in which information management is deployed. However, implementing successful electronic storage (e-storage) and electronic archiving (e-archiving) requires good understanding of basic information standards and protocols upon which the storage system depends. In the construction industry, the uncertainty over the standards and lack of interoperable knowledge platforms reduces the ability to access information. There is also a rise in information and document loss, malpractice of propriety information, fraud, and unauthorised changes in design. Another problem is that digital standard protocols that were designed for an open and trusted community have inherited flaws that allows human error, tampering and changing of individual files. The lack of appropriate archiving tools in proper pattern has affected the implementation of archiving systems. Research suggests that an approach towards new digital standards, protocols and knowledge platforms for global use of digital information is required.

This paper sets out a new framework to facilitate the use of appropriate and adequate mechanism for digital information management in construction. The four basic steps are: (i) develop a strategy for archiving management systems; (ii) identify and review current information knowledge platforms; (iii) understand and assess tools and technologies; (iv) disseminate and implement e-archiving. This is to allow IT managers; designers and software project managers in the construction industry understand and deploy the elements of e-archive to implement digital information for life long archiving.

Keywords: construction engineering, digital information , electronic archiving

Introduction

Implementing successful electronic storage (e-storage) and electronic archiving (e-archiving) requires a good understanding of basic information standards and protocols upon which storage and archive system depends. The challenges presented by e-storage and e-archiving are well documented (Hedstrom and Montgomery, 1998). In the construction and engineering sectors, the uncertainty over the standards and lack of interoperable knowledge platforms reduces the ability to access archived information. However there is an increasing demand for electronic document management tools for e-storage and e-archiving (Veitch, 2003). This pressure has highlighted a number of problems. These include: (i) standard of interoperability; (ii) support of legacy systems; (iii) planning the implementation of e-archive in a heterogeneous computing environment (Abouzsakhar and Mason, 2003); (iv) a rise in information and document loss, fraud and unauthorised changes; (v) digital standards designed for the open and trusted community have inherent flaws that allow tampering and changes to individual files; (vi) the transfer of digital information is not viewed as an effective solution for long-term digital archiving; and the strategies to migrate to new formats before current ones deteriorate are not in place (Butler (2003); (and vii) deciding which information or document to archive and for how long (Bloor, 2004).

The consequence of this that, information stored on corporate networks or systems does not have the mechanisms and components for implementing effective e-archiving systems that are secured and cost effective. Literature suggest that as the methods of creating documents and its formats increases, companies are finding it difficult to control or provide access to archived information (e-Government Public Records Office, 2001; Adshead, 2003). However, the urgency and extent of the difficulties faced by companies attempting to implement e-archive is not well documented. Construction engineering presents special problems because of the varied forms and formats of information that are held in project records. In order to facilitate the introduction of comprehensive e-archiving that meets special needs of construction engineering organisations, research was carried out to investigate archiving in general with the view of developing a framework for implementing e-archives. This paper presents preliminary findings of this study and a framework developed to address the problems identified.

Research Approach and Questions

A case study was conducted in a construction organisation. The perceptions and practices of archiving were examined through an exploratory case analysis. The case design was chosen to match the objectives and description of theory building (Benbasat *et al*, 1987). The case design was an empirical research approach suitable for studying emerging and complex organisational systems (Yin, 1994). The study involved interviews main decision-makers and staff to answer the following research questions:

- What strategies are in place aimed at making significant improvements to the company's archiving system?
- Are there any guidelines in place that facilitates the process of digital archive management?

- Did the company appreciate the fundamental problems in adopting an appropriate infrastructure and technology?
- Which IT infrastructure capabilities have the largest impact in implementing digital archiving?
- How did the company measure up to the requirement of best archiving management practice and its goals?

The Company Studied

The company is involved in construction related issues and is a major international manufacturer of construction and engineering equipment in the UK. The firm employs 1600 people on two sites less than a quarter of a mile apart. One site houses the main head quarters that deals with the day-to-day management of the UK group and the second houses the manufacturing facility and divisional headquarters for the corporation's building construction products unit. The divisional office is responsible for logistics services under the supervision of the head office. The organisation employs both permanent and temporary staff. The number of temporary staff fluctuates depending on the level of production. Currently, the annual turnover of the company is approximately £350 million.

Vision for Information Management

According to the General Manager although renowned for its innovative engineering, construction equipment and services, the same cannot be said for the way documents are managed on day-to-day basis. As part of their desire to improve information management, the firm conducted a preliminary study to broadly identify the general problem areas and make recommendations that would lead to the implementation of an effective document management system with electronic archiving in mind.

Current state

In order to address perceived and practical problems with records and document management, a project team was formed. The drive for the formation of this team was the result of storage problems the company experienced recently. The remit of this team was to identify, initiate and implement corporate strategies aimed at making significant improvements to the company's archiving system.

One of the first actions of this team was to recommend the destruction of documents emanating from projects more than 8 years old in order to cut the cost of maintaining paper archives. In addition, with certification for latest ISO in mind the team decided to introduce a set of guidelines. However, because the guidelines were based on US practices, they were found not to comply with UK legislation. For example, the UK law stipulates project records to be kept for a minimum of 8 years, other legislation requires only 6 years. To conform to the requirements at that time, the team recommended that based on US practices all documents should be destroyed after the 8-year retention period. To facilitate this process a commercial paper shredder machine was purchased to recycle the paper but how this process was to be managed could not be agreed.

Records Management

The records department currently manages all the archives for the company. This archive contains literally thousands of documents from different departments. The first problem with the archive is that, it is a manual system, secondly, the archive is duplicated in various

departments so users are not sure whether the archive is actually up to date. Consequently, all respondents indicated that the current system was so slow that it effectively hinders their work.

In view of this, the departmental managers interviewed stated that, the ability of the records department to adopt new methods and technology to radically improve the efficiency of the archiving system is unlikely to happen soon. This is because of uncertainty over whether to develop and initiate guidelines based on UK practices whilst there seems to be confusion over the appropriate technology to adopt. The need for urgent action was underlined by the fact that the weaknesses of the system have been blamed for legal problems with clients in recent years.

Communication

Presently, the only way documents are transferred within the company is via e-mail using Microsoft Outlook's file attachment facility. Due to issues such as security and general traceability of this method, the majority of data for day-to-day information transfer is by paper. Interviewees acknowledged that communication between departments and staff: (i) is ineffective because large volumes of paper are exchanged; (ii) produces duplication of documents and work; (iii) allows the loss of important documents; (iv) retrieval is slow; (v) information is not always accessible to project team members when required.

Storage space

The effect of these problems and methods of information exchange has put further pressure on storage space for documents in offices and in the records department. As such, documents are piled up in every available storage place. To tackle this pressure, microfilming technology has been attempted. Even with this technology, only a small percentage of documents (estimated at less than 10%) are held on microfilm archives. Such is the pressure that plans are underway to build another storage site for keeping documents. However, because of financial constraints it has been decided to extend microfilming further to release more storage space.

Current database system

As pointed so far, a concerted attempt has been made by this company to reduce the pressure on storage space and improve access to archives using microfilm technology. However, because this has not been successful, the shredding of 'expired' paper records has been recommended. This apparent lack of success underlies the fact that documents are being generated faster and in larger volumes than these solutions can possibly handle. The reason is the widespread use of software for document creation and editing and yet IT solutions are not in place to manage the archiving and retrieval process. Some attempt has been made through the company's database, which was set up to hold information on where all records are held. This includes information on the physical location such as shelf number and owner name.

The fact that current database has not been developed further despite the availability of such technology suggests that barriers for IT utilisation in this area exist. This is because the potential benefits for managing information electronically, and reducing the handling of physical documents such as drawings are immense. Savings in management time, disputes with clients and demand for office and storage space can be addressed in the long to medium term.

Main Problems Areas

The studies investigated show that senior managers are keen to tackle archiving problems by implementing e-archiving. Within the limits of resources, there is a strong case to adopt information management systems with e-archive as its main function, to deal with the problems listed in Table 1 below. Although these are typical information systems problems faced by IS professionals on daily basis, in the context of this construction engineering, the complexity of their storage problems require special attention.

Table 1: Summary of Problem areas in the organisation

Organisation Issues	Staff Interviewed	Problems areas
Document Management	Chief Auditor	<ul style="list-style-type: none"> • Lack of corporate strategies for archiving • Higher cost of paper • No control of documents • Lack of decision making • Outdated archiving system • Retrieval of documents very slow • Disputes with clients due to inadequate system
Communication	Technical Director	<ul style="list-style-type: none"> • Ineffective volumes of paper exchanged • Duplication of work and documents • Disappearance of important documents • Slow retrieval of information • Over reliance on paper based communication between departments • Information not accessible to project team members when required
Storage/Archiving	Accountant	<ul style="list-style-type: none"> • Pressure on storage space due to excessive documents • Financial constraints for extended storage space
Database Systems	Records retention chairman	<ul style="list-style-type: none"> • IT solutions not in place to manage archiving & retrieval process • Barriers for IT utilisation

Discussion of These Problems

Based on the findings from the case study, the current state of information archiving management practices were recognised. This problem can be categorised under four main areas. These are: (i) inability to improve the company's archiving system; (ii) no strategies in place that facilitates the process of archiving management; (iii) archiving management issues affect the company's ability to retrieve information that is up to date; and (iv) there are problems with identifying and adopting an appropriate infrastructure technology for e-archiving.

Inability to improve the company's archiving system

The ability to develop a coherent and sustainable archiving management policy appears to be lacking. For example, the company acknowledged the importance of efficient archive management but no attempt has been made to formulate one to initiate change. On the other hand, the company illustrates a situation where the problems of archive management were accepted but the attempt to develop a corporate strategy to improve the company's archiving system lacked focus due to financial constraints. Interview with senior executives suggested that the dilemma is whether their prime concern should be applying new technologies to relieve storage pressure space or work in an entirely new way.

No strategies in place that facilitate the process of archiving management

The investigation suggests senior managers are keen to tackle documents and records archiving problems by implementing a document management system within the limits of resources. The chair of the strategic group indicated that, the lack of corporate strategies regarding document archiving has led to higher cost of paper with outdated archiving system. This has slow down retrieval of documents. Not only is the archiving system slow according to the technical director, there is also duplication of documents and works in the archiving and information is not accessible to departments and project team members when required. The pressure on the storage space is due to excessive use of paper documents according to the accountant. Consequently financial constraints for extending the archiving space is a barrier.

Overall, there is very little reuse of documents and very little information passes from design, engineering and construction to operations. However, only in one case that management is attempting to initiate policies to use IT. As the case shows, software applications are used routinely to generate documents but for legal and cultural reasons paper is still the sole medium of information exchange even within the same organisation. Above all, the records retention chairman indicated that, there is no corporate IT solutions in place to manage archiving and retrieval processes.

Archiving management issues affect the ability to retrieve information that is up to date

The recognition of the high cost of maintaining manual processes led to the development of database system using Microsoft access tool with limited success. Documents such as client documents are manually filed with access limitations to documents. Communication of design documents is by paper and hence retrieval of computer aided design files are slow. Overall, the implication of information affects the company's ability to interact with all project parties. There are no current guidelines in place for construction information storage and retrieval that will help understand archiving technologies. The systems available on the market are not designed for their complex archival needs.

Problems in adopting appropriate infrastructure technology for electronic archiving

Based on the information provided by the director of the strategic group through interviews, when asked which IT infrastructure capabilities have the largest impact in their company, the director indicated that, the survey conducted by the company includes IT infrastructure. Currently, there is no project collaboration system and the company uses a LAN network with TCP/IP protocol. The technology used at their sites includes Thin Ethernet. Part of the Internet connection is via modem and ISDN with security a critical problem. However, it has been indicated that, the transmission speed is very slow and the network operating system

needs upgrading. The network operating system currently is Windows NT and 95 clients. Peripherals such as plotters and printers are not networked. Although a physical network exists, there is no established means of transferring documents electronically to both internal and external partners. The company uses Mechanical Desktop and AutoCAD for drawings. Part lists and material lists are generated from the same software but are not integrated. Production departments use Microsoft Project for scheduling. The records department under intense pressure has no IT software solution in place to manage the archiving of documents.

Information Technology is always changing but the case study show that all respondents were unsure of the real opportunities presented by IT systems at present. The company was not aware or willing to consider the range of collaborative software and tools available to resolve infrastructure issues for archiving. The result as this case illustrates is that, experience of implementing corporate IT systems is lacking and it is clearly affecting their ability to examine the potential of emerging IT or appraise current infrastructure. To overcome this problems, the next section recommends and propose a framework that when followed, can help the construction and engineering industry tackle digital archiving management problems that could enable implementation of best practice information management.

Recommendation

This paper suggests five key steps and actions to be considered as part of an implementation framework for e-archiving. These are: (i) review current document creation process for e-archiving; (ii) initiate and develop a corporate strategy; (iii) identify and review current e-archive platforms; (iv) understand and assess appropriate information technology tools; and (v) disseminate and implement e-archive system.

Review current document creation process for e-archiving

The first step towards document creation process for e-archiving presents the construction and engineering organisations with opportunity to review its information management processes in its entirety. This review can be aided by examining what value each information process adds to the final product. One way of achieving more effective business systems is by the removal or minimisation of non-value-adding processes or activities. This stage is very important because investment in IT will only be of value if it provides the means rather than constraints organisational development in its widest context (Moreton and Chester, 1997). For this purpose, standard reengineering techniques are useful aids. The object in this phase is to identify any weaknesses in functions within various departments, propose changes in procedures that will further enhance efficiency and question traditional practices.

Initiate and develop a corporate strategy

Once the review of current processes has been completed, information will be available to formulate specific requirements for introducing new technical developments. The aim is to enrich the functionality available for digital archiving and reduce duplication and implementation costs. Here the main consideration is at what point the organisation needs to move active documents to the archiving systems. Before embarking actual physical implementation, two areas should be tackled. The first is to implement the required system and the second relates to the key application areas where digital information archiving management will be used. If the organisation already has software package that manages files then the challenge is to centralise the system to provide users with a single point of access to

their range of archive records with adequate control facilities. The option chosen for implementing the required system have a major impact on how suppliers are short-listed and selected. If the organisation wants a single user software package to run on an existing PC then the software can be purchased off the shelf and installed. On the other hand if the organisation wants a system to run on existing networks that would integrate with existing business systems then the following implementation issues are critical:

- The storage capacity required.
- The extent of automation of business processes required.
- The extent of the requirement to re-use and edit archive documents.
- The expected volume of retrieval from the archive.

Identify and review current e-archive platform

Any electronic records/information management system must support and secure long-term storage of documents. Currently it is cost effective and desirable for performance purposes to hold all active electronic documents on a storage device. The preferred back up media are high-density magnetic tape and recordable disks. These media accept computer formatted data files and writes that data to optical disks without a change in output format. Where the requirement is to manage high volumes of documents particularly, documents held as page images or multi-media information (images or video or audio data), then consideration has to be given to moving inactive documents from magnetic disk storage to tape or optical disk storage. Where the decision is made to implement an electronic archive, the choice of data and document storage becomes very important because this depends on the companies' particular needs. Apart from using Compact Disc technology or COLD that comes with every basic system, users can choose between Storage Area Networks (SAN) and Network Attached Storage (NAS) where communication network is in place or is affordable.

Storage Area Network (SAN)

SAN involves a network whose primary purpose is the interconnection of storage elements, which connects to other systems (such as file servers). The difficulty inherent in a SAN overcoming the limitations of the architectures typically used to connect file servers to storage systems is to implement a more open 'any-to-any' network (Document Manager, 1999). A true SAN is enterprise-wide, incorporating heterogeneous storage and networking equipment. SANs are typically deployed to implement high availability disaster protection, to ensure server and storage resilience and to speed up, back up and archiving activities. SAN centralises and consolidates storage. Datalink, (2004) suggested that, a SAN implementation can actualise data storage management benefits and reduce costs and overheads such as:

- Reduction in staffing requirements
- Manage much larger data volumes per person than it is possible with other storage configurations
- Fewer purchased of servers for storage
- Centralisation of storage will free data-centre or floor space
- Reduction in annual maintenance costs
- Reduction in power and cooling requirements.

Network Attached Storage (NAS)

NAS is defined as an open architecture for managing and consolidating data storage operations in today's corporate and enterprise networks (Enticknap, 2000). NAS uses storage appliances that can be complete file servers attached to a network and made available to other

servers using standard protocols. This gives users shared data and document access in heterogeneous environments as well as enabling system administrators to consolidate storage from multiple desktop and server systems in a centrally managed data pool. According to Mayer, (2002) NAS separates application servers and data and stores the data on storage devices that perform dedicated file serving task. The benefits however include:

- Ability to improve performance based on dedicated file serving processing
- Ease of administration thus ability to set a common set of files to a multiple client population
- Able to ease capacity expansion and installation

Differentiating between SAN and NAS

The key feature of SAN is that it uses a separate network dedicated to storage traffic. Typically a 1 Gbits/s fibre channel is preferred, but they can be built on Ethernet or over WANs for long distance data back up. Significantly, SANs are block based rather than file based so servers can use storage as they please. However, because of the need for a second network, SANs are suitable for centralised applications, whereas NAS are better suited for distributed information with a number of branch offices especially as the branches are unlikely to have the IT staff needed to support the more complex SAN option. Even with a single site, size is also an issue because it is only when an organisation needs to store and access 500 GB of data or more, that SAN becomes more cost effective. SANs can also be distinguished in that, the storage devices whether tape drives, disk drives or disk arrays are directly attached to the network. Another key difference between NAS and SAN is that, NAS fixes the problems of storage being in short supply by consolidating it in one place where it can be protected properly. With increasing LAN speeds NAS can even provide networked storage that is faster than locally attached storage devices.

Understand and assess appropriate IT tools

Although it may not be viable for all construction and engineering organisations to undertake their own software development, it is crucial that there is an adequate awareness of the environments and tools within which off-the-shelf and bespoke electronic archive solutions are developed. This is essential because, there is no single tool that can meet any one company's management needs (Caroll, 1997). Consequently, being able to deploy the appropriate tools or applications that could meet a company's requirement means an appreciation of the scope for choosing a framework of software applications to reduce the management headaches during implementation. A number of enterprise archiving system need to be understood to ensure the highest level of interoperability of the platform with other applications and other clients. For example Microsoft SharePoint Portal storage server is a flexible solution that enables an organisation to utilise existing information effectively (Microsoft, 2001). This server is designed around an industry and internet standards, such as object linking and embedding database (OLE DB), Microsoft ActiveX Data Objects (ADO), Extensible Mark-up Language (XML), and HTTP. Development is easy because the use of Microsoft Visual Studio allows integration of Active server pages (ASP) functionality into the portal.

Disseminate and implement e-archiving

To implement e-archiving system, it should be noted that, the emphasis placed on information management for e-archiving systems for construction engineering organisations depends on particular needs. The diagram below is an illustration of how information can be visualised

from creation till archiving based on the simple e-archive infrastructure charted below. However, the common requirement is for project/product management that mostly involves the collaborative production of complex documents such as CAD designs. It is therefore essential that, applications that support compound documents need provision for checking-out-checking-in and strong versioning procedures. Managing the e-archive effectively is an integral part of the database. The archive will consist of almost a wide geographic area and a twenty-year retention period. In addition, the archive will contain information such as data and design documents and will allow access to wide area networks (WAN). The system to manage this archive consists of a hardware component to store the data and a software component to access the archive. Before entering the archive management module, It is assumed that the user has accessed the metadata library "query and access" section and has chosen an image. With a collaborative access tool, two or more people can access the same data set simultaneously. Figure 1 illustrates a simple generic diagram of archiving infrastructure.

The process involves the system receiving documents such as invoices and orders from departments and clients. This process also provides a link to the document storage process by providing access via transient storage area. For example when documents are stored, the information manager can view the type of documents from the corporate server and can be able to update the archiving system if authorised to do so. The firewall and other security features would protect document from being tampered. The storage process, which follows document capture for archiving and retrieval marks documents using specific entry words, phrases, or symbols in the document. Documents can also be retrieved within or from external parties outside the organisation electronically through this process. Documents archived can then be accessed through document searching facilities using appropriate index and classifications.

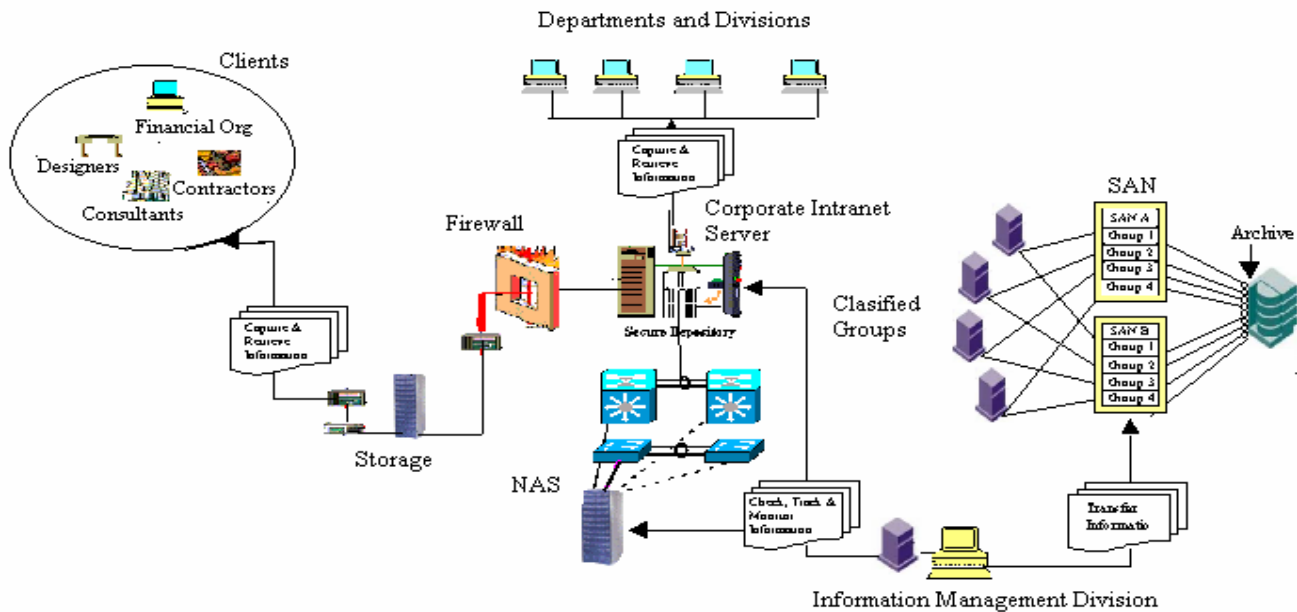


Figure 1: A simple generic e-archiving systems

Time and cost are important factors when implementing information for life-long archiving. It is therefore recommended that time and speed spent looking and requesting for information from the system should be taking into account. Depending on the type of archiving system that the organisation wants to establish the medium of storage should be state-of-the-art multimedia information systems to preserve and facilitate the utilisation of data generated within construction information management. Cost analysis for the archiving systems should be considered especially the cost of implementing and maintaining archives.

Summary and Further Work

Digital archiving management systems have become more affordable over the last few years and software applications have emerged to help business managers implement them. Digital archiving is designed to derive its value from best practice information and business processes using electronic media. Storage and archiving however, has become paramount importance in knowledge platforms in which information management is deployed. However, implementing successful e-storage and e-archiving requires good understanding of basic information standards and protocols upon which the system depends. This paper has outlined the challenges of implementing e-archive to: (i) support of legacy systems; (ii) plan implementation of e-archive in a heterogeneous computing environment; (iii) reduce the rise in information and document loss fraud and unauthorised changes; and (iv) set digital standards that will prevent tampering and changes to individual files. Based on the findings, this paper proposes a framework for dealing with these issues. The four basic steps of the framework are: (i) develop a strategy for archiving management systems; (ii) identify and review current information knowledge platforms; (iii) understand and assess tools and technologies; (iv) disseminate and implement e-archiving. This is to allow IT managers,

engineers and software project managers in the construction industry understand and deploy the elements of e-archive to implement digital information for life-long archiving.

Future information and records management needs more robust and secure systems. For this reason, further research on security and infrastructure for electronic archive management in construction engineering should be explored further. Security in this context relates to the technologies that can be used to secure digital and non digital information. This research is currently in progress. This will focus on developing guidelines that will encourage best practice and help facilitate the construction supply chain. This will be a significant step forward from previous information management research that has typically focused on managing departmental processes for storage of project information and documents. The investigation will include well known technologies such as storage area networks and network attached storage as means of implementing comprehensive e-archiving solutions.

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