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COST ANALYSIS AND LONG TERM PLANNING OVER THE LIFECYCLE OF AN ENTERPRISE STORAGE SOLUTION

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Abstract

This document will cover the basics of the purchasing decisions in the acquisition of data storage infrastructure including Direct Attached Storage (DAS), Storage Area Networks (SAN) such as Fibre Channel and iSCSI, and Network Attached Storage (NAS). This document will focus on Storage Infrastructure Technologies and Network Storage Solutions. The basics of an Enterprise Storage Infrastructure will be explored to aid a Technology Manager in choosing a technology for an Enterprise Storage Solution. The primary focus for this document will be to aid a manager in making a purchasing decision for the selection of storage technologies. This article covers recommendations for establishing an Enterprise level storage solution for file sharing and networked data storage. This document will also cover purchasing options as well as Economic Analysis such as Present Worth, Net Present Worth, and Annuities for our recommended storage solution. An Economic Engineering Analysis is covered later in the document to establish the Total Cost of Ownership associated with purchasing, installing, maintaining and upgrading an Enterprise Storage Solution over the lifetime of the product.

Keywords: Direct Attached Storage, Storage Area Networks, Network Attached Storage

Introduction

One of the primary challenges for a Technology Manager within the Field of Information Technology is to recognize and accept innovation in the area of data storage technologies. Understanding and deploying a storage solution is a difficult process that can consume a large portion of a Technology Manager's time and budget. This paper will attempt to define and organize the long-term cost analysis of an Enterprise Storage Solution. Through the careful planning, research, and implementation of a storage solution, managers can save a significant portion of their budget, reduce unnecessary risks, and reduce the chance of failure.

Summary and Definition - Enterprise Storage Solution

As defined by Whatis.com (2006) "Enterprise storage is a centralized repository for business information that provides common data management and protection, as well as data sharing functions, through connections to numerous (and possibly dissimilar) computer systems".

There are two distinct methods of a storage solution, software and hardware. A software storage solution is a commercial entity used to manage and represent data from a Direct Attached Storage (DAS) device. A software storage solution consolidates and organizes storage media for use with data warehousing,

data integrity, backups, and reliability. One of the newest approaches to software storage solutions is using a clustered file system. Clustered file systems allow for the direct access of the primary hardware storage solution for access by concurrent servers.

This document will focus on the acquisition of a storage solution for file sharing among a 500 employee user base. A software storage solution is primarily used for the distinct use of applications which can benefit from a clustered file system. File sharing does not inherently allow for the capability of utilizing cluster file system technology. Due to the requirements of our scenario, this document will primarily discuss issues and the economic impact on choosing hardware Enterprise Storage Solutions and how to choose the optimum solution to best fit the identified requirements.

Hardware storage solutions are physical entities used for data storage. Hardware storage solutions are a collection of hard disks that are controlled by a management interface. This document is written with the intended purpose of helping a manager recognize the appropriate criteria in determining an appropriate hardware storage solution. Hardware storage solutions can consume a considerable amount of an Information Technology Department's fiscal budget. In recognizing the economic impact of choosing a hardware storage solution, this document will cover hardware storage technologies, pricing, and purchase options. To aid in the understanding of the different available technologies and which of these technologies are optimal for a file serving solution, this document will discuss the different hardware interface types and networking protocols that are commonly used in industry.

Enterprise Storage Infrastructure

In order for a manager to make a decision on the potential storage solutions available, a manager must first define the storage requirements for their enterprises potential storage needs. Enterprise Storage Solutions are purchased based on total disk volume. Storage solutions are scalable. Scalability allows for future expansion of the total storage volume to coincide with the growth of the potential needs of the purchaser.

The initial purchase of a hardware storage solution usually includes volume discounts for a first time purchase. The initial housing unit, controller, and disks will be shipped as an all-inclusive system with the ability for future growth. After the initial purchase, additional services can include costs associated with additional research, shipping, and support. These reasons are partially responsible for why it is very important that a manager conduct research prior to the initial purchase.

As stated earlier, it is important to first define the needs of the storage solution. For example, if you plan to purchase a storage solution to accommodate 500 employees for file sharing, you would need to recognize the potential data storage of each user. It would also be important to recognize the future needs of the department for expansion and departmental growth. One method for determining storage volume is to take the total number of employees multiplied by the average assumed storage volume for users. In this example, the researcher has assumed the department will allot a server quota to limit storage volume for each user to 2,000 megabytes. This figure can vary according to the workload and storage needs of the user base. To calculate our initial purchase, we will utilize the following equation:

V = (U x Q) 1.4
V = Total volume
U = Number of users
Q = Quota allotted per user

The 1.4 coefficient is an assumed growth rate of approximately 40%. Over the author's 10 years of experience as a Data Storage Administrator, this equation has been proven as an efficient initial starting point that allows for potential growth and scalability of a select user base. Please note that this equation offers a starting point only. This will allow enough capacity for growth during the initial purchase. The coefficient can be adjusted according to the growth rate of the company. It is vital that the Storage Solution that we choose be scalable in the circumstance that our initial storage requirements reach maximum capacity. Based on the above equation, the initial purchase of our data storage volume would be 1,400,000 megabytes (1.4 terabyte) of storage.

V = (500 x 2,000) 1.4 = 1,400,000

Key Storage Characteristics

Microcomputer technology is a fast growing field. The necessary research to determine which technology would best suite the needs of an Enterprise Storage Solution can be overwhelming. Disk storage is divided into two distinct categories, storage infrastructure technologies and network storage solutions. Each category represents a specific technology that determines data throughput, disk input/output, and data protocols. The following section will identify key storage technologies available for hardware storage solutions.

Storage Infrastructure Technologies

Storage infrastructure technologies represent the core technologies for data storage. Specific technologies have been developed over the years to accommodate the need for specific data transfer speeds and to ensure data integrity. Storage Infrastructure Technologies define the underlying technology used for disk access and communication at the lowest level of data storage. The hard disk interface determines the primary methods of communication, throughput, disk input/output, and data integrity. This section will discuss the various hard disk interfaces associated with today's market integration. We will discuss several of the more common technologies used in industry.

Serial ATA (SATA/SATA-II)

SATA, also known as Serial ATA, is a disk storage technology derived from earlier ATA (Advanced Technology Attachment) standard made possible by the IEEE (Institute of Electrical and Electronics Engineers). SATA is commonly used in workstations and low-end servers as their primary data storage units. SATA offers significantly faster data transfer and flexibility of implementation over legacy ATA technology. SATA offers a significant cost reduction as compared to current Storage Infrastructure Technologies. For the above mentioned reasons, SATA is commonly used in data storage solutions that require considerable data storage volume. SATA-II enhances the original SATA technology that increases data frequency throughput. SATA allows for a data transfer rate of 150 megabytes per second compared to SATA-II which allows for a 300 megabyte per second data transfer.

Ultra320 SCSI

In contrast to Serial Attached SCSI, a technology discussed later in this section, Ultra320 SCSI is a parallel SCSI standard. SCSI (Small Computer System Interface), pronounced "skuzzy", is a standard hard disk interface and command set for data communication and storage. Ultra320 SCSI is an extension to the family of parallel SCSI technologies. Parallel SCSI is quickly being replaced by Serial Attached SCSI. For replacement of legacy parallel SCSI systems that require updated data storage capacity and performance, Ultra320 hard disks offer increased performance and capacity without replacing the storage infrastructure. Ultra320 parallel SCSI doubles the maximum data transfer rate of previous parallel SCSI solutions. Ultra320 SCSI offers a maximum data transfer rate of 320 megabytes per second. The following list illustrates several of the key advantages to using Ultra320 in contrast to earlier parallel SCSI technologies: (Ultra320 2006)

- Faster, more reliable data transfer
- Backward compatibility with all SCSI versions
- Increased reliability and better signal integrity
- Improved bus utilization and throughput

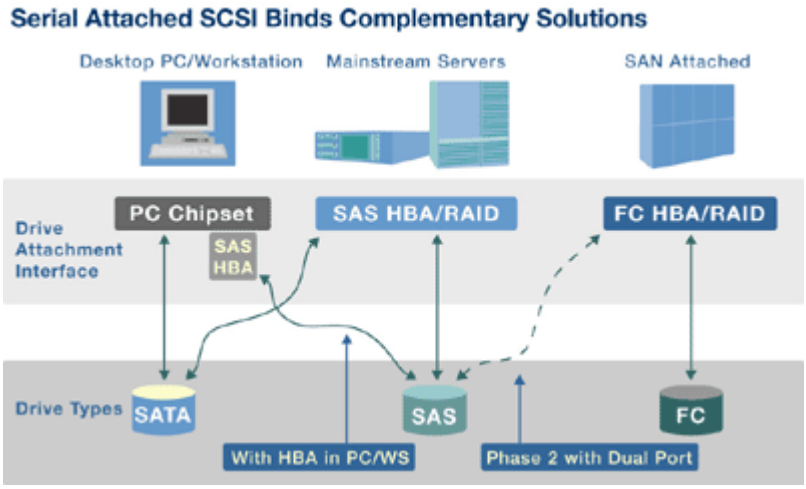
Serial Attached SCSI (SAS)

SAS, or Serial Attached SCSI (Small Computer System Interface), is a new technology that takes advantage of several of the key advantages found in SATA, but still utilizes the lower level SCSI protocol system. SAS supports 16,384 addressable units and allows for data transfer speeds of up to 3.0 gb/s. Data transfer speeds of SAS are expected to reach 6.0 gb/s in the near future.

Seagate expresses Serial Attached SCSI as having tremendous potential. The following statement from Seagate outlines the potential of Serial Attached SCSI:

> "Boasting features that liberate SCSI from its parallel predecessor, Serial Attached SCSI (SAS) delivers new levels of breakthrough speed and connectivity while retaining the functionality and reliability that has made SCSI the premier enterprise storage I/O standard for over two decades." (Serial Attached SCSI 2006)

The following image dictates how the future of Serial Attached SCSI will offer interconnects into all mainstream systems, including desktop computers and high end storage solutions.



(Source: SAS Technical Specifications 2006)

Fibre Channel (FC)

The term Fibre Channel (FC) is often comprehended as a network topology architecture. While this is true, Fibre Channel technology has grown into more than a network topology. FC is used in all aspects of storage technology, ranging from the network topology used for Storage Area Networks in addition to a Storage Infrastructure Technology used for Direct Attached Storage and the underlying hard disk access technology. Fibre Channel hard disk technology utilizes a revolutionary new command set for use in high end storage systems. Fibre Channel has evolved into a multi-faceted technology that encompasses a range of existing technologies and infrastructures.

Fibre Channel hard drive interfaces have seen a sharp rise in demand based on the industries needs for high performance data storage. The following statement from Seagate expresses some of the benefits of the Fibre Channel hard drive interface:

> "Fibre Channel has firmly established itself as the premier serial interface, and over the past decade Seagate has driven the development of this powerful technology. Fibre Channel provides for unparalleled disc drive performance, scalability, security, and data integrity. Seagate's Fibre Channel hard disc drives, Cheetah 15K and NL35 Series, enable a new class of tiered storage solutions that seamlessly integrate into mainstream Fibre Channel architectures, while delivering far greater flexibility, scalability and security than other storage interfaces" (Fibre Channel 2006).

Redundant Array of Independent Disks (RAID)

Redundant Array of Independent Disks (RAID) is a technology that increases performance by spanning disk access in parallel across disk sets. RAID technologies consist of a grouping of hard drives and coordinates disk input/output through a RAID controller. Data integrity, fault tolerance, and disk input/output speed are a few of the benefits offered by RAID. The following quote from Seagate summarizes the importance of using RAID technology in an Enterprise Storage Solution.

> "RAID (redundant array of independent discs) is a concept in storage subsystems that can deliver higher levels of protection against down-time and data loss than conventional disc drives. RAID refers to a drive architecture designed to safeguard critical data through redundancy. In theory, RAID arrays composed of conventional discs can function for hundreds or even thousands of years without losing data because of a disc failure" (RAID 2006).

Storage Infrastructure Technologies Summary

To continue with the example in the previous section, the primary role for the example Enterprise Storage Solution is for file storage and sharing. File storage and sharing can consume a lot of disk storage, but only requires minimal disk speed. For file sharing, it is imperative that we have data integrity and fault tolerance. In determining the appropriate technologies required for our example scenario, the information gathered in previous sections of this document can help us determine the proper technologies to maximize cost efficiency, storage capacity,

data speed, data integrity, and fault tolerance. As stated above, the primary characteristics of an Enterprise Storage Solution used in the role of a file server are maximum disk scalability and data redundancy.

The following list enumerates the key performance considerations when choosing a Storage Infrastructure Technology:

- Data Transfer Rate
- Access Time
- Capacity
- Cost Per Megabyte (CPM)
- Reliability

Although SAS, FC, and Ultra320 outperform SATA-II substantially in two of the four performance considerations, our primary concern is capacity and CPM. SATA-II offers higher capacity drives at the lowest CPM. The primary requisite of the example scenario is cost efficiency and data storage scalability. The primary technology for determining fault tolerance and redundancy is through a RAID architecture which is independent of the hard drive interface. Based on the above criteria, it would be beneficial and cost efficient to utilize a RAID configuration using SATA-II hard disks.

Network Storage Solutions

Network storage solutions represent the technology required for running an Enterprise Storage Solution. Network Storage Solutions offer concurrent access to vast quantities of data. The two primary Network Storage Solutions this article will cover are Storage Area Networks and Network Attached Storage.

Network Storage Solutions offer network topologies that are scalable and offer the flexibility to support the data storage needs for larger industries. The primary role of a Network Storage Solutions is to provide data networks that consist of data storage devices and all dependent interconnects to ensure the appropriate functionality of all communication channels.

A network storage solution is not a requirement. For smaller operations, a network storage solution may be unnecessarily complex. Direct Attached Storage (DAS) is a technology offered to Small and Medium Business (SMB) segments to offer high performance data storage without the complexity of a Network Storage Solution. In the example represented earlier, the user base of 500 may require a more elaborate and scalable platform. Concurrent client access to large volumes of storage indicates the need for a Network Storage Solution. The following sections describe the currently available Network Storage Solution technologies. These sections will emphasize the key characteristics of each technology in helping to fulfill the requirements for an Enterprise Storage Solution file server.

Storage Area Network (SAN)

A Storage Area Network (SAN) is used to attach servers to a network of storage devices. Pcmag.com, a highly regard online Information Technology journal, states the following definition for SAN:

> "A network of storage disks. In large enterprises, a SAN connects multiple servers to a centralized pool of disk storage. Compared to managing hundreds of servers, each with their own disks, SANs improve system administration. By treating all the company's storage as a single resource, disk maintenance and routine backups are easier to schedule and control. In some SANs, the disks themselves can copy data to other disks for backup without any processing overhead at the host computers" (Storage Area Network 2006).

Storage Area Networks offer the choice between two primary technologies; Fibre Channel (FC) and iSCSI. A more detailed description of each of these two technologies is included later in this section. A summary of the advantages and disadvantages of Storage Area Networks are covered in the Network Storage Solutions Summary. Device management and data transfer are the foundation for Storage Area Networks.

Storage Area Networks control direct data volume access via Logical Unit Numbers (LUN). A LUN is an addressable data storage slice configurable through the primary SAN controller. Storage Area Networks operate at block level input/output. Block level input/output is considered the most efficient facility for conducting data storage communication and allows for compatible applications to efficiently control disk input/output. As stated by Alan Earls of SearchStorage.com:

> "The major difference between iSCSI and NAS, says Randy Kerns, senior analyst with Greenwood Village, Colo.-based Evaluator Group, is that, like FC, iSCSI handles data in blocks while NAS moves it in files. Applications that lend themselves to block-based I/O, for example Microsoft SQL and Exchange, are ideal candidates for iSCSI" (Earls, 2004)

Fibre Channel (FC)

Fiber Channel (FC) is a SAN topology that was developed under the same concepts as a switched network frame. FC uses the concepts of World Wide Names (WWN) to control communication across Fiber Channel Fabrics. A FC Fabric is a collection of disks that are consolidated and organized via a centralized management interface. The FC network throughput operates at 1, 2, or 4 gigabit per second. Please note that SAN technology operates at a serial throughput of bits per second, while other storage network technologies operate with a throughput of bytes per second.

iSCSI

Internet SCSI (iSCSI) is a new contender in the field of Storage Area Networks. iSCSI performs disk input/output at the block-level. Similar to FC, iSCSI is attached as full duplex communication channel for drive access. Data volumes are mapped to Logical Unit Numbers configured on the SAN management interface.

As defined by Simon Gordon of Searchstorage.com, "iSCSI is sending SCSI commands in IP packets. To be more specific, iSCSI is designed to be a protocol for a storage initiator (usually a server) to send SCSI commands to a storage target (usually a tape or disk) over IP" (Gordon 2003).

iSCSI host configuration offers both a hardware and software initiator. An initiator is the primary facility for initiating communication from a host to the target controller. Hardware initiators are proprietarily engineered Ethernet adapters that offload processor intensive routines to package and transmit SCSI commands over the Internet Protocol. Software initiators are specialized drivers used within the Operating System of a host machine to perform the routines to package and transmit data over a standard Ethernet adapter.

Network Attached Storage (NAS)

Network Attached Storage (NAS) is a Network Storage Solution that utilizes network infrastructure for connecting data storage devices. Network Attached Storage devices can connect into an Internet Protocol (IP) network and offer services for other network devices. The primary difference between SAN and NAS Network Storage Solutions is the underlying communication protocols and the level of access via the transport facilities. NAS is considered the least complex of the two technologies. The primary concern with NAS technology is network congestion. NAS is the most affordable and cost-effective IP based network storage solution available on the market. The primary advantages of NAS storage is the cost per megabyte. The disadvantages of NAS storage is the considerable protocol overhead and slight reduced performance in disk input/output. NAS storage is an effective solution for use with file serving.

Network Attached Storage Solutions contain two facilities in conducting its operation. NAS solutions contain a front-end servicing system and a backend storage facility. A NAS front-end servicing system operates at the Application Layer of the OSI Network Model and is tunneled over IP (Internet Protocol). The NAS front-end servicing system allows for client access through either the Common Internet File System (CIFS) or Network File System (NFS) protocol. The NAS back-end storage facility is a Direct Attached Storage (DAS) unit dependently connected to the front-end servicing system. These two facilities are shipped to operate as an all-inclusive system and will usually be configurable through a vendor controlled management interface.

In contrast to SAN, NAS operates at the file level. CIFS and NFS file shares handle file locking and servicing. Although file level access is considered less efficient that block-based input/output, the underlying Application Layer protocols uses file level input/output. As stated earlier in this document, the primary requirements in our example scenario are data storage scalability and CPM. The performance degradation for file level input/output is considered unfeasible for many applications. Because both the application level file access and NAS operate at the file level, the file level input/output operation is acceptable for file sharing and data storage.

Network Storage Solutions Summary

SAN and NAS are often confused technologies. As stated above, SAN operates at the block level and controls channel-attached storage. NAS operates at the file level and uses opportunistic file locking and file sharing via the Application Layer of the OSI Network Model. The primary differences between SAN and NAS are best stated by Pcmag.com:

> "SAN-NAS terminology is confusing (storage area network vs. network attached storage). They both fall under the "storage network" umbrella, but operate differently: the channel-attached SAN extends the disk channel, whereas the NAS is another node on the network" (Storage Area Networks 2006).

There are several key considerations for choosing a Network Storage Solutions. Cost, scalability, and ease of administration are of primary importance in our example scenario. Storage Area Networks offer improved performance over Network Attached Storage. The Cost-Per-Megabyte is significantly increased and the administrative overhead is more demanding with SAN technology. Our recommended solution must ease administration tasks and lower Total Cost of Ownership. Using the above information, the Network Attached Storage technology using SATA-II drives in a RAID configuration is the optimum solution for implementing file sharing in an Enterprise.

Key Storage Characteristics Summary

SAS, FC, and Ultra320 devices can triple or quadruple the cost of a storage infrastructure. A file sharing storage solution can be function properly on 300 MB/s file input/output. For our scenario, the increase in file transfer speeds of other storage infrastructure technologies is not cost effective. We chose to use a RAID configuration due to the nature of our scenario. Data integrity and reliability must be sustained. The Network Attached Storage network topology is commonly used in conjunction with SATA-II RAID devices. The coupling of a SATA-II RAID device running on a Network Attached Storage topology is used to maximize cost-efficiency, scalability and performance. Network Attached Storage does offer a slight performance overhead due to the protocol and mechanism of delivery for disk input/output. For the role of file serving, this overhead is expected and accepted.

Economic Analysis

In the earlier sections of this document, we have covered storage solution technologies and defined our example scenario. This section will continue with the example scenario and proceed to analyze the cost of implementation. To reiterate our example scenario, we have a 500 user network that requires a 2.0 gigabyte per user quota storage solution for file sharing. Based on our key performance considerations, we have chosen to use a RAID configured SATA-II storage infrastructure technology based on the Network Attached Storage (NAS) Network Storage Solution. SATA-II was chosen as the recommended Storage Infrastructure Technology based on Cost-Per-Megabyte. After having researched our options for a storage solution technology, we must now evaluate all commercial offerings and select a commercial Enterprise Storage Solution.

Investments and Planning

After researching the capabilities and costs for various commercial offerings for the recommended Enterprise Storage Solution, the author found the best value offerings from Hewlett-Packard. In many commercial business environments, a purchase above $2,000 is usually placed through a bidding process. After receiving quotes and discussing the requirements with IBM, Dell, EMC, and HP, the author's projected cost of the needs for the example scenario Enterprise Storage Solution reached a cost range from $10,000 to $48,000. The lowest cost solution that met all of the requirements we have defined was $9,803 from HP. An HP solution offers an all-inclusive, fully integrated Network Attached Storage device that eliminates the need for separate server hardware. It is the author's experience that HP offers top quality products and support.

Recommended Purchase

HP Enterprise Storage Solution
StorageWorks 600 All-in-One Storage System

Product Specifications (source: HP, 2006)

Product: HP StorageWorks 600 All-in-One Storage System – 1.5TB SATA-II
Form Factor: 5U
Processor: Dual Core Intel Xeon 2.67 GHz/1333 MHz FSB with 4MB L2 Cache
Storage Included: 1.5TB (6 x 250GB SATA Hot Plug)
Remote Management
Memory: 1GB Standard

Additional Accessories

HP 1GB Fully Buffered DIMM PC2-5300 2X512 Memory (Add $299.00)
Care Pack: HP 3Y SupportPlus24 AiO600 SVC (Add $1985.00)
Installation Service: HP Installation ($360.00)

Pricing and Shipment

Purchase Price: $9,803.00 (shipping and tax not included)
48 Month Lease: $265.66 monthly
Estimate Shipping Time: 5-7 days

Extended warranty for Enterprise Storage Solutions is based on total volume. The predicted cost for extended warranty is assuming that we have no need for extending the volume past 1.5 terabytes. The following

summary gathers information to help us determine the yearly annual annuity and net present worth of our purchasing decision.
Cost: $9,803.00
Life: 4 years
Warranty: 4 years
Extended warranty: $1,985.00 1.5 TB for 3 years
Annual interest rate: 5%

Cost Analysis

The following section summarizes a cost analysis for both outright purchase and leasing. The primary reason behind the cost analysis is to aid the manager in understanding which purchasing options are most beneficial. The first section includes total cost in the form of present worth calculations (PW) and annual worth (AW) for outright purchase. The second section covers annual worth (AW) and total cost (TC) for leasing.

Outright Purchase

Present worth and annual worth formulas are provided below. Please note that Compound Amount Factor, Present Worth Factor, and Capital Recovery Factor are available for reference in Appendix D in the Engineering Economics text (Riggs et al., 1996).
PW = Cost + Extended Warranty (Present Worth Factor)(Compound Amount Factor)
PW = $9,803 + $1,985(P/F, 5%, 4)(F/P, 5%, 7)
PW = $9,803 + $1,985(0.82270)(1.40710)
PW = $9,803 + $2,298
PW = $12,101

AW = Cost (Capital Recovery Factor) + Extended Warranty(Present Worth Factor)(Compound Amount Factor)(Capital Recovery Factor)
AW = $9,803(A/P, 5%, 7) + $1,985(P/F, 5%, 4)(F/P,5%,7)(A/P, 5%, 7)
AW = $9,803(0.17282) + $1,985(0.82270)(1.40710)(0.17282)
AW = $1,694 + $397
AW = $2,091

The annual worth (AW) of our Enterprise Storage Solution over 7 years, if the technical requirements remain constant, is $2,091. The total cost of this purchase over 7 years is $12,101 and is represented by the present worth equation (PW). At the end of this period, we sustain a minimal salvage value of the initial purchase. With the rate of change for Information Technology, the salvage value after 7 years is trivial and is not included in these equations.

Lease Agreement

Under a lease agreement, the annual worth (AW) and total cost (TC) over the course of 7 years is stated below. Please note that these equations are simply the multiplication of the number of compounds.

AW = Lease Cost per Month (Compound Payments per Year)

AW = $265.66(12)
AW = $3,188

TC = Annual Worth (Compound Payments)
TC = $3,188(7)
TC = $22,316

Conclusion

The primary goal of this paper was to define the requirements for and estimate the long-term cost of an Enterprise Storage Solution. We have introduced a real world scenario, and produced the necessary information to aid an Information Technology manager in making a purchasing decision for an Enterprise Storage Solution. As stated in the previous sections, we were able to purchase and deploy an Enterprise Storage Solution to meet the file sharing needs for 500 users for the cost of $2,091 annually. Based on the research of the cost analysis, a total savings of $10,215 can be saved through an outright purchase of our Enterprise Storage Solution. This savings shows the dramatic impact that interest rates can have on a long-term lease. The final conclusion was to outright purchase an HP All-in-One NAS appliance using SATA-II disks in a RAID configuration. This storage solution is cost efficient, reliable, and scalable. HP and the All-in-One series of NAS-SATA-II devices are some of the most respected NAS storage solutions available on the market. The life expectancy of our storage solution is approximately 7 years, at which time the company will need to conduct further research for product evaluation and replacement.

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