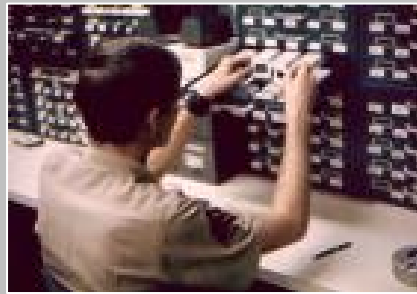


Digital Dilemma:

Storage and Backup Solutions to Accommodate Today and Set the Standard for Tomorrow



A Proposal Presented by
Julie Angarone
Computer Support Specialist
Department of Art and Archaeology
Princeton University
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Executive Summary

This proposal is about the storage and backup of digital images, a problem not readily noticed by the customers of the Visual Resources collections, but a problem that has been increasing steadily over the past few years. As faculty have gravitated towards using digital images, Visual Resources has kept up with the demand by scanning slides, using digital cameras to shoot images from books, and buying collections in digital form. But where are all of these images stored? Are they safe? What happens if the building burns down or the computers break? Faculty, too, are feeling this same issue as they struggle to control their own collections.

I liken the difference between faculty and Visual Resources needs to that of a family versus a restaurant. Every family needs a refrigerator, as does every restaurant. Family refrigerators come in many shapes and sizes, but restaurant refrigerators are not only bigger, with more storage, but they depend on a backup power supply so that the restaurant's investment in food is not destroyed by a power outage. So too is the scope of Visual Resources. Visual Resources feeds many customers, and therefore needs a large centralized storage solution with a plan for failure; a plan for restoring images should the main storage be compromised in any way.

Refrigerators have been similar in size, shape, and price for decades. However, unlike the refrigerator metaphor, changes in technology for digital storage are coming fast and furious. Storage solutions need to be addressed on an as-needed basis to avoid being trapped in expensive solutions that may become obsolete. We need to purchase storage that will be perfect for our current needs and that of the next one to two years. To buy too much storage, or very expensive storage that grows as our needs grow would be to overlook the fast pace of technology which could very well provide larger storage for half the price in the very near future.

It is my goal, therefore to propose a very specific solution which will not only store our current images in one place, but be easy to back up, easy to administrate, easy to access, and easy to replace. The solution I have found is the Buffalo Terastation 2.0 Pro NAS (BTP). It fulfills each of my goals listed including one that is important to the department: the price is right. The BTP solution paired with the purchase of two 500 gigabyte external drives will provide centralized storage and easy-to-restore backup of all the images in Visual Resources for an estimated two years.

My proposal will begin by explaining the history behind our use of digital images including how we have stored them and backed them up. I will also share my findings on how the issue has not really been addressed by experts in the field while visual resource people in ours as well as other universities struggle to find a solution. I will clarify the need for more efficient methods for both storage and backup as I introduce my solution of a network attached storage device which is easy on the wallet as well as the upkeep and backup. I will further detail the plan to implement my solution as well as the people who will be involved.

Table of Contents

Executive Summary	i
Table of Contents	ii
Our Situation	1
Historically	1
File Size	1
Where Are They Now?.....	1
Redundancy	1
Backup Fees	1
Background.....	2
Elsewhere on Campus	2
Other Universities.....	2
Objective	3
The Need for Centralized Digital Image Storage.....	3
Backup Procedures that Make Sense (Cents)	3
Plan.....	4
Equipment for a Central Storage Solution	4
Consider the Present and the Future	4
What Else is There?	4
Why a Server is NOT Right for Us.....	4
The Backup Plan.....	5
Fault Tolerance.....	6
Planning for Failure	6
Assessment.....	7
Advancements in Technology	7
Tracking the Growth Rate of Storage Needs	7
Monitoring the Backup.....	7
Communicating.....	7
Personnel	8
Julie Angarone, Computer Support Specialist.....	8
Trudy Jacoby, Director of Visual Resources	8
David Connelly, Photographer.....	8
Visual Resources Staff	8
Budget	9
Timeline.....	10
Conclusion	11
Works Cited.....	12

Background

Our Situation

Historically

Visual Resources, a unit in the Department of Art and Archaeology at Princeton University, is responsible for maintaining a collection of images for use in teaching and research. The collection historically consisted of photographs, then lantern slides, then 35mm slides. Now, as slides are being phased out, the use of digitized images is becoming the preferred method of presentation in classrooms. As technology has changed, storage has changed with it. Photographs were stored in boxes or large file drawers. Lantern slides required a different size box. 35mm slides needed drawers that were wide and long, but not very deep. Digitized storage also has unique requirements which we are now forced to consider closely.

File Size

Over the past five years our collection of digitized images has increased substantially and our method of scanning and storing images has changed as well. Instead of simply scanning on an "as requested" basis with little thought to keeping the image, we are digitizing by course and we keep not only the presentation image, but also a master file in tiff format to maintain a high quality image.

Images for classroom use are typically 2 megabytes in size while master files are an average of 20 megabytes each. Our current collection totals approximately 37,000 master images at 20 megabytes each and 37,000 presentation images at 2 megabytes each for a total of approximately 834 gigabytes (where 1 megabyte = 1024 bytes and 1 gigabyte = 1000 megabytes). Due to the large and ever increasing number of images, our current storage of these images needs to be reevaluated.

Where Are They Now?

Typical computers in Visual Resources have hard drive capacities of 160 gigabytes. At least 100 gigabytes sit unused. Two staff computers, however, have 250 gigabyte hard drives and have been using their extra space to help store some of these 37,000 images. David Connelly, the photographer and digital image specialist in Visual Resources has a 250 gigabyte hard drive as well as a 400 gigabyte external drive which stores the majority of the digital images. As you can see, there are at least four separate hard drives involved in the storage of the 74,000 images.

In June of 2005, Trudy Jacoby, Director of Visual Resources, and I were looking for a storage solution much as we are now. At that time we knew we would need at least one terabyte (1000 gigabytes) for future needs, but we were uncomfortable with the reviews that the only available solution, the LaCie Big Disk, was garnering ("LaCie"). We knew that if we waited a year there would be more options available for less money. It was then that we decided to distribute our images over the available space on the staff computers while we waited for technology to meet our needs. The biggest advantage to this scheme was to have the data backed up for free.

Redundancy

One of the most important considerations in storing data in digital form is backup. Data must exist in more than one physical location (Moore). At Princeton University, the Office of Information Technology (OIT) performs nightly backup for every device attached to the network. OIT backs up data to a physical location over a mile away from where Visual Resources resides in McCormick Hall. Presently, backup of the digital images, currently distributed over staff computers, is free because the Dell Optiplex computers that are storing the images are classified as DeSC computers (standard university office equipment purchased with specific configurations in order to be supported and backed up at no cost to the department). OIT wants everyone to use the same computer configuration because it is easier to support: both in supplying a standard software set and in troubleshooting problems. Hence the free backup is part of the incentive to get departments to buy the recommended systems. The university has no such standard for large storage needs.

Backup Fees

Instead, OIT has a formula for charging for backup of storage space. The first 150 gigabytes is \$8.00/month. Each subsequent gigabyte is charged \$0.80/mo. When we apply this formula to our current storage need of 834 gigabytes it amounts to approximately \$6700/year - a cost which will increase as our digital collection increases. Such an exorbitant amount requires careful consideration and has prompted me to research how others are attacking the digital dilemma.

Background (continued)

Elsewhere on Campus

The School of Architecture had a similar situation as they have also been transitioning from slides to digital images. Over a year ago, The School of Architecture opted to buy a Dell PowerEdge server. The PowerEdge is 108 pounds with dimensions of 17 x 9 x 28 inches. It starts at \$4,100 with a mere 146 gigabytes of storage space, and at least three of those gigabytes go to server software ("PowerEdge 2800"). The server is housed in a special machine room and requires the onsite computer support personnel to have server administration experience. The server allows for internal expandability up to three terabytes, with each additional 300 gigabyte hard drive approaching \$500. The School of Architecture has made a substantial investment which requires them to stay committed to the solution they chose regardless of how technology changes in the near future. The School of Architecture pays OIT for backup.

Other Universities

We are not alone in our digital storage dilemma. I spent some time researching how other universities are tackling the changing technology. I started by searching for journal articles which would depict the current standards of digital storage. Instead of finding storage issues, I found a plethora of articles on how to digitize and manage images. Management and storage are different in that management in the world of academic visual resources refers more to the organization of the data including the cataloguing data that is attached to each image. Our concern is not with data management as we already use our "home-grown" management applications, Almagest and Pictor. Rather, we are mainly concerned with storing our master files. There seems to be no readily available information from scholarly journals regarding image storage standards.

I then went to the Visual Resource Association (VRA) website. The website had no main topic referring to image storage, so I checked the archive of the listserv. There I found confusion on the topic of storage: people who did not understand the difference between a terabyte and a megabyte; people who incorrectly believed they would need \$200,000 for a terabyte of storage space; and people who were recommending the LaCie Big Drive without knowing the platform of other users. LaCie's Big Drive works well on Macintosh computers but has poor reviews for PC use ("LaCie").

The VRA website did have a list of member universities however, so I wrote to a representative sample of ten universities. I only received three replies, but they were all familiar and similar. Table 1 summarizes their methods.

University/Contact	File Size/Storage	Backup
Emery University/David Lower	Master files: 18 Mb tiffs stored on 600Gb USB external drives and duplicated on CD's and DVD's Presentation files: using Luna Insight on a Unix server	Nightly onsite tape backup
Binghamton University/ Marcia Focht	Master files: 10,000 19 Mb tiffs stored on 400Gb drive on a Dell PowerEdge Server and duplicated on DVD's Presentation files: stored on DVD's, sent to ARTstor and DSpace for presentation	Nightly onsite backup
Rutgers University/ Donald Beetham	Master files: 18 Mb tiffs stored on DVD's Presentation files: using Luna Insight under control of the university, also stored on 3 external SimpleTech hard drives	The edited files are backed up nightly by the university. The raw files, as stored on CD's are not backed up.

Table 1: Summary of Storage Strategies at other academic Visual Resource venues

Objective

Emphasize the Need for Centralized Digital Image Storage

Over the past year our plan to scatter the digital images across the staff computers has had problems. Dell motherboards on over one hundred computers campus-wide had bad capacitors. The symptoms of the troublesome motherboards ranged from dead USB ports to dead hard drives. Unfortunately the three computers we were using for image storage were plagued by these troubles. Each instance resulted in downtime ranging from one to three days, most of which was time needed to restore the digital images from backup over the network.

Had the Dell computers been reliable, our plan may have succeeded and would not have caused us to rethink it. However, too many people were affected by the downtime. The latest instance occurred at the end of the academic year when a professor who was going on leave wanted to take images with him and was unable to do so. Not only were we unable to supply the professor with his images, we weren't even sure where to begin looking for them.

The sheer number and size of the digital images demands that the storage solution be centralized. When an image is needed there should be one quick access point to locate it. The loss of productivity over the past year has led me to seek out not only a solution that will be large enough to contain all our images, but also one that will provide immediate access and will have fault tolerance to diminish down time.

Introduce Backup Procedures that Make Sense (Cents)

The frustrating thing about the free off-site backup provided by OIT is the time it takes to restore data. Because the data backs up over the network, it also must be restored over the network. During the day, while sharing bandwidth with the rest of the campus community, it takes over an hour to restore three gigabytes. Over night the process goes faster. However, restoring 834 gigabytes takes a long time regardless of the time of day. The restoration is also dependent on the power staying on. It is not unusual for the building power to go off and then on at least once a week as well as during any thunderstorm. Any time the power goes out the restore must be restarted and then monitored for error messages if some of the data has already been restored. Again, productivity has been lost during this tedious process.

A new backup procedure is in order. It must be reliable. It must include an off-site iteration. It must be easy to restore. The time, space, and equipment that are involved in backup can add up to a large monetary commitment. The ideal solution will include a strategy to limit the monetary cost inflicted by OIT's substantial fees ("TSM Usage").

Plan

Equipment for a Central Storage Solution

I am proposing the purchase of a Buffalo Terastation Pro NAS 2.0 for consolidation, centralization, and storage of digital images in Princeton University's Department of Art and Archaeology Visual Resources. The Buffalo Terastation Pro NAS 2.0 (BTP), in a RAID 5 configuration for fault tolerance, allows a total of 1.5 terabytes of storage ("Buffalo Terastation"), almost double what is currently needed.

The BTP is essentially a small box holding four 500 gigabyte hard drives. With dimensions of 6.6 x 8.7 x 9.5 inches and weighing sixteen pounds, the BTP takes up a very small space (Figure 1). It is also extremely easy to implement. We simply place it on a desk, plug it into the wall, attach a network cable and start storing data.



Figure 1: The Buffalo Terastation NAS Pro 2.0

The reputation of the BTP is applauded in the reviews that are trusted by computer professionals such as CNET (Jacobi), and Trusted Reviews ("Buffalo Technology"). Both tout the advantages and durability of the BTP.

Consider the Present and the Future

Due to the fast pace of changing technology and prices, the BTP is ideal because it will allow us to meet our current needs without a huge monetary commitment. The BTP is available through several different vendors for under \$2,000. By only buying the minimum solution to face our current and near future needs, we are leaving the door open to a different solution as technology dictates in the coming years. The BTP was chosen instead of several other storage solutions due to its size, reputation, administrative needs, and the lack of commitment to a large expensive server that will be obsolete in two or three years. Other solutions that were considered include the Apple Xserve and the Dell PowerVault.

What Else is There?

The Apple Xserve starts at \$7,000 for less storage space ("Choose Your Xserve") than the BTP. The Xserve is a server that requires an additional storage unit in order to be comparable in capacity to the BTP. It includes features such as an email server and a print server, neither of which is needed for our purposes, both of which increase the price.

The Dell PowerEdge is similar in scope and price to the Apple Xserve ("PowerEdge 2800"). It is the model that was chosen by the School of Architecture. It starts with 146 gigabytes of storage with the ability to add 300 gigabyte drives at \$500 each for a total of only three terabytes. While the storage is impressive, it is also expensive and locks the buyer in regardless of new technologies.

Why a Server is NOT Right for Us

A server would necessitate a learning curve in server software for the computer administrator (me). No such learning curve is necessary with the BTP. The BTP simply needs to be attached to the network which is already in my realm of expertise.

I feel that both the Xserve and PowerEdge are beyond our scope and would also commit us to an expensive solution that would not be in our best interest as the pace of storage space technology is ever increasing. I predict that a four terabyte solution will be available within two years at a comparable cost to the BTP. I have sculpted this proposal with that possibility in mind. Buying only what we need to get us through the next year or two may seem to indicate a lack in planning for an increase in digital images. On the contrary, by buying only what we need, we are looking to the future with our eyes wide open fully expecting the technology to out-pace our needs. The money saved now can be applied to the next iteration of network attached storage in two years.

Plan (continued)

The Backup Plan

The nature of an image file is static. Unlike Word documents that might be updated daily thereby necessitating a nightly backup, once an image is stored, an image file will remain unchanged. Therefore an initial backup followed by a weekly backup is sufficient. While the easiest backup solution is simply to pay the \$6,700/year for the university backup, I feel it is in the best interest of the department to explore options that may be more labor intensive, yet less expensive.

The BTP wisely includes two USB ports for the user to attach external hard drives specifically for backup purposes. By backing up to local external hard drives, restore time would be much faster: hours instead of days. Therefore, I propose the purchase of two 500 gigabyte external hard drives (Iomega ~\$380 ea.) to backup the BTP data directly to these drives (Figure 2). Remember that we currently only have 834 gigabytes of images so two external drives will be sufficient for now. To take this solution one step further, I propose that the external hard drives with the data from the BTP be attached to the DeSC computers once a week to receive an additional backup. Again, the DeSC computers receive free backup, so we would be circumventing the OIT fee by using DeSC computers to backup the external drives. This way the data would be stored in a different physical location than the original data, satisfying the criteria for a backup to be located off-site. While this solution requires more effort, the effort is minimal and will decrease the downtime when a BTP fails.

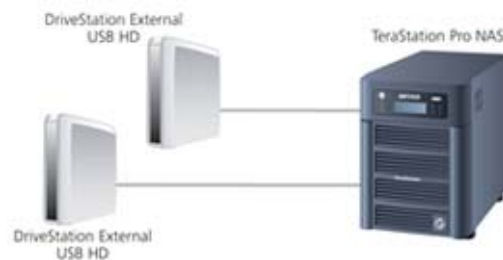


Figure 2: Backing up to external hard drives

Plan (continued)

Fault Tolerance

It is worth explaining here a little about fault tolerance. The BTP actually allows for storage of two terabytes of data. However if one of the four hard drives in the BTP fails, it must be replaced and the data it contained must be restored, which, as stated above, takes days over the network and hours when using an external USB hard drive. Luckily, the BTP also includes a fault tolerant configuration called "RAID 5". RAID 5 will store all the data on three of the BTP hard drives and use the fourth hard drive for parity information. If one of the three drives fails, a simple replacement can be made and the parity drive will immediately restore the data onto the replacement. If the parity drive fails, simply replace it and the parity information will be rewritten based on the files of the other three disks. Figure 3 illustrates the different possible configurations available on the BTP, including my suggestion, the RAID 5.

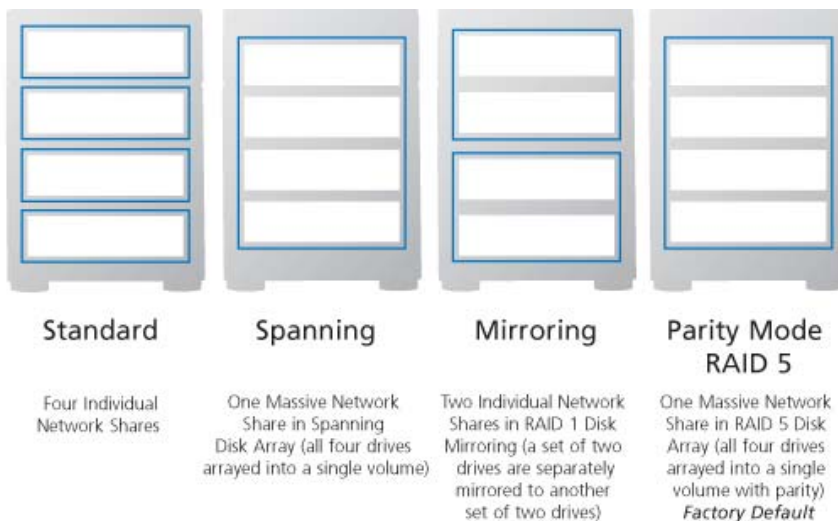


Figure 3: Possible Buffalo Terastation Pro 2.0 Configurations

Planning for Failure

Although we are not hoping for failure, we are planning for it. We are planning for failure on several levels. The first level of protection is the RAID 5 configuration. The second level is the backup to external USB hard drives for a quicker restore of data. The third level is attaching the external USB drives to DeSC computers for free off-site backup through the network using OIT. Even if the Visual Resources Director, Trudy Jacoby, decided to pay the \$6,700/year for the OIT backup, it would still be in the best interest of time and productivity to utilize the local backup to the USB external hard drives in order to minimize restore time.

Assessment

Advancements in Technology

The most important aspect of this project is that of the fast pace of technological advancements. What we buy today will be obsolete in a very short time. I am predicting that the BTP will get us through two years before the next iteration of storage solutions is both available and affordable. Each month I intend to research the internet for the current state of terabyte storage solutions.

Tracking the Growth Rate of Storage Needs

With that in mind it is imperative that we track our pace of adding images to the BTP. Visual Resources currently catalogs images using the homegrown Access database application called Pictor. Currently Pictor reports the productivity of the staff with a simple query that counts the number of records added by each staff member in several different categories. I propose that we build a similar query that will specifically track the number of digital images that are created and catalogued each month. I will sit with Trudy Jacoby monthly and evaluate the BTP storage solution using these statistics.

Monitoring the Backup

Further, I will implement the backup procedures as well as document the method and train the staff on how to backup to the USB external hard drives. The usability of the documentation will be tested by the staff and adjusted accordingly based on their comments. The real test of the backup procedure will come when the BTP fails. At that point I will thoroughly document the probable causes of failure as well as the steps taken to restore data.

Communicating

Trudy Jacoby and I already meet weekly to discuss Visual Resources issues. We will keep the BTP on the weekly agenda noting any issues and idiosyncrasies. Further, we will reevaluate the solution every June. Part of that reevaluation will include communicating with other universities to not only share our method of storing digital images, but also to find out if others have come up with better methods. In the short communications I have already had with other universities, I have come to realize the need for an industry standard. Every Visual Resources section nationwide has the same problem with digitized storage. It is a waste of time for each one to investigate and implement different solutions. A long range plan that is posted on the Visual Resource Association website is needed to guide the industry and simplify the issue.

Personnel

Julie Angarone, Computer Support Specialist

On the surface this proposal is for computer equipment, and as such I, Julie Angarone, will be the main person involved in implementing the equipment. I will purchase, receive, set up, and maintain all of the equipment

Trudy Jacoby, Director of Visual Resources

However, this proposal is about more than equipment. It is about centralizing digital images in order to increase productivity. The Visual Resources Staff will be able to store and retrieve images faster if they all know exactly where to put them. To that end, the Visual Resources Director, Trudy Jacoby, will dictate the organization of the files and she will be deciding on naming and grouping conventions. This aspect is necessary in order for the equipment objectives to be successful.

David Connelly, Photographer and Digital Image Specialist

David Connelly is the photographer and digital image specialist. He creates the digital images, either by scanning slides, or using a digital camera to photograph images. David is responsible for getting the images from his computer to the BTP for storage. He will be following Trudy Jacoby's conventions as stated above and will be responsible for alerting the staff when new courses or collections have been added to the BTP.

Visual Resources Staff

The Visual Resources staff is in effect our "end-users" and as such play an integral part in this solution. They will be the ones using the BTP daily and will be given the opportunity to report the success and failures they experience.

Budget

Buffalo Terastation Pro NAS 2.0 **\$2,000.00**

The Buffalo Terastation is the heart of this proposal. It fulfills all of our requirements in that it is small in size, it gives us ample storage space for the images we have now and in the near future, it is easy to install, manage, backup, and is inexpensive.

Extended Service Contract **\$150.00**

The Buffalo Terastation comes with a one year warranty whereas the extended service contract covers parts and service for an additional two years.

(2) 500 Gigabyte USB External Hard drives @ \$400.00 each **\$800.00**

The external hard drives will be used for a weekly local manual backup of the Buffalo Terastation and then will be attached, also weekly, to the DeSC computers to backup to OIT .

Belkin 10-Outlet SurgeMaster Gold Series Surge Protector **\$50.00**

All computer equipment is susceptible to power surges which might result from fluctuations in power or even lightning. This surge suppressor will protect the Buffalo Terastation from these fluctuations.

Annual Administration Cost **\$3,000.00**

Visual Resources is currently funding 5% of Julie Angarone’s salary for computer support. The research for this proposal will not end after the purchase of the Buffalo Terastation. Every June Julie will be reevaluating the present state of image storage and comparing it to the available technology as well as the storage solutions employed at other universities. In addition, backup, maintenance, and troubleshooting of the Buffalo Terastation will be Julie’s responsibility. It is appropriate to fund an additional 5% for a total of 10%, or an increase from \$3000 to \$6000 annually.

Total Cost for Year One **\$6000.00**

Note that \$6,700 for OIT backup is not included here. It is expected that the solution outlined will alleviate the need to pay this fee.

Timeline

Preliminary Research

- | | |
|---------------|--|
| May 30, 2006 | Meet with Trudy Jacoby, Director of Visual Resources to discuss her storage needs and funding possibilities. |
| June 2, 2006 | Complete Funding Analysis. |
| June 12, 2006 | Consult with CDWG vendor for price and extended service information |
| June 12, 2006 | Complete Pre-proposal. |
| June 26, 2006 | Complete Proposal. |

Submission and Approval

- | | |
|----------------|---|
| September 2006 | Submit proposal to Visual Resource Committee (VRC). |
| September 2006 | Upon approval by the VRC, purchase equipment. |

Implementation

- | | |
|-------------------------|---|
| October – November 2006 | Put equipment in place, transfer current images to BTP, test and document backup procedures, give access and training to Visual Resource Staff. |
| December 2006 | Evaluate procedures and report status to the Visual Resource Committee |
| April 2007 | Update Computer Administrator's job description to include responsibility for the BTP |
| June 2007 | Research current state of the art including new storage technology and best practices at other universities. |

Conclusion

Digital images are relatively new to university visual resources collections nationwide, perhaps even worldwide. The sticking point to finding a one-size-fits-all solution is not the money. It is the technology. An ever-changing world with technological innovations occurring faster than typical visual resources staff can determine current and future needs makes it difficult to commit large sums of money to any permanent solution.

There is no end in sight to how many images we will want to store. Neither is there an end in sight to how many terabytes will eventually be available in a small, inexpensive, manageable solution. . What is good news is that as technology in storage size increases, price decreases. That fact alone makes it prudent to buy only what we need when we need it.

The best we can do is to plan for what we have now and only a year or two into the future. As such the BTP outlined in this proposal is the perfect solution for our needs. I am confident that you will agree with me and look forward to moving forward to implement this solution.

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