Disk to Disk Data File Backup and Restore.

Implementation Variations and Advantages with Tivoli Storage Manager and Tivoli SANergy software

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September 26th, 2001

Data backup procedure.
Data file backup has historically been performed by copying data from the disk being backed up to a data tape backup device. Many times this is accomplished by simply connecting a data tape backup device directly to the computer that needs to be backup up. A data copy is made at a point in time and moved from the disk to the tape by the host computer.

For small numbers of computers, manually accomplished backups like this are relatively simple. But for large numbers of computers, many of which must remain up and running with full processing power available to their applications twenty four hours a day, this method can get a bit cumbersome. For people with many computers, a data backup/restore application program makes backups even easier.

With multiple computers need their data files backed up, many times it’s easier and more convenient to use a single data tape device connected to one host computer – a centralized backup device. With centralized backup devices, there are two ways to configure backup programs

1. Distributed Backups – Each computer that needs to be backed up runs a copy of the backup program which makes each of them a “backup server”. Then, one-at-a-time, on each computer, the backup application can be started to copy the required data across the network to the centralized tape device. Or vice versa.
2. **Centralized Backups** – Only the computer with the tape device runs the backup application making it the only “backup server”. The backup program then reaches out across the network to the other computers, the “backup clients”, that need to have their data backed up. The advantage of this approach is that a regular schedule for backups can be developed that allows the backups to occur automatically. The backup server then one-at-a-time, reaches out to each computer across the network and backs up its data.

### The bottlenecks.

If a single computer is handling all the backups, as in the “Centralized Backup” example above, it will obviously be a bottleneck. But depending on the speed of the processor and amount of memory in that computer, there are a few other bottlenecks that will be reached long before nearly any backup server runs out of horsepower.

Data tape devices are typically not as fast as the disks they are backing up. An average disk today can maintain a “read” bandwidth of 15MegaBytes per second (MB/sec) or more. “Writes” are usually about half the speed of “reads”. Only the fastest tape drives can keep up with 15MB/sec. A typical disk array used on most servers will maintain closer to 50MB/sec or more. Therefore depending on the size of the data being backed-up and the amount of memory available on the computer involved, the backup process must hesitate often to wait for the tape to catch up. This increases the individual backup “window” for each computer being backed up and for the entire backup cycle for any number of computers.

Of course the easiest way around this is to simply provide more data tape backup devices for simultaneous use. Two devices will cut your backup window in half. This way, two computers can back up their data to two separate tape drives at the same time. Four tape drives will allow four computers to do backups at the same time, effectively cutting the total backup window down to one quarter of the time it would have taken with one tape drive. But be aware that if enough tape drives are connected to just one computer, that computer may then become the speed bottleneck.

But more likely, the network is the next bottleneck. The typical corporate computer network is many times slower than the typical disk drive. A 100BaseT Ethernet LAN will usually yield little more than 5MB/sec of throughput. The theoretical maximum is only 12 MB/sec. So even with the fastest data tape drive and a slow disk, both will be waiting to get data through the LAN. Multiple tape drives won’t do much to help. Especially if they’re all connected to the same computer with only a single network connection.
A faster LAN will help. Gigabit Ethernet (GigE) will occasionally hit speeds of 30MB/sec – twice as fast as any single disk or tape drive, again making the tape drive the bottleneck. But the CPU power required to pump data over the network at that speed can rob the application running on the computer of a large percentage of its performance. LAN data protocols are notoriously CPU intensive. Think of the times your cursor is reduced to jumping across the screen while downloading something big from the LAN. The same thing happens to a powerful server running a mission-critical application while transferring data over the LAN.

As an example of a typical backup window, if twenty computers create or change a total of 20 Gigabytes of business-critical data every day (1 Gigabyte each), those 20 Gigabytes of data should be backed up everyday. If your network connection is the bottleneck on your system and it's capable of only 5MB/sec, it will take a minimum of 67 minutes to backup all 20 Gigabytes of data. That doesn't include the time required for tape setup and switching, and tape starts and stops which could easily bring that time to over two hours.

While two hours a day devoted to backups may be fine for some businesses, others have data backup needs that are an order of magnitude larger. 200 computers at 1Gigabyte of data each enlarge the raw data transfer backup time to more than 10 hours. Add in tape starts and stops and changes and that could again double to a little less than a full day. At that scale of backup, most people will want to find a way to eliminate their bottlenecks. The most common approach is to use a GigE network instead of 100BaseT Ethernet network. GigE, running at nearly 30MB/sec, would shift the smallest bottleneck back down to the tape device which is probably running at 15MB/sec. With that improvement, the backup window would be reduced to less than four hours for the raw data and less than eight with tape starts/stops and setups. With two tape drives running in parallel, the window is reduced to only four hours. With four tapes in parallel that time is reduced to two hours. But short of getting more tape drives, without a major change in backup methods, that's about as fast as it will get.
The bandwidth matching option using “Disk to Disk”.
A better method of planning for backups is to match the bandwidths of all the components involved—disk drives, network connection, and tape drives. Unfortunately, data tape drives will probably never be as fast as disk drives. So to better match bandwidths, backups can run from disk to disk. To do this, in addition to centralized tape drives for backups, add a centralized disk array for backups. Then backups of all the required computers are performed disk to disk over the fastest possible network connection. For a small incremental cost, this method provides a number of benefits not attainable with disk to tape backups.

1. **Faster backups** – the computer being backed up never needs to wait for the tape drive so backups are shortened. For small data files that would normally require frequent starts and stops of the tape drive, the speed improvement can be substantial. For large data files that normally stream to tape at full speed, the higher bandwidth of the disk shortens the backup window. From the computer’s point of view, once the data is on the backup disk, the backup is complete.

2. **Multiple simultaneous backups** – the backup disk array can be written to simultaneously by many computers so multiple computers can be backed-up at the same time shortening the entire backup window. No need for multiple tape drives running in parallel to speed backups.

3. **Offline recording to tape** – broadening of the backup-to-tape window allowing the migration of data from disk to tape to happen at a more leisurely scheduled pace. And eliminating the need for multiple tape drives to run in parallel. Since the primary backup to disk has already happened in the shortest amount of time possible, the secondary backup to tape can happen at a much slower pace.

4. **Much faster restore** – more than 90% of restores are requested within 48 hours of a backup. Just as backing up to disk is faster, restoring from disk is also faster. If the backup disk is large enough to hold two days worth of backups, 90% of restores will happen at disk-to-disk speeds.

In our example above, if the majority of computers being backed up utilized fast internal disk arrays running at 30MB/sec, and a GigE network connected those computers to a backup server containing a fast disk array also capable of 30MB/sec, the backup that took four hours when going to tape will now take less than two hours. But because of these high bandwidths traveling over GigE, high CPU utilization will result. And of course, while pumping 30MB/sec over that GigE network, most every other computer trying to use the network will find it extremely slow.
Offloading your LAN with a second LAN
If you can’t spare two hours of network downtime for all the computers connected to your network the obvious next step is to install a second LAN exclusively for backups (and other critical data movements). While this won’t speed up your backups (if you’re already using Gigabit Ethernet), or reduce your CPU utilization while the data movements are happening, it will free your primary LAN connection to make it available for normal data traffic.

Offloading your LAN with a SAN
If your servers cannot endure the few minutes of reduced CPU power every day that moving large amounts of data over a LAN will require, the final step is to again install a second network exclusively for backups and other critical data movements. Instead of using Ethernet or GigE, build this network out of Fibre Channel to create a Storage Area Network (SAN). The SAN connects multiple computers to centralized data storage devices. The use of centralized storage has been proven to save time and manpower and increase reliability and uptime.

SANs provide higher bandwidth than LANs
A SAN is a relatively new type of computer network that uses the same data protocol as your normal SCSI connection between computer and disks. While GigE would typically provide little more than 30MB/sec, SANs made out of 1Gig Fibre Channel regularly carry as much as ninety MegaBytes of data every second. SANs made out of 2 Gig Fibre Channel regularly carry 180MB/sec.

SANs use less CPU power than LANs
Counter-intuitively, Fibre Channel running at 90MB/sec or more requires only a tiny fraction of the power of any computer it runs on. While GigE running at 30MB/sec requires as much as 50% of the CPU power of even the fastest modern microprocessors, Fibre Channel running at 100MB/sec uses closer to 5% of nearly any CPU’s power. This leaves 95% of the CPU power available for use by the computer’s primary application.

A basic SAN is configured to provide each connected computer with it’s own disk volume(s) on centralized storage. If you have a hundred computers, the centralized storage device must be broken into at least one hundred disk partitions, each one formatted by the computer that “owns” it, with the file-system it needs.
In this respect, basic SANs are very different from basic LANs. LANs allow multiple computers, running various operating systems, to all access the same disk volumes and even the same data on those disk volumes, at the same time. Modern operating systems have evolved to the point where they incorporate a “distributed network file system” that allows this transparent sharing of storage resources across a network. Modern operating systems don’t know how to make Storage Networks do the same kind of heterogeneous storage sharing. So SANs are treated as if they were just another disk connection. Consequently SANs only allow each computer to get at its own disk volumes.

This is a problem for backups and restores using the disk-to-disk method. When performed across a LAN, multiple computers CAN get at the same disk volumes at the same time to deposit their backed up data. This ability provides one of the four advantages of disk-to-disk backup – parallel backups. A basic SAN does not allow this to happen. Instead, with a SAN, the permissions of which computer owns which disk volumes must be changed, one-at-a-time. Much like going all the way back to a regular LAN connection with just a single tape backup device.

**Tivoli SANergy software**

SANergy makes applications “think” they are still using just a regular old LAN when in-fact, they’re using the SAN for all large data movements. With Tivoli SANergy software running on all the SAN-connected computers, any SAN-connected computer can have access to the backup server’s disk storage via the SAN. With SANergy, multiple computers can access the same storage at the same time via the SAN.

**Hybrid distributed/centralized backup/restore via a SAN with TSM**

To take maximum advantage of this LAN-SAN fusion capability provided by SANergy, Tivoli Storage Manager (TSM) backup/restore software has been modified to remove the final bottleneck experienced by the largest networks – the backup server itself. TSM version 4.2 fuses the best of centralized data backup with the best of distributed data backup. Each computer connected to the SAN is both a backup client and a backup server. A single TSM server manages the schedules of backups and owns the database of backed up data, but each client has a data movement engine – the storage agent - that takes the burden of data movement off the TSM server. In this way, a single server never becomes the data bottleneck regardless of how much data from how many computers must be backed up.
For many organizations, standard networks and disk-to-tape backups are adequate. But for some networks, so much critical data is being created so often that more extreme measures must be implemented to keep the data available in the case of a hardware failure. Disk-to-disk backups and restores implemented via a SAN using Tivoli Storage Manager and Tivoli SANergy software provide:

- Faster backups from disk to disk
- Multiple simultaneous backups/restores from disk to disk
- Offline recording from disk to tape
- Faster restores from disk to disk
- Reduced traffic on the LAN – LAN-free - with a SAN
- Reduced CPU utilization on all computers connected to the SAN
- Reduced workload on the Backup Server with a SAN

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