Direct Attached Storage (DAS)

Module 3.1
Direct Attached Storage, or DAS, is the most basic level of storage. DAS devices either reside as an integrated part of the host computer (e.g., hard drives, removable storage devices, etc.) or directly connected to a single server externally (such as RAID arrays or removable media). As the first widely popular storage model, DAS products still comprise a large share of the installed base of storage systems in today's IT infrastructures. In this module, we will look at what DAS is, its components, management issues, and the challenges that DAS presents.
What is DAS?

For the purposes of this module DAS is defined as directly attached storage without the introduction of FC network connected systems, which will be discussed in a later module.

One of the features of DAS is that the storage resources are dedicated only to the hosts that are using them. This allows for bottlenecks to storage to be alleviated by adding resources only to pathways that require them. The storage within the array remains partitioned between the systems using the storage (i.e., the data on the devices assigned to the servers/clients is dedicated to the use of that specific directly attached server/client only).
**DAS Benefits**

- Ideal for local data provisioning
- Quick deployment for small environments
- Simple to deploy in simple configurations
- Reliability
- Low capital expense
- Low complexity

Internal DAS is a viable option for small environments because it is relatively easy to deploy and inexpensive in simple configurations.

External DAS is ideal for localized data connectivity in environments with a single host or a few hosts. For example, small businesses or departments and workgroups that do not need to share information over long distances or across an enterprise.

Small companies traditionally utilize DAS for data serving and email, while larger enterprises may leverage DAS for mission critical application data in a data center environment.

DAS also offers ease of management and administration since it is either handled by:

- The server/client’s OS (for internal DAS)
- A management interface to the intelligent array housing the storage (for external DAS).
The physical elements of DAS include:

• CPU
• Connectivity
• Storage devices

There are many options for each of these elements as shown.
DAS Connectivity

Block-Level Access Protocols:

- ATA (IDE) and SATA
  - Primarily for internal bus

- SCSI
  - Parallel (primarily for internal bus)
  - Serial (external bus)

- Buss and Tag
  - Primarily for external mainframe
  - Precursor to ESCON and FICON

Logical attributes of Direct Attached Storage (DAS) include the use of block-level access protocols such as ATA (IDE) and SCSI.
In internal DAS architecture, the storage devices are internally connected to a host computer via a physical bus.

The physical bus has distance limitations. These limitations are overcome by using a parallel protocol to give faster access to devices. Note: This also results in less voltage utilization (less heat).

Most internal buses have a limited number of devices which they can support.
The slide illustrates some common internal bus connectivity cables for devices. Notice that a serial connectivity bus requires fewer strands than a parallel cable due to the serial nature of the protocol. This reduces the number of data pathways, which generally means that less data per second can be transferred.
External DAS connects the client device to the external storage device directly via Fibre Channel or other hard connection.

External DAS overcomes the following limitations:

- Internal space of host
- Number of devices that can be connected
- Some distance limitations

External DAS also:

- Allows for centralized management of storage devices
- Facilitates repair and maintenance
- Easier to swap components due to facilities offered by the array.

Note: The Host Bus Adapter (HBA) could be one of many adapters supporting many differing protocols, (e.g. SCSI, FireWire, Serial ATA, USB, etc.).
**DAS Management: Internal**

- Host provides:
  - Disk partitioning (Volume management)
  - File system layout
  - Data addressing

- Direct Attached Storage managed individually through the server and the OS

Internal DAS is generally managed through the host and OS or by some third party software. Device management provides many features including:

- Disk/volume partitioning/management
- File system specific layouts for the OS
- Data addressing for storage and retrieval of data
A key feature of external DAS management is that the host OS is not directly responsible for any fundamental management of the resources (e.g. LUN creation, filesystem layout, and data addressing).

External DAS also introduces the option of multiple pathing to storage resources, although some high-end hosts do offer this internally as well. Internal multi-pathing is more susceptible to system failure. External multi-pathing may be more resilient, depending upon the specific host failure. An additional feature of multi-pathing to storage is the ability to load balance I/O to improve data transfer.

A primary cost component for businesses today is managing a multi-vendor storage infrastructure and the data on that infrastructure. Multi-vendor internal DAS storage must be managed individually and by placing the majority of storage externally on single vendor arrays, management becomes more centralized and skill sets required for multi-vendor management can be reduced.
DAS Performance Considerations

Factors to be considered for DAS performance:

• Hard disks
• Memory cache
• Virtual memory (paging)
• Storage controllers
  • Protocol supported (e.g. SCSI, FireWire, USB, etc.)
• RAID level
• Bus

The following may impact DAS performance:

• Hard disk – Seek time and rotational latency impact performance. The block layout of the stored data also impacts performance with respect to fragmentation.
• Virtual memory – Paging to disk can slow system due to resource contention (i.e., the virtual memory process competes with applications for disk resources).
• Storage controller - Controller cache can improve performance. However increasing the number of cache locations can lead to data loss in the event of a disaster if failsafe mechanisms are not implemented at all levels. The type of protocol/interconnectivity must also be taken into consideration for the application.
• RAID level – Based on the application workload profile, i.e. percentage of read I/O and write I/O, the RAID level can adversely impact performance.
  – For example, in RAID 5 there is a write penalty, so it may not best for applications that require frequent sequential writes.
• Bus - Higher throughput speed provides better performance, but the distance may exclude specific buses from consideration.
The motherboard here has an embedded HBA with an IDE bus connector for the cable connection. The cable is attached to this connector. The hard disk is then attached to the other end of the cable.
Here is an example of the elements that can be used in an external DAS implementation.
**DAS Challenges**

- Hosts must be directly connected
- Data availability
- Data slowdowns possible
  - CPU congestion, caching, multi-pathing
- Scalability is limited
  - Number of connectivity ports to hosts
  - Number of addressable disks
  - Distance limitations
- Downtime required for maintenance

DAS poses several challenges:
- Hosts must be directly connected.
- Data availability:
  - Many single points of failure (i.e., bus, multiple path software, host, application, etc.). There is no redundancy or fault tolerance for the existing system.
  - Inability to share data or unused resources with other hosts simultaneously.
- Scaling is simply a matter of adding more LUNs to the servers attached to the array.
  - The host’s hardware limitations restricts the amount of growth that can be accommodated. For example, the number of ports available on an external array and number of hosts that can be actually connected to an internal bus is limited.
  - Both internal and external DAS have a finite bandwidth available for data I/O to the attached servers. When capacities are being reached, data availability may become compromised. This will have a ripple effect on the performance of all the hosts attached to that specific device or array.
  - Distance limitations of the medium used for connectivity will determine feasibility.
- Due to the fact that devices are directly attached to the systems, there are few if any server implementations that will allow for drastic device reconfiguration, addition or removal of systems drives, new HBA insertion or removal, etc. without having to first power down the host. This makes scheduled downtime planning and storage provisioning necessary.
**Module Summary**

Key points covered in this module:

- **DAS can be:**
  - An integrated part of the host computer
  - Directly connected to a single server

- **DAS is made up of a CPU, connectivity, and storage devices**
  - There are several options within each of these categories

- **DAS connectivity uses block-level access protocols**
Check Your Knowledge

- What are the physical elements of DAS?
- Give an example of when DAS is a good solution.
- Describe internal DAS connectivity.
- Describe external DAS connectivity.
- What are some areas that you need to consider as part of DAS management?