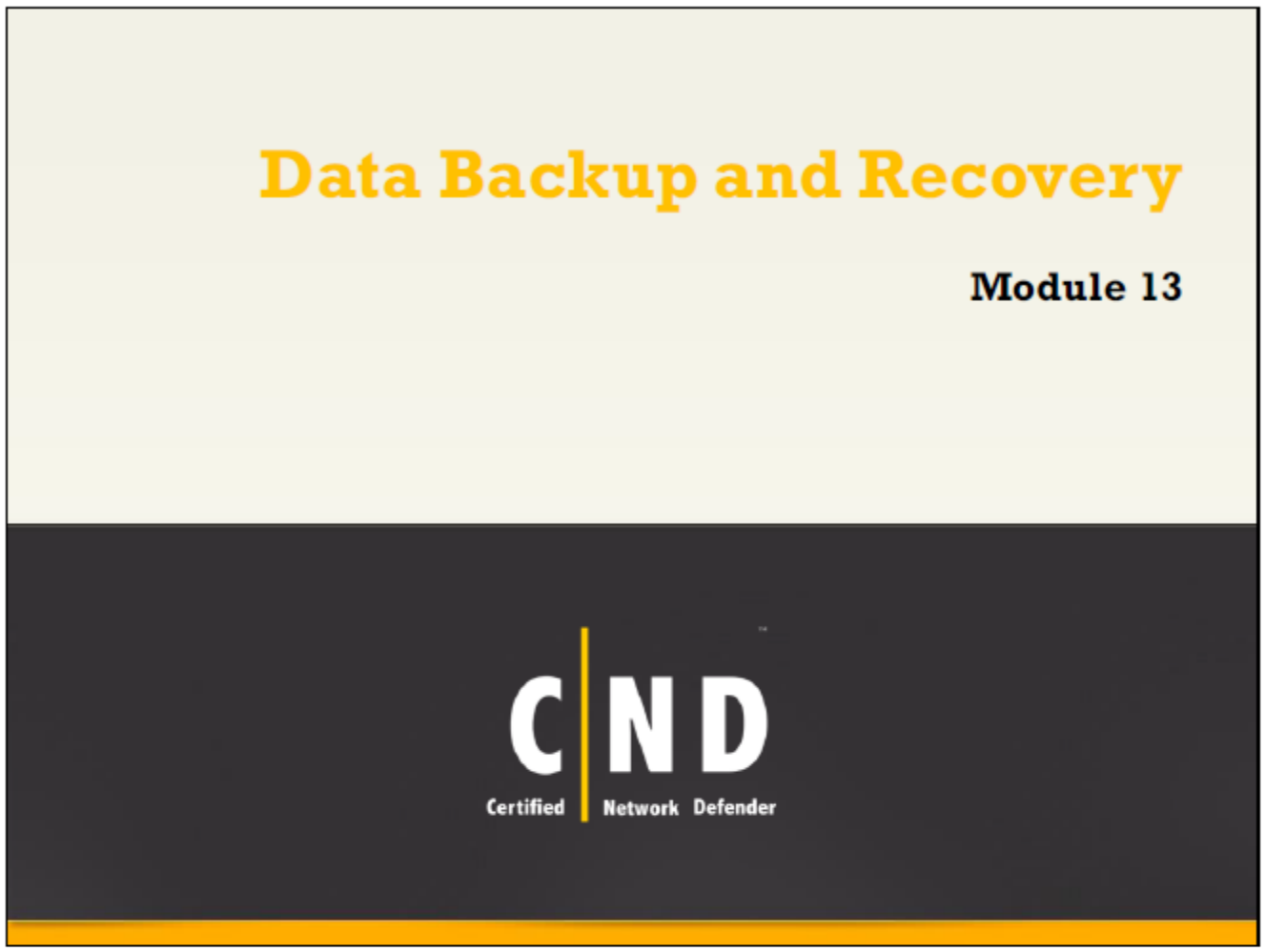
Data Backup and Recovery

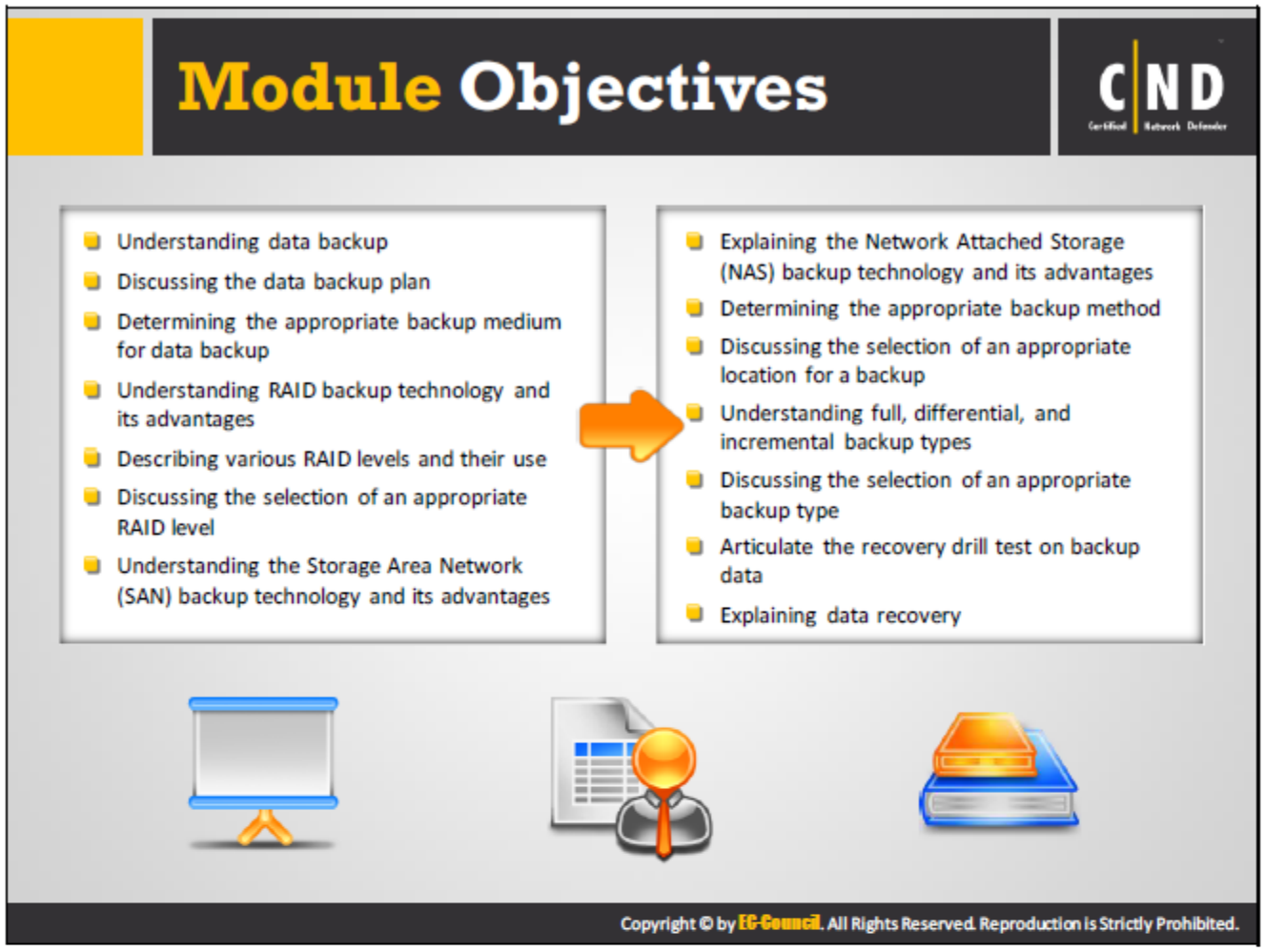
Module 13



Certified Network Defender

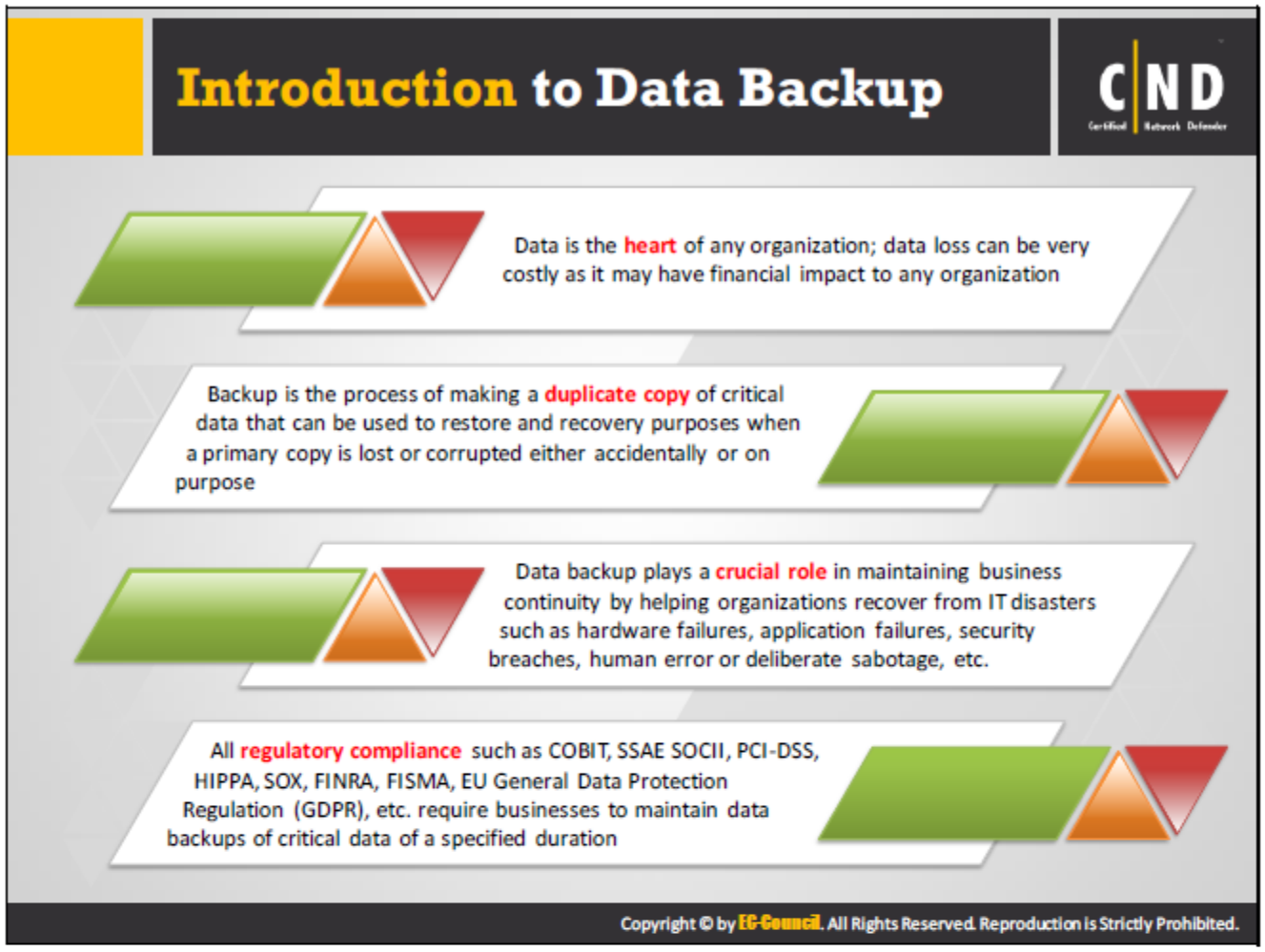
Module 13: Data Backup and Recovery

Exam 312-38



Data loss is a major risk facing organizations today. Loss of critical data can incur a lot of damage to the organization. Any organization that encounters a severe data loss has a higher probability for facing serious issues later. It is important to perform regular backups of the important data.

This module describes a detailed process for data backup and recovery. A network administrator is required to perform data backups for the organization on a regular basis. This module will help plan and perform data backups for the organization.



Data backup is the process of copying or storing important data. The backup copy will help you restore the original data when data is lost or corrupted. Backup is a mandatory process for all organizations. The process of retrieving the lost files from the backup is known as restoring or recovery of files.

The main aim behind data backup is to protect data and information and recover the same after data loss. Data backup is mainly used for two purposes: To reinstate a system to its normal working state after damage or to recover data and information after a data loss or data corruption.

Data loss in an organization affects the financial, customer relationship and company data. Data loss in personal computers may lead to a loss of personal files, images and other important documents saved in the system.

There are several reasons for data loss:

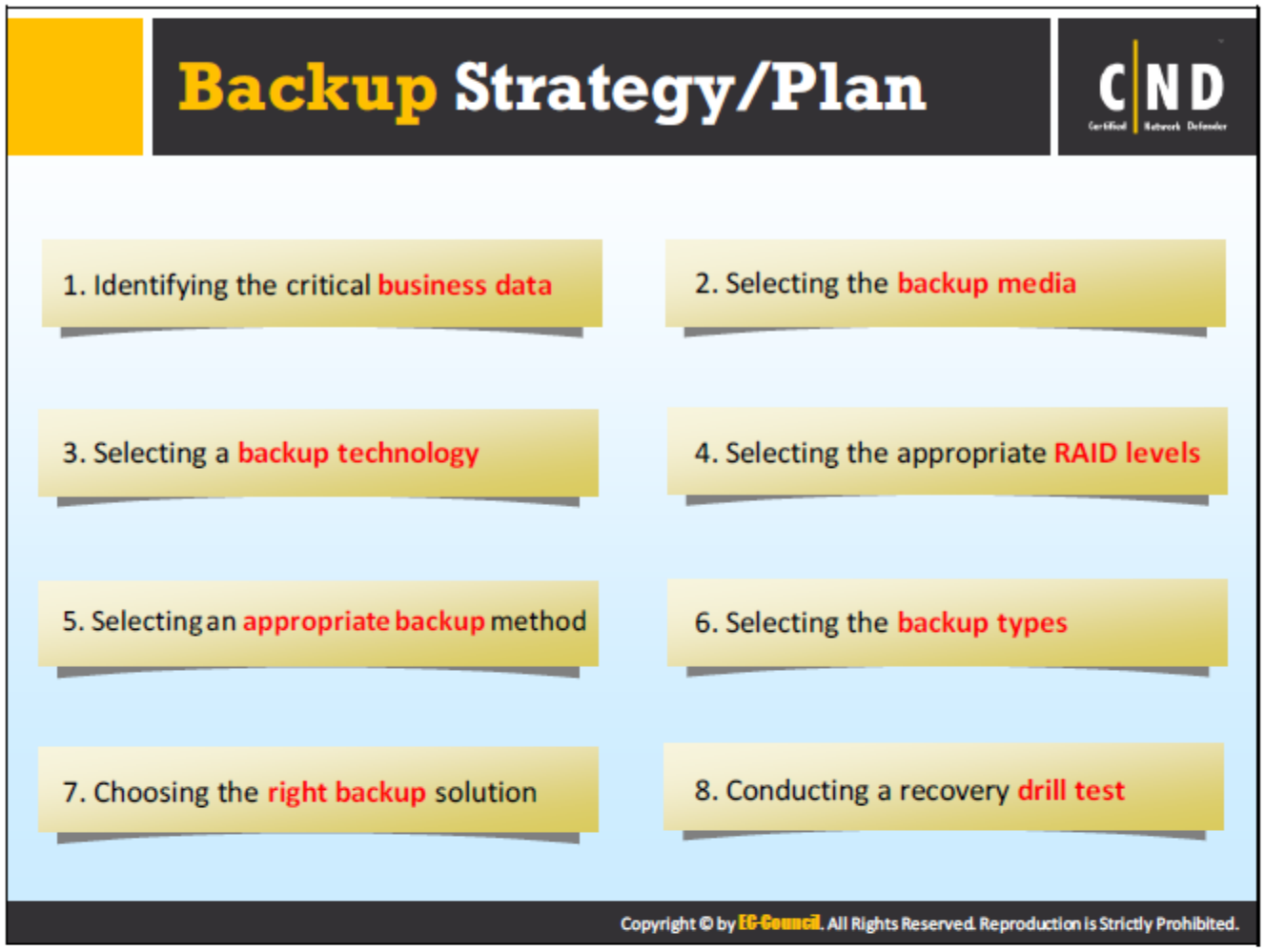
- **Human error**: Deletion of data purposefully or accidently, misplacement of data storage devices and errors administering databases.
- **Crimes**: Stealing or making modifications to critical data in an organization.
- **Natural causes**: Power failures, sudden software changes or hardware damage.
- **Natural disaster**: Floods, earthquakes, fire etc.

There are many benefits for performing a data backup:

- Offers access to critical data even in the event of a disaster, giving peace of mind in the workplace.
- Backup of critical data prevents the organization from losing its business. Helps them retrieve data anytime.
- Data recovery helps organizations recover lost data and helps maintaining their business.

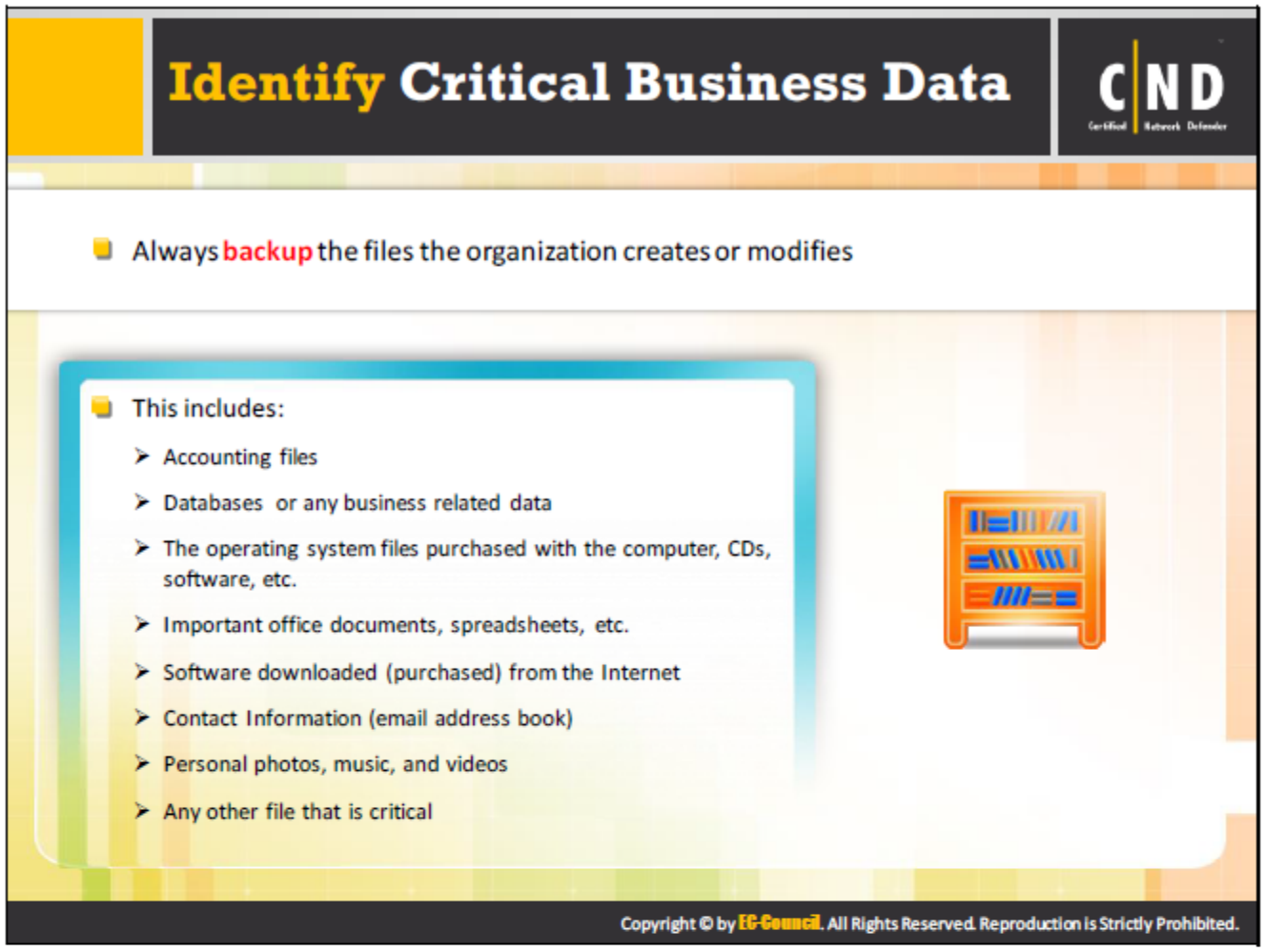
It is recommended that every organization perform a data backup on a regular schedule to run their business successfully and efficiently.

To avoid severe damage to the organization's assets, it is important to design a strategy for a successful data backup process. This data backup strategy will act as a blue print while working on the data backup process for the entire organization moving forward. Certain companies also create a data backup policy that is required while implementing the backup strategy.



An ideal backup strategy includes steps ranging from selecting the right data to conducting a drill test data restoration. Although the backup strategy might differ among the organization, it is important to consider the features below before drafting a backup strategy:

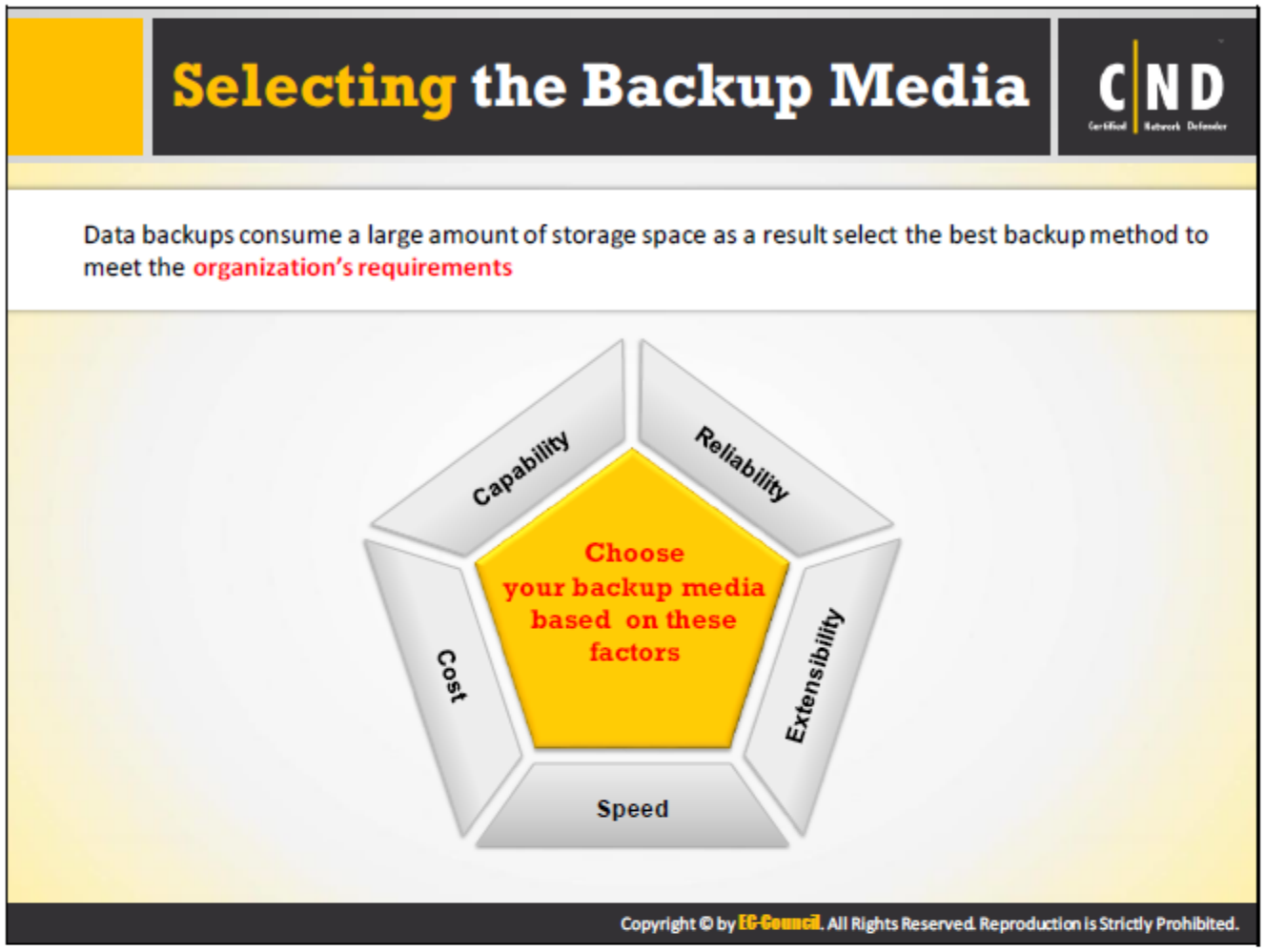
- The backup strategy should have a data recover feature from any external device. These devices may include servers, host machines, laptops, etc.
- If the data loss is due to a natural disaster, the backup strategy should not be restricted to only a certain number of incidents. The strategy should also cover the methods for recovering the data after a natural disaster has occurred.
- The strategy should include the steps to recover the data at the earliest stage.
- The lower the cost for data recovery, the more financial benefit to the organization.
- Auto recovery options should be included in the backup strategy as well, as they reduce the chances of human-error during the recovery process.



Every organization has an abundance of data. An organization should identify critical data or files that require backup. The criticality of the data is based on the importance it serves to the organization. It requires analyzing and deciding which information is more important to the organization functioning properly. The critical data consists of revenue, emerging trends, market plans, database, files including documents, spreadsheet, e-mails, etc. Loss of such critical data can affect the organization immensely.

Determining what is included in the most critical data:

- Organize a business impact analysis to determine the critical functions and data in an organization. They need to identify processes and functions that depend and co-exist with the critical data.
- Examining the documents and implementing them in order to recover critical business functions.
- Create business teams to evaluate the impact of what data damage would do to the business.
- Provide adequate employee training covering the strategies and plans for recovery.



Choosing the best backup media is a common concern within most organizations. The selection of the wrong media device leads to the segregation of data to many different media devices. With a better well thought out plan, selecting the proper media will enable a better level of data backup.

Once the data is identified, it is important to choose the correct backup media to store the data. Backup media selection depends on the type and amount of data the backup will consist of. At times, data backup consumes a large amount of space and as a result attention is required while selecting the best backup media for the situation and to fulfill the needs of the organization.

Choosing the best backup media is based on the following factors:

- **Cost**: Organization should have backup storage mediums that best fits within their budget. Backup media should have more storage space than the data that will be contained on it.
- **Reliability**: Organizations must be able to rely on the data stored on the backup media without fail. Organizations must select the media that is highly reliable and not susceptible to damage or loss.
- **Speed**: Organizations should select backup mediums which require a reduced amount of human interaction during the backup process. Speed becomes a concern if the backup process cannot be completed while a machine is idle.

- **Availability**: The unavailability of the backup medium poses as an issue after a data loss or data damage. Organizations should decide on a medium that is available all the time.
- **Usability**: Organizations should select the media that is easy to use. An easy media type has great flexibility during the backup process.

Backup Media

Media	Capacity	Advantages	Disadvantages	Illustrations
Optical Disks (CD, DVD, Blu-ray)	~200 GB	▪ Affordable, easy to store and transport	▪ Several manual disk swaps may be required due to the limited data capacity ▪ Recording and verifying backup is slow	
Portable hard drives/USB flash drives	No limit	▪ Relatively high storage capacity than using optical disks ▪ Ideal for the home or small office ▪ Recording backup is fast	▪ More expensive than DVD backups	
Tape drives	No limit	▪ Backup media for enterprise level ▪ Easy to store and transport	▪ Expensive	

Examples of media used for data backup are:

Optical Disks (DVD, Blu-ray)

DVD recordable disks can store up to 8.55 GB and are readily available. DVD's store more data and available at affordable rates, in bulk if need be. However, DVD's are not used as much as in the past, as external hard drives are available at reasonable prices and can store more data than DVD disks.

Blu-ray is compatible for use with both PC and consumer electronic environments. The data encoding feature in a Blu-ray allows more data storage.

- **Advantages**:
  - Less expensive and easy to store.
- **Disadvantages**:
  - Slow data storage.

Portable Hard drives/USB Flash Drives

Portable hard drives are considered a better medium for data backup when compared to a DVD or Blu-ray. They are available in high capacities and may be used for the smaller backup requirements. Flash drives are available in different sizes and have the ability to store large backup files.

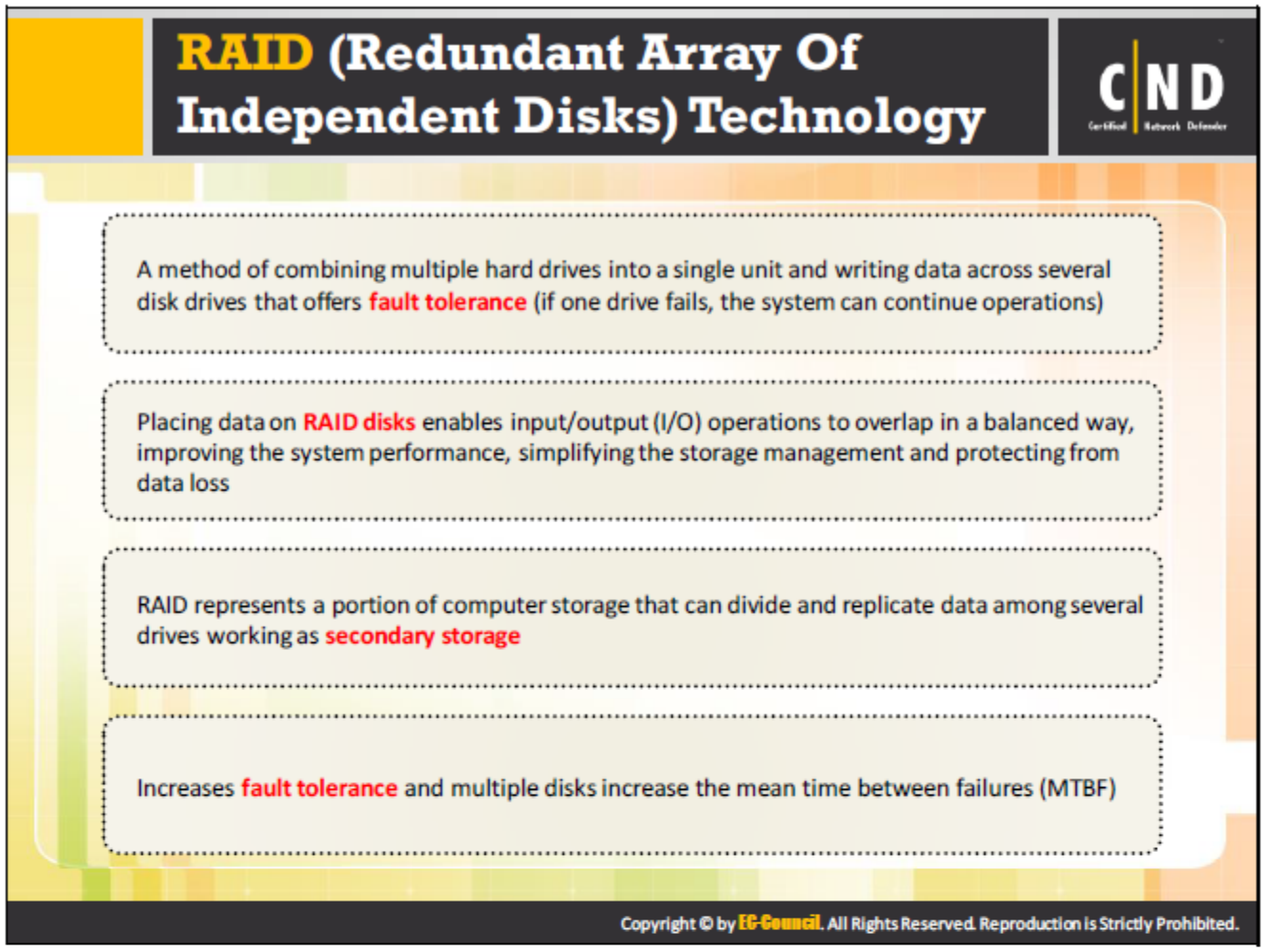
Another hard drive option available is RAID. It contains two or more hard drives. The second drive may be used to copy data stored in the first drive. This process allows important data to be preserved. Any change in the data will be automatically reflected in all other drives as well.

- **Advantages**:
  - High storage capacities.
  - Very high speeds.
- **Disadvantages**:
  - Expensive compared to DVD/Blu-ray.
  - Recommended less for small backups.

Tape Drives

The Tape drive is considered the best source of media for data backup. It facilitates data backup at the enterprise level. Tape drives are used for storing programs and data.

- **Advantages**:
  - Easy to store and transport.
  - Requires no user intervention
    - Tape backup is completely automatic.
- **Disadvantages**:
  - Very expensive for home users.
  - Home computers require additional hardware and software updates to use.



Many organizations depend on RAID technology for handling their critical backup needs. Especially with the increases in data flow and data volume. Organizations are expanding their networks in order to improve their productivity in the market. However, this additional increase can cause network bottlenecks. The probability of losing data due to a disaster, threats, mistakes and hardware failure hamper an organization's ability to grow. RAID technology overcomes these situations providing an option for data availability, high performance, efficient and accessible recovery options without a loss of data.

Understanding RAID technology

RAID technology is a method of storing data in different places on several disks. Storing the data on multiple disks improves the performance of the IO operations. RAID technology, functions by implementing multiple hard disks into one logical disk. It allows storing the same data in a balanced way across an array of disks. The effective implementation of this technology helps address the complex issues for fault tolerance. The data organized in RAID levels depends on the RAID storage techniques and installation methods used. Usually the implementation of RAID is done on a server. Personal computers do not necessarily need this technology, they can still setup and utilize it in a smaller environment than an enterprise.

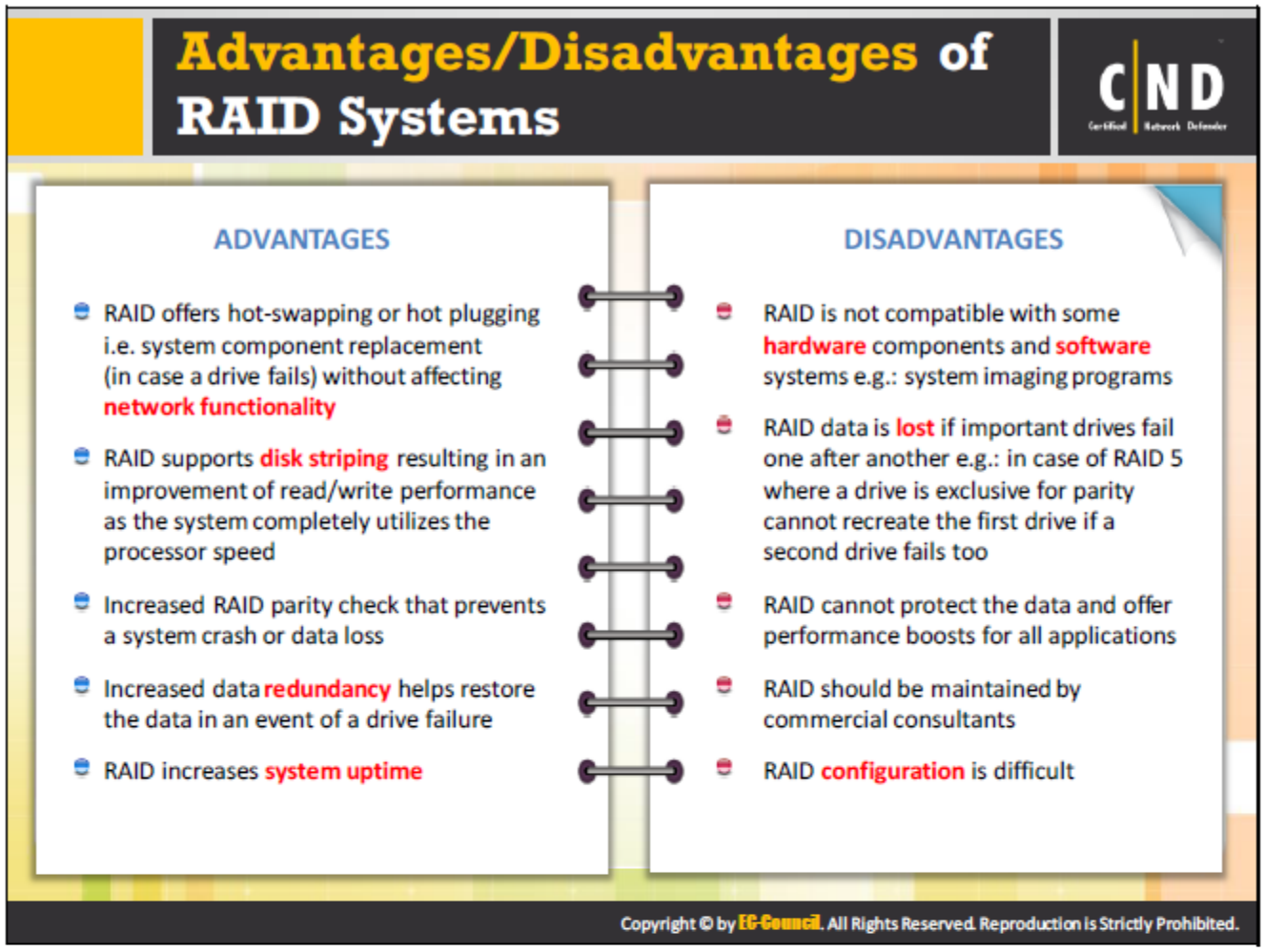
For RAID to function effectively, it has six levels: RAID 0, RAID 1, RAID 3, RAID 5, RAID 10, and RAID 50. Each level of RAID has the following features:

- **Fault-tolerance:** Fault tolerance is if a disk fails to work, other disks will continue to function normally.

- **Performance:** RAID achieves high performance during read and write processes across multiple disks.
- **Competence:** This is defined by the amount of data stored. The storage capacity of the disks depends on the particular RAID level chosen. The storage capacity does not need to equal the size of the individual RAID disks.

All the RAID levels depend on the storage techniques below:

- **Striping:** Data striping divides the data into multiple blocks. These blocks are further written across the RAID system. Striping improves the data storage performance.
- **Mirroring:** Data mirroring makes image copies of the data and simultaneously stores this data across the RAID. This affects fault tolerance and data performance.
- **Parity:** Parity uses a striping method to calculate a parity function of a data block. During drive failure, the parity recalculates the function using the checksum method.



Before RAID technology was introduced, many organizations used a single drive to store data. RAID technology is found across all storage devices in an organization. RAID has advantages and disadvantages depending on the RAID level implemented.

Advantages of RAID Systems

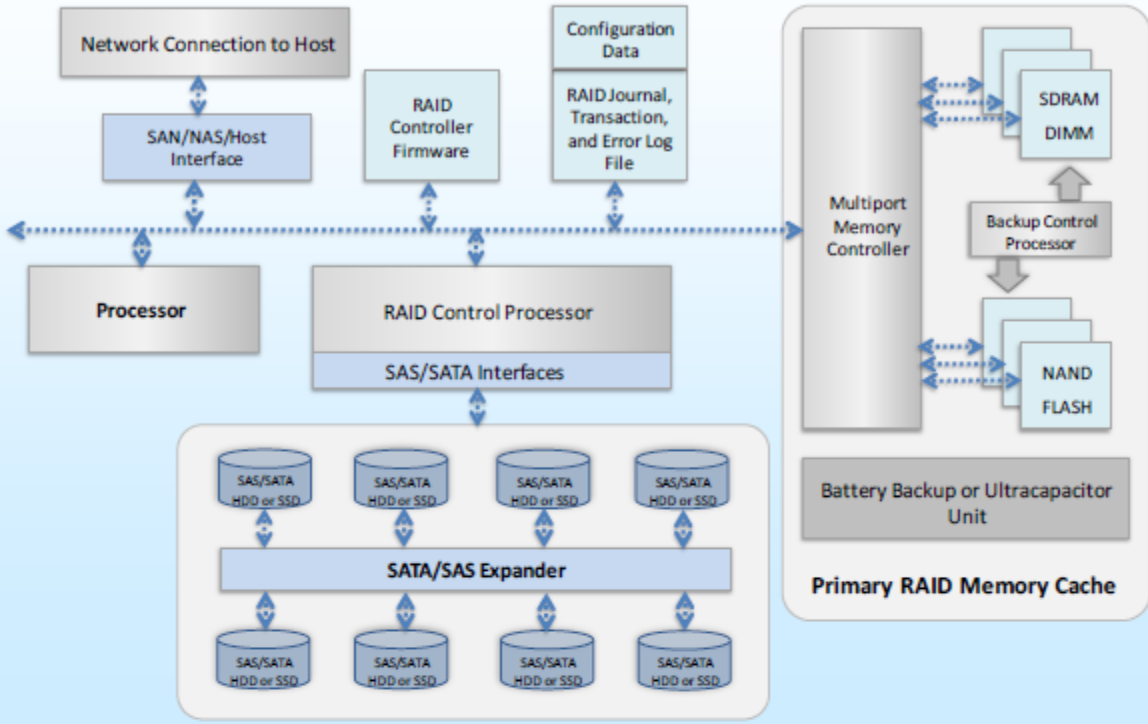
1. **Performance and Reliability:** RAID technology increases the performance of reading and writing the data on disks. The speed of the process is much faster than using a single drive as storage. It improves the performance by distributing the I/O. The RAID controller distributes data over several physical drives making sure not to overburden a single drive in the RAID system. RAID sustains the reliability of data even if a disk fails. The failed components can be replaced in a RAID system without shutting the system down. This feature is called Hot-Swapping. The replacement process does not affect how the other disks function or the network.
2. **Parity Check:** Parity check is a process where the RAID system compares the data stored in the crashed system with the data stored in the other disks. This check process is accomplished on all the drives. The parity check is performed after first mirroring the data. Regularly performing parity checks detects the probability of a system crash, preventing a loss of data.
3. **Data redundancy:** Failure of a disk can occur at any time. Data redundancy is important for the organization. RAID provides enhanced data redundancy in case of a hardware failure.

4. **Disk Striping:** Disk striping improves the read/write performance of the data. The data is divided into small chunks and spread amount multiple disks. Depending on the RAID level implementation, the data is divided in bytes, bits or blocks. Data reading and writing can be done simultaneously on a RAID system.
5. **System uptime:** This is a metric that detects the reliability and stability of a computer. System uptime defines the time the system can be left unattended without any assistance. Configuring RAID on a system helps enhance system uptime. A high system uptime in an organization signifies their productivity is high.

Disadvantages of RAID Systems

1. **Writing Network drivers:** RAID technology is designed so can be widely used on servers. The major disadvantage of RAID technology is the writing of all the network drivers. RAID technology is complex and this process can be time consuming.
2. **Non-compatible:** Different systems support different types of RAID drives. Certain hardware or software components may not be compatible with the RAID drive configured on the server. This non-compatibility may lead to the RAID not functioning properly. The compatibility between the RAID drives, hardware and software must be checked prior to configuring the system. RAID can protect data for all the applications available on the network.
3. **Loss of data:** The RAID drives function in the same environment. The drives can become non-functional due to mechanical issues. The potential data loss increases in if the disk failure occurs one after another. When two drives fail at the same time, recovering the data from the disk becomes difficult.
4. **Time consuming in rebuilding:** Drive capacity has increased much more than the transfer speed. Recovering data from large storage capacity drives can be time consuming. In such scenarios, rebuilding a failed disk can also be time consuming. Increasing the number of drives won't help increase the data transfer speed.
5. **Economically high:** Implementation of RAID technology can be economically high. Organizations need to hire consultants to sustain its performance. It also requires external RAID controllers and hard drives to function correctly and this adds to the overall cost to the organization.

RAID Storage Architecture



RAID Storage Architecture (Cont'd)

RAID Controller

Manages the array of physical disk drives and presents them to the computer as if they are logical units

Primary RAID Memory Cache

Cache is used to write the data in transition, A RAID system uses a cache to speed up I/O performance on the storage system

IDE, SATA or SCSI Interface

Internal drives are connected using these interfaces; Connection to the server is also through one of these interfaces

nvSRAM

nvSRAM is the fastest non-volatile RAM in the industry with 20 ns read and writes access time

Multiport Memory Controller

Provides access to a bank of memory, helps achieve high efficiency with random address accesses

NAND Flash Memory

Provides non-volatile storage for the RAID system's primary cache

SDRAM

Dynamic Random Access Memory (DRAM) that is synchronized with the clock speed the CPU

Disk

The hardware presents the RAID to the host system as a single and large disk

The RAID architecture depends on two principles: Redundancy and Parallelism providing a wide range of storage facility options with better performance and freedom from disk failures. The wide demand of the Internet has caused an increase in the use of RAID systems because of its high data storage capabilities and management systems. There are many implementations available for RAID depending on the application and these implementations depend on factors like: parallelism, duplication, and redundancy.

In RAID architecture, the switch receives the data from servers connected to the network. The switch sends the data to the processor at a later stage. The processor transfers the received data to the RAID controller. The RAID controller may be implemented either as hardware using a RAID-on-Chip (ROC) or in software. The ROC can contain the I/O interfaces, processor, host interface and memory controller. The ROC is installed directly in a motherboard using an expansion card or in an external drive enclosure.

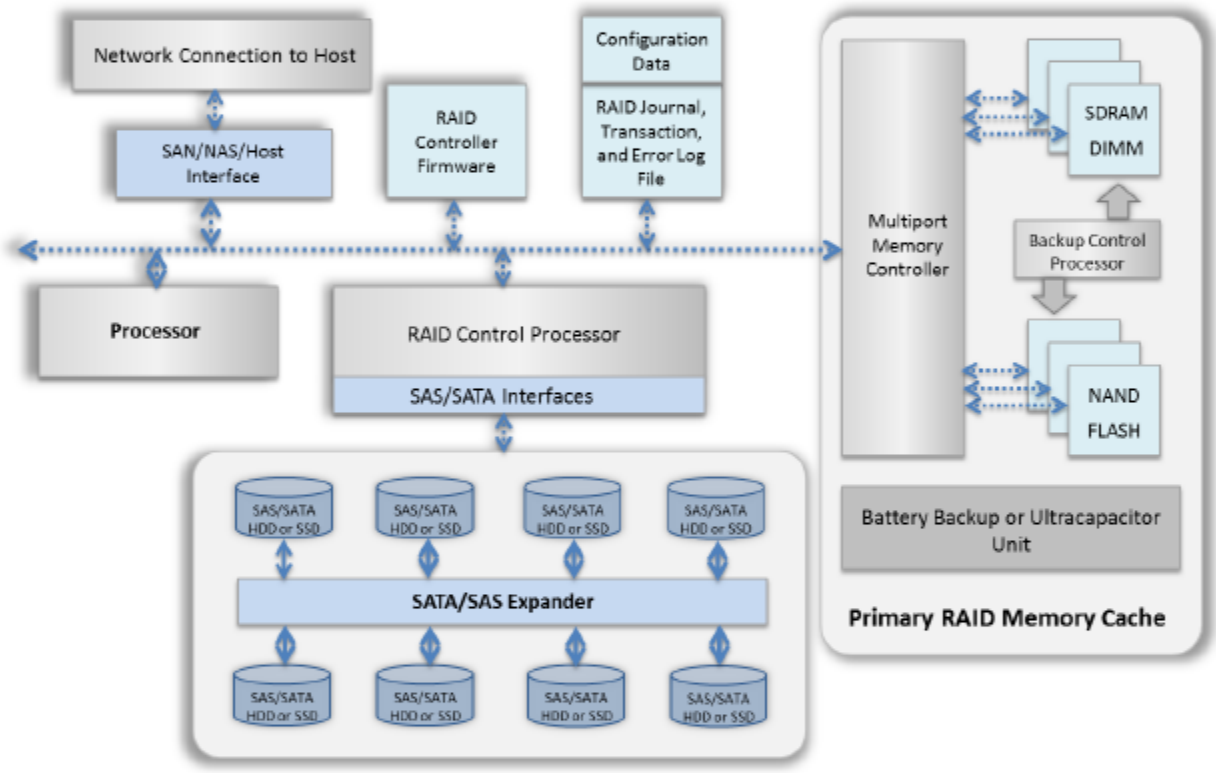


FIGURE 13.1: RAID storage architecture

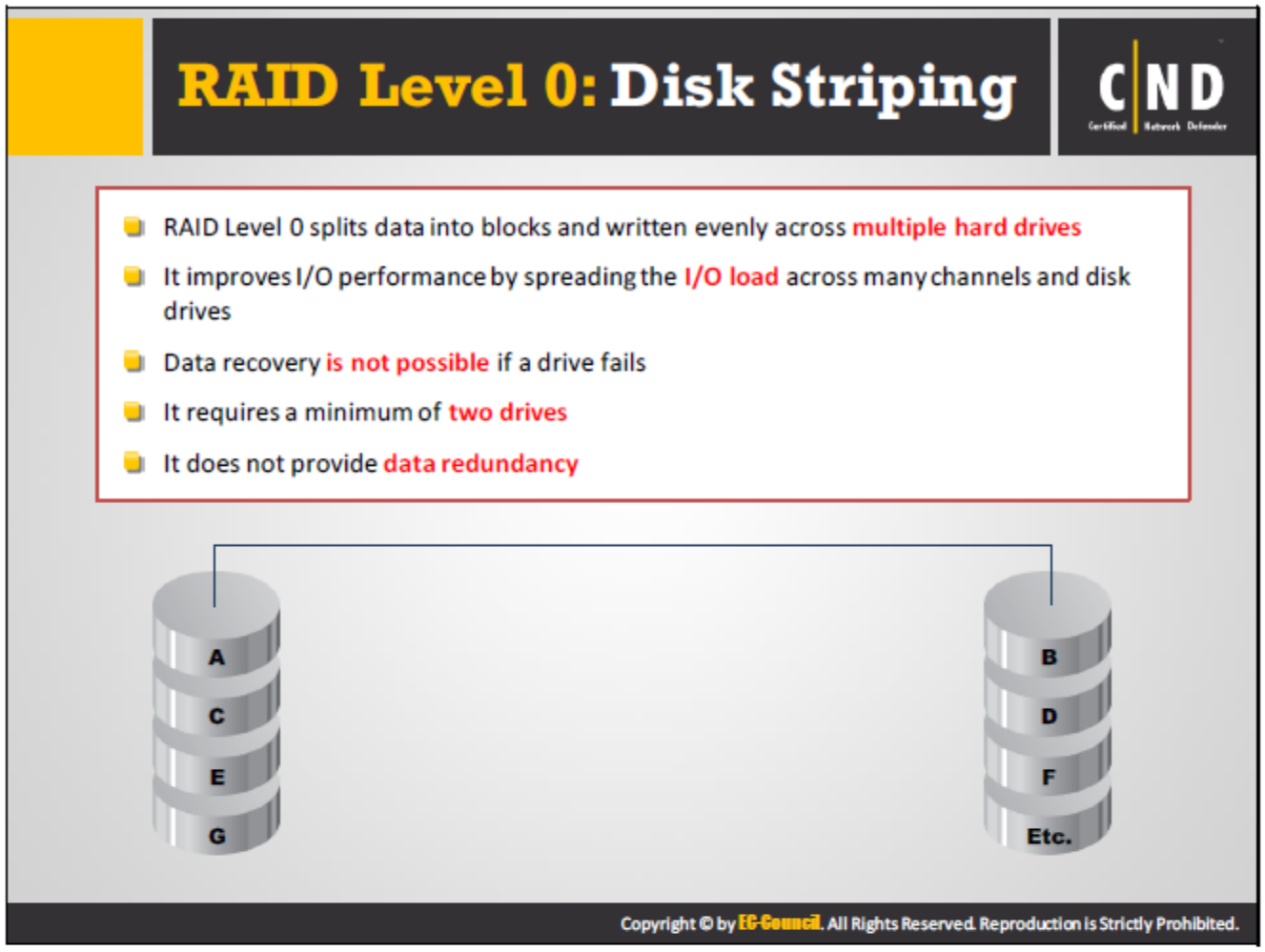
The RAID storage architecture outlines how the RAID server functions. The processor controls the entire function of the drive arrays and interfaces. It provides flexible and high performance functions. The architecture in the figure above shows a RAID system can depend on HDDs as well as SSDs. The processor requires DRAM and NAND flash memory. The installation of NAND flash memory provides non-volatile storage to the primary RAID memory cache.

A battery backup or an ultra-capacitor unit in the primary RAID memory cache is helpful when the RAID Control Processor goes suffers from a power failure. In this scenario, the battery backup independently copies the DRAM's contents to the NAND flash memory. A battery backup is an inexpensive alternative during a power loss. The architecture shows the requirement of non-volatile memory in the RAID controller firmware, RAID Journal, transaction and the error log file.

The major components of a RAID architecture include:

- **RAID Controller**: This is either hardware or software based and contains hard disk drives or solid state drives as a single logical unit. A RAID controller has permission to access multiple copies of files present on multiple disks, thereby preventing damage and increases the scope of system performance. In a hardware RAID, a physical controller manages the RAID array with a controller in the form of a PCI card that supports SATA or SCSI. A software RAID works similarly to a hardware RAID, except they provide less performance when compared to the former.
- **Primary RAID Memory Cache**: The RAID controller has direct access to the cache memory, enabling faster read and writes access to the storage system. The cache is used to store the changing data. Cache memory is bigger in size and uses high speed SDRAMs. A normal cache memory has a write cache and a separate read cache. The read cache decreases the latency for the read process. The write cache memory consists of two types:
  - **Write-through mode**: Writes data directly to the disk after the host sends the data, bypassing the cache memory. The host sends the next data item after receiving a confirmation the writing process completed.
  - **Write-back mode**: Data sent from the host is written to the cache memory. The host may perform other actions while the RAID controller transfers data from the cache to the disk drive. The RAID controller acknowledges the write process to the host soon after writing the data to the cache. Issues may arise if a RAID controller sends an acknowledgement before the data has been completely written to the disk.
- **IDE, SATA, or SCSI interface**: IDE, SATA, or SCSI are device cables that transmit signals to read/write to and from the drive. These are mostly used for connecting drives internally. Also, servers are connected using these interfaces.
  - **IDE**: Integrated Drive Electronics (IDE) allows the connection of two devices per channel. Normally used for internal devices as the cables are large and flat.
  - **SATA**: Serial ATA deals with hot plugging and serial connectivity. The hot plugging technique may be used to replace computer components without the need to shut down the system. SATA enables only one connection per connector and it is not flexible for industrial purposes.
  - **SCSI**: Small Computer System Interface (SCSI) allows multiple devices to be connected to a single port at the same time. SCSI uses a parallel cable for attaching internal and external devices.
- **nvSRAM**: Non-Volatile SRAM, nvSRAM has a faster read and write process due to the presence of a standard asynchronous SRAM interface. nvSRAM enables adequate data storage capabilities without the need for a battery during shut down. nvSRAM finds its best use in applications that require high speed and non-volatile storage at a low cost such as the medical industry. nvSRAM backups the data even in the event of a power failure.

- **Multiport Memory Controller**: A MPMC provides access to memory for up to eight ports. A memory controller can be present as a separate chip or as integrated memory.
- **NAND Flash Memory:** Flash memory is a storage medium designed from electrically erasable programmable read - only memory (EEPROM). NAND and NOR are two types of flash memory. The main aim of NAND flash memory is to reduce the cost and increase the capacity. NAND flash memory does not require power to retain the data. NAND flash memory has improved its read-write cycles with reduced voltage demands.
- **SDRAM:** Synchronous dynamic random access memory or synchronous DRAM is memory that is synchronized with the clock speed of the processor. This increases the number of instructions the processor can perform. SDRAM speed is measured in Mega Hertz (MHz). The memory is divided into several sections called banks that allow the device to operate on several memory access commands simultaneously.



Depending on the requirement of your organization, you can choose any RAID level available. RAID levels have a foundation for performance, fault tolerance or both.

RAID 0 deals with data performance. In this level, data is broken into sections and is written across multiple drives. The storage capacity of RAID 0 is equal to the sum of the disk's capacity in the set. RAID 0 does not provide fault-tolerance. Failure of one disk can lead to the failure of all the disk in a level 0 volume. The probability for recovering data from a RAID level 0 is minimal at best.

The data distribution in a RAID Level 0 is equal among all the disk sets, resulting in high performance. With concurrent high performance, the throughput of the read and write operation on multiple disks is equal to the throughput of the array of disks. Increased throughput is an advantage for RAID 0, considering data recovery is unavailable. Software and hardware RAID controllers support RAID 0, helping to boost server performance.

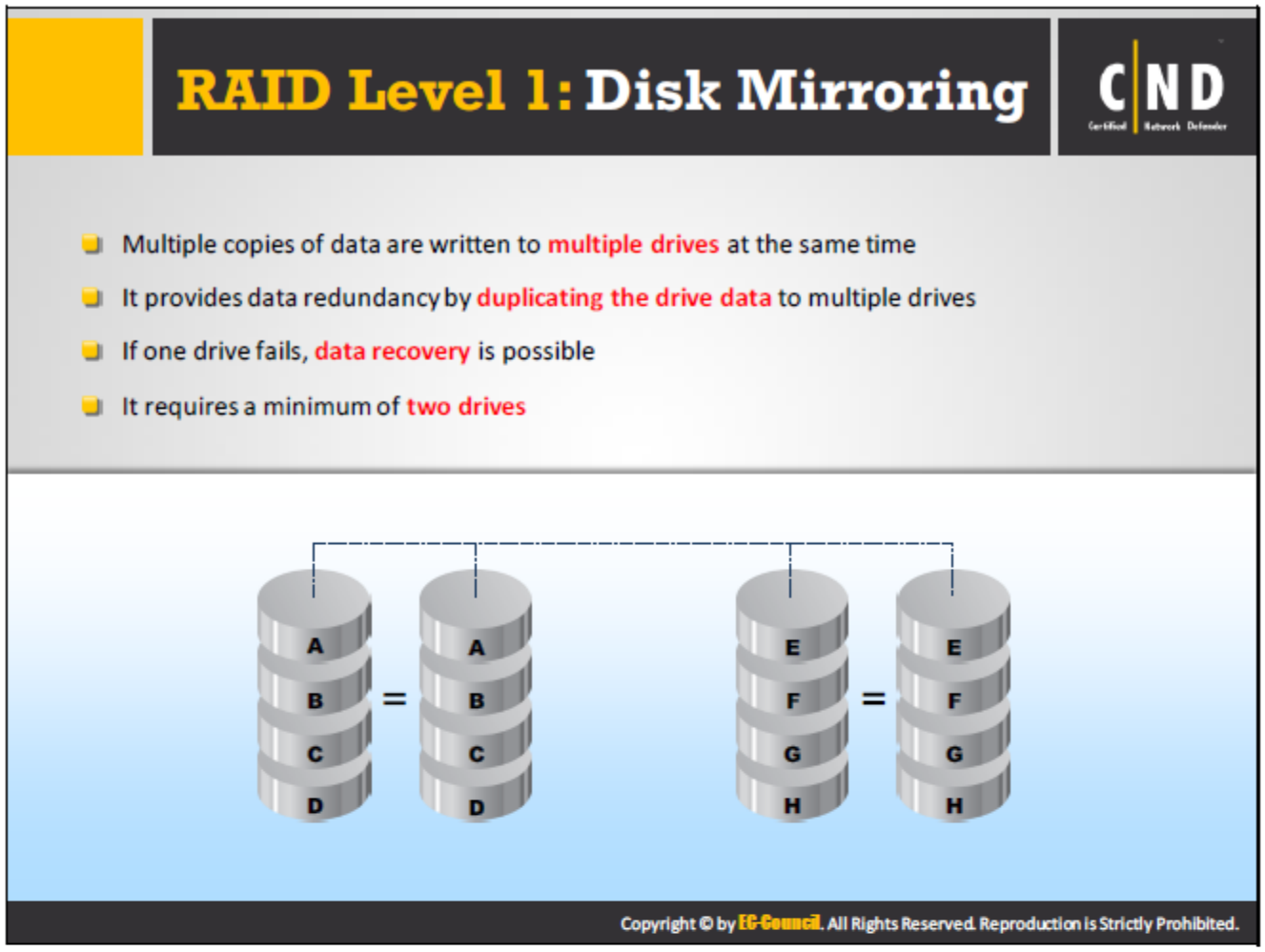
Example: Assume that the IT infrastructure has a hard disk with high performance. The data in the hard disk is transferred at a very high speed. All the large and critical files are stored in this disk. However, if this disk fails the entire contents of the files will be affected, leading to unavailability of the data. It is advisable to not store any critical data in a RAID level 0.

Advantages of RAID Level 0

- **Read and Write Performance:** RAID level 0 has very good read and write performance. The performance is even greater if the controller supports independent reads and writes to different disks in the array.
- **Cost:** RAID level 0 is cost effective compared to the other RAID levels.
- **Implementation:** Is easy to implement as the data is divided in a sequential set of blocks. There is no storage loss as the max capacity is used.

Disadvantages of RAID Level 0

- **No redundancy:** With no data redundancy, data loss is greater.
- **Non-critical data:** Data that is not critical to the organization can be stored on RAID level 0. This level does not use mirroring. If the critical data is lost on a RAID Level 0 recovery is not possible.
- **Unreliable:** If one disk fails, the entire network will be affected.



A typical RAID 1 contains an exact copy of the data on two or more disks. RAID 1 writes data on multiple drives and multiple mirror drives at the same time. Failure of one drive does not affect the data on the other drives. This allows data retrieval from the mirror drive. Similar to RAID 0, RAID 1 provides no parity, stripping or spanning of disk space across multiple disks. RAID 1 can be used in accounting, payroll and other financial applications.

RAID 1 is suitable in environments where read performance matters more than the write performance. RAID 1 has improved read performance since the data in the disk can be read at the same time simultaneously.

RAID level 1 provides data reliability, since failure of one disk can still provide access to the same data mirrored on the other disks. In a RAID 1 hardware implementation, a minimum of two disks is required. In a software RAID 1, data can be copied to a volume of the disk. RAID 1 reduces the total capacity by half.

Example: If a RAID 1 server with two 4TB drives is configured, the storage capacity will be 4TB not 8TB.

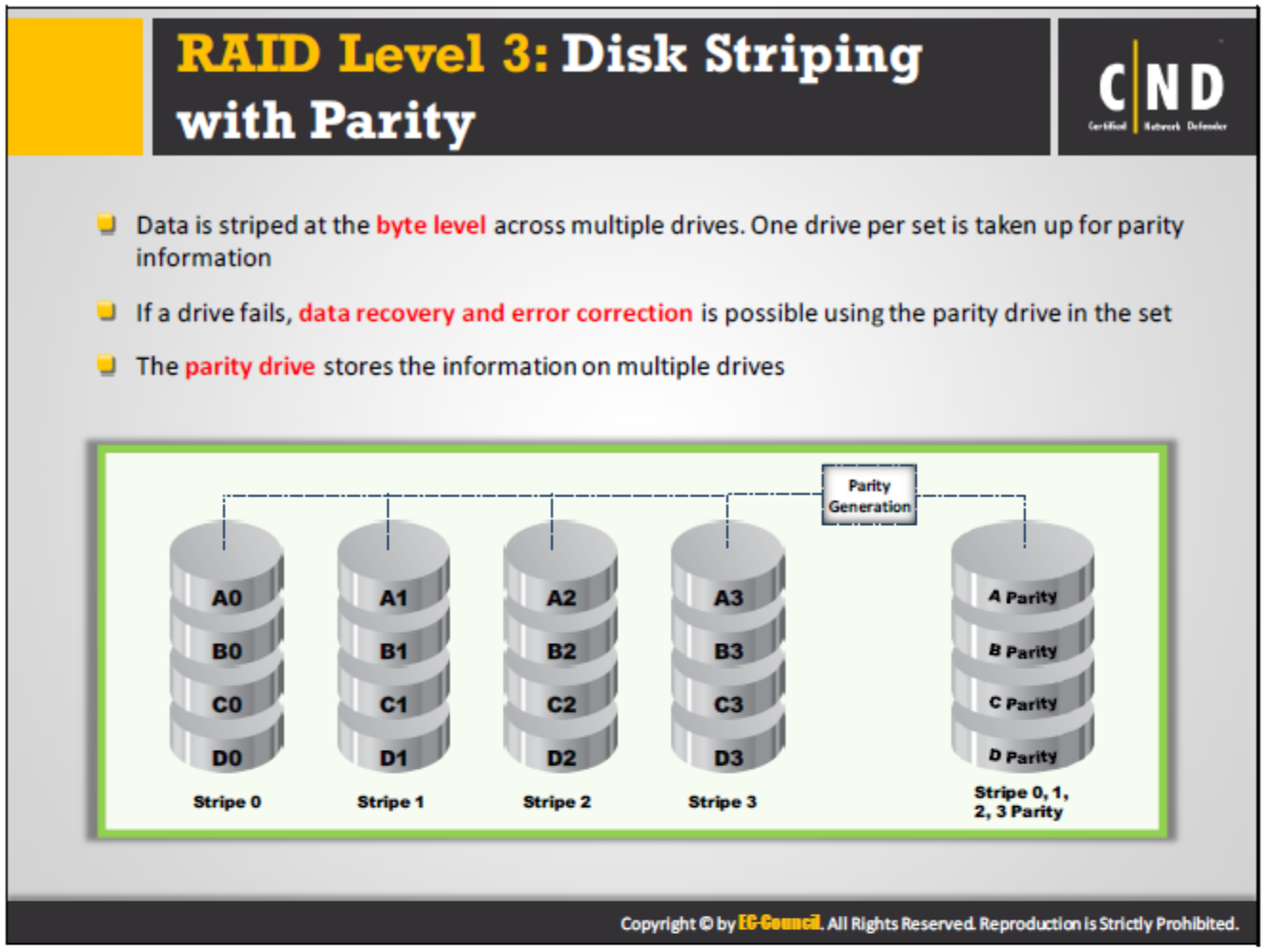
The drive that accesses the data first will service the request. The write throughput in RAID 1 is always slower because every drive needs to be updated. The slowest drive will limit the performance. It is only has fast as its slowest drive. RAID 1 will continue to function as long as there is at least one drive working.

Advantages of RAID Level 1

- **High read performance:** Because there are two disks, the read performance is higher in a RAID Level 1 system. Data can be read simultaneously while being written on the other disk. The redundancy feature is excellent.
- **Compatible:** RAID 1 is compatible with hardware and software RAID systems, including controllers.
- **Reliable:** The mirroring feature in a RAID 1 ensures the data will be available. Making it more reliable than a RAID level 0.

Disadvantages of RAID Level 1

- **Capacity:** RAID Level 1 undergoes duplexing, which is the need for twice the amount of disk space for storage.
- **Hot-swapping unavailable:** If a disk fails to run, it cannot be replaced while the server is still in operation. This is called hot swapping. RAID level 1 does not provide the hot swapping feature.



RAID Level 3 is disk striping with parity. It uses striping and parity as its main feature to store the data. To implement a RAID level 3 system, a minimum of three disks is required. The data is stored on multiple drives at the byte level. This RAID level dedicates one drive to store the parity information. The byte level division allows the drives to work simultaneously. At any time either a read operation or a write operation can take place. RAID 3 is a good choice for specialized databases or single-user systems.

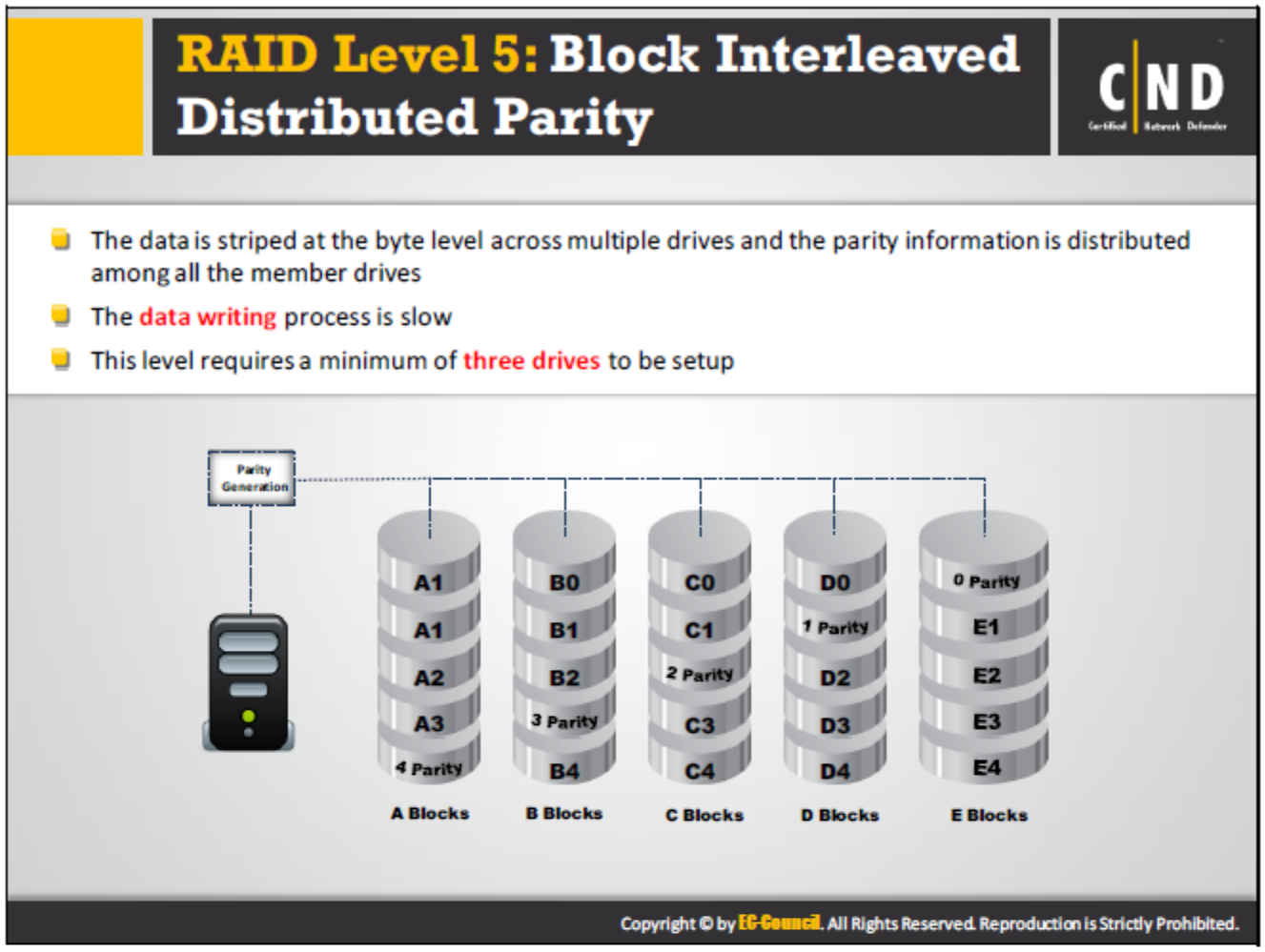
The RAID level 3 has a high transfer data rate along with data security. It can perform data recovery and error correction by calculating an exclusive OR (XOR) of the information recorded on the parity drive.

Advantages of RAID Level 3

- **High throughput:** RAID level 3 provides high throughput for read and write operations for large data transfers.
- **Resistant:** This RAID level is resistant to disk failure and breakdown.

Disadvantages of RAID Level 3

- **Complexity:** Installation and configuration of a RAID level 3 system is very complex. It requires a larger amount of resources to implement.
- **Slow performance:** Random operations affect the performance, reducing the speed.



RAID Level 5 is block interleaved distributed parity and includes a block-level striping with a distributed parity. The parity information is distributed among all the drives, except one drive. The data chunks in a RAID level 5 system are larger than the regular I/O size, but they can be resized. To prevent data loss after a drive fails, data can be calculated from the distributed parity.

The RAID 5 needs at least three disks, but for better performance, more than three disks can be used. RAID 5 is not a good choice for write operations on the system. If a disk fails, it takes a long time to rebuild the RAID 5 array. When the array is being built again, the performance can degrade making it vulnerable to additional disk failure. This level offers significant read performance as the disks satisfy the data requests independently.

RAID 5 is found most often in file and application servers, database servers, web, e-mail, and news servers.

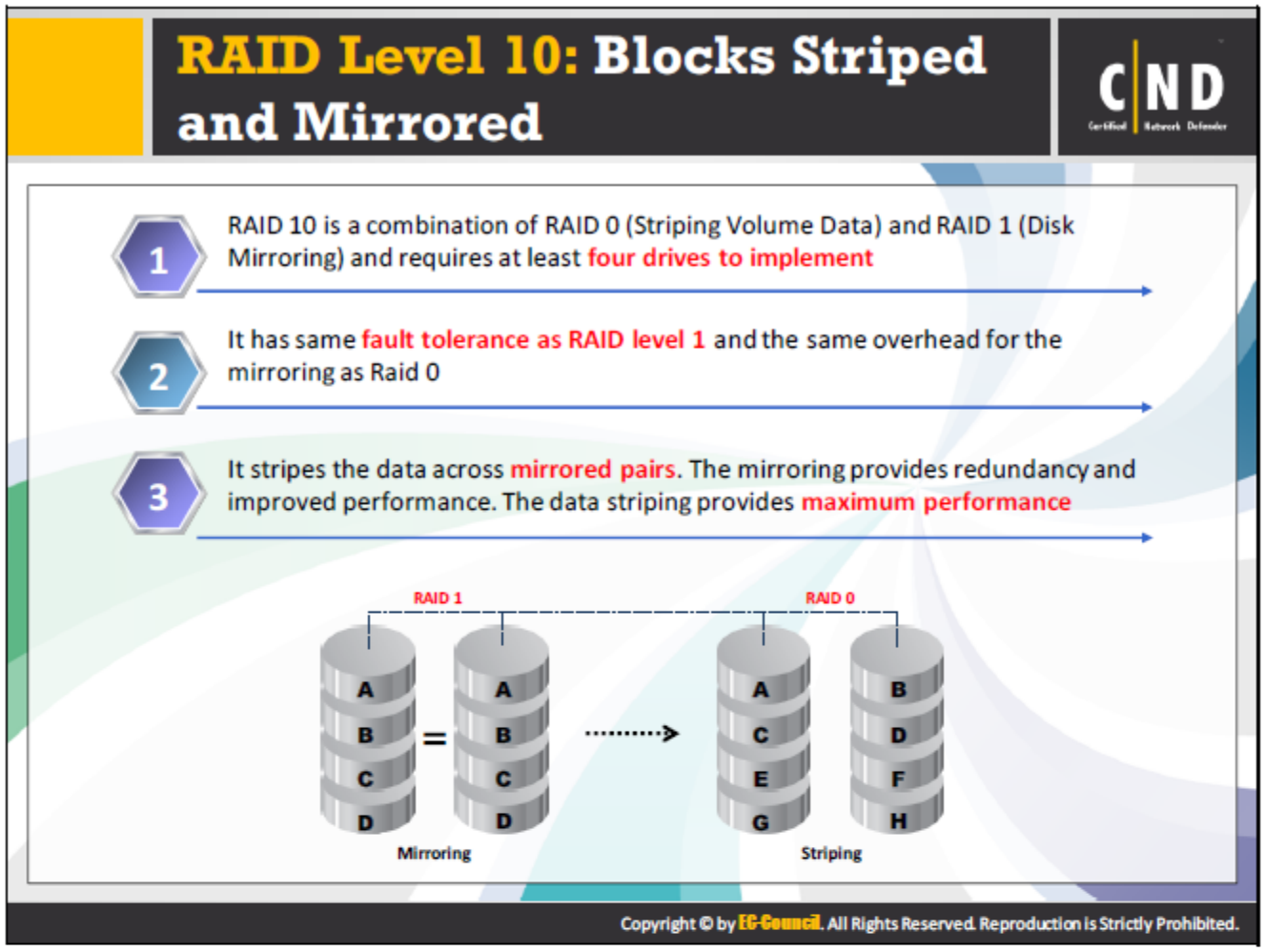
Advantages of RAID Level 5

- **Read data:** Among all the levels of RAID, level 5 has the highest read data transaction rates.
- **Withstand failure:** The RAID 5 level can withstand the failure of a single drive, without affecting the loss of data.
- **Hot swapping:** In case of a disk failure, the failed disk can be replaced with a new one, without a server shutdown.

Disadvantages of RAID Level 5

- **Slow write operation:** Servers built using RAID 5 suffer performance issues with write operations and these can eventually be affected with reduced speed.

Example: Employees accessing a database on a RAID 5 server will reduce the production time of the server.



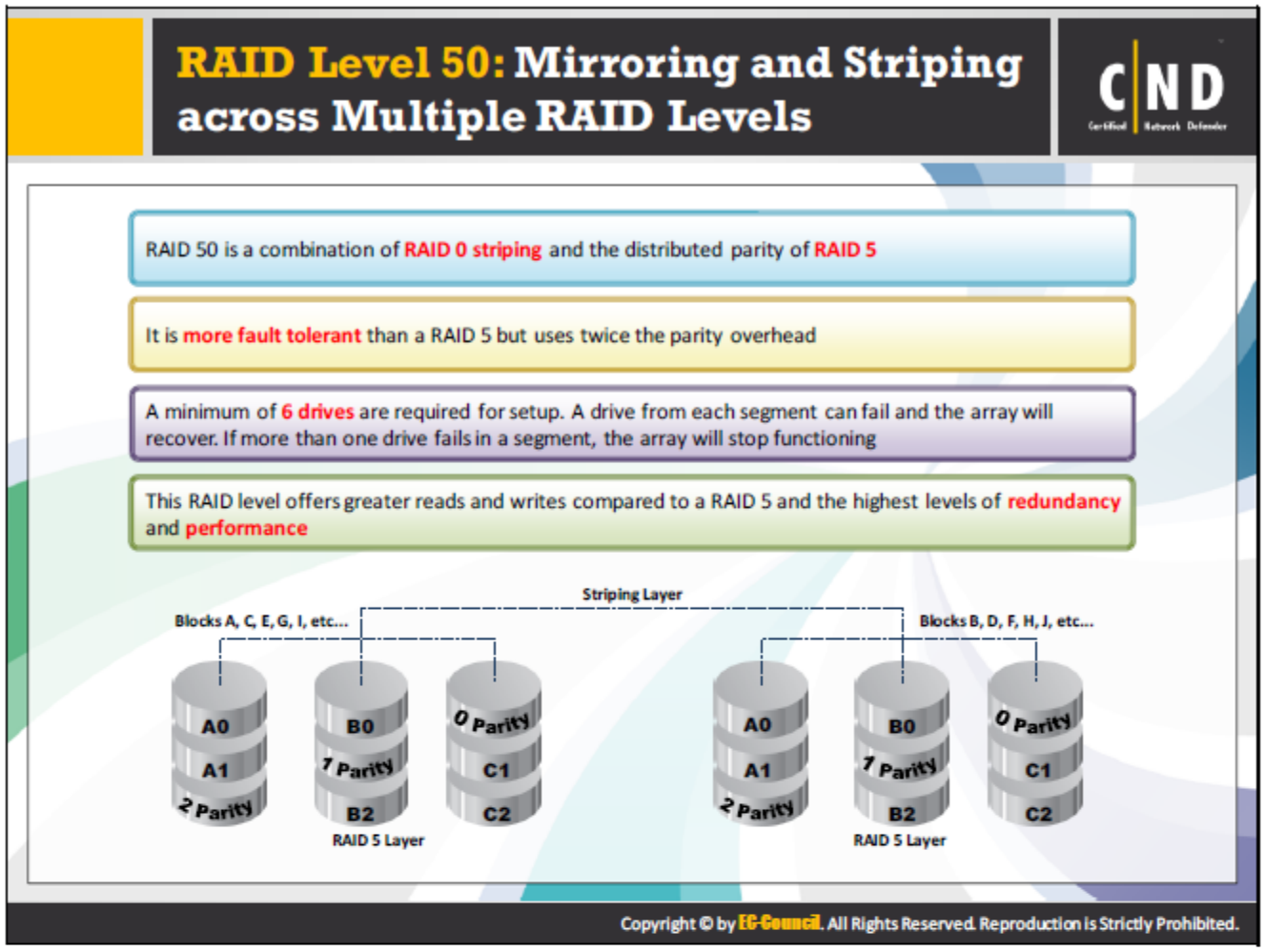
RAID Level 10 includes disk striping and mirroring in a nested hybrid RAID level. It is a combination of RAID level 1 and RAID level 0. It is also called as "stripe of mirrors". The level can symbolically be represented as RAID 1+0 or RAID 10. RAID 10 includes the mirroring of RAID 1 without the parity and striping of RAID 0. The performance of RAID 10 is higher than a RAID 1. RAID level 10 has the same fault tolerance as RAID level 1. It requires a minimum of four drives for its operation. RAID 10 is a great choice for database servers, web servers, email, etc. and can be used on hardware or software RAID implementations.

Advantages of RAID Level 10

- **High operations:** With a combination of RAID Level 1 and 0, it provides high I/O operations.
- **Better throughput:** Compared with other RAID levels, RAID 10 provides better throughput and higher latency.
- **Efficient write operations:** The write operations of this level are efficient and is often implemented on database servers and other servers performing write operations.

Disadvantages of RAID Level 10

- **Expensive:** RAID 10 is expensive compared to other RAID levels, as it requires twice as many disks.



RAID level 50 includes mirroring and striping across multiple RAID levels. This level is a combination of the block level striping of level 0 and the distributed parity of level 5. The configuration of RAID level 50 requires a minimum of six drives. This level undergoes a hot swapping process when a disk fails.

RAID 50 is an improvement over RAID 5, specifically for its write operation and fault tolerance. RAID level 50 can be implemented on servers that run applications requiring high fault tolerance, capacity and random access performance. This level offers data protection and faster rebuilds compared to a RAID 5 system. When one disk fails in a segment, it only affects that segment and not the entire array. Only that segment is rebuilt. The rest of the array functions normally.

Advantages

- **Security:** The data stored in a RAID 50 is more secured than in a RAID 5. With a larger storage capacity, this level offers more than RAID 5.
- **Non-degradable:** With the use of a minimum of six drives in the configuration environment, failure of one disk does not impact the server function configured on this level.
- **Read and write performance:** The read and write performance of RAID level 50 is far better than RAID level 5.

Disadvantages

- **Controller:** Only a sophisticated controller can handle RAID level 50.

Selecting Appropriate RAID Levels

RAID	Disk Utilization	Fault Tolerance	Large Data Transfers	I/O Rate	Data Availability	Key Problems
Single Disk	Fixed 100%	No	Good	Good	Single drive MTBF	Data Lost when disk fails
RAID 0	Excellent 100%	Yes	Very Good	Very Good	Poor MTBF of drive	Data Lost when any disk fails
RAID 1	Moderate 50%	Yes	Good	Good	Good	Use double the disk space
RAID 3	Good – Very Good	Yes	Very Good	Good	Good	Data Lost when any disk fails
RAID 5	Good – Very Good	Yes	Good – Very Good	Good	Good	Lower throughput with disk failure
RAID 0+1	Moderate 50%	Yes	Good	Very Good	Good	Use double the disk space
RAID 1+0	Moderate 50%	Yes	Very Good	Very Good	Very Good	Very expensive, not scalable
RAID 30	Good – Very Good	Yes	Very Good	Excellent	Excellent	Very expensive
RAID 50	Good – Very Good	Yes	Good – Very Good	Excellent	Excellent	Very expensive

Selection of any RAID level should be based on the needs of the organization and the features offered by each level.

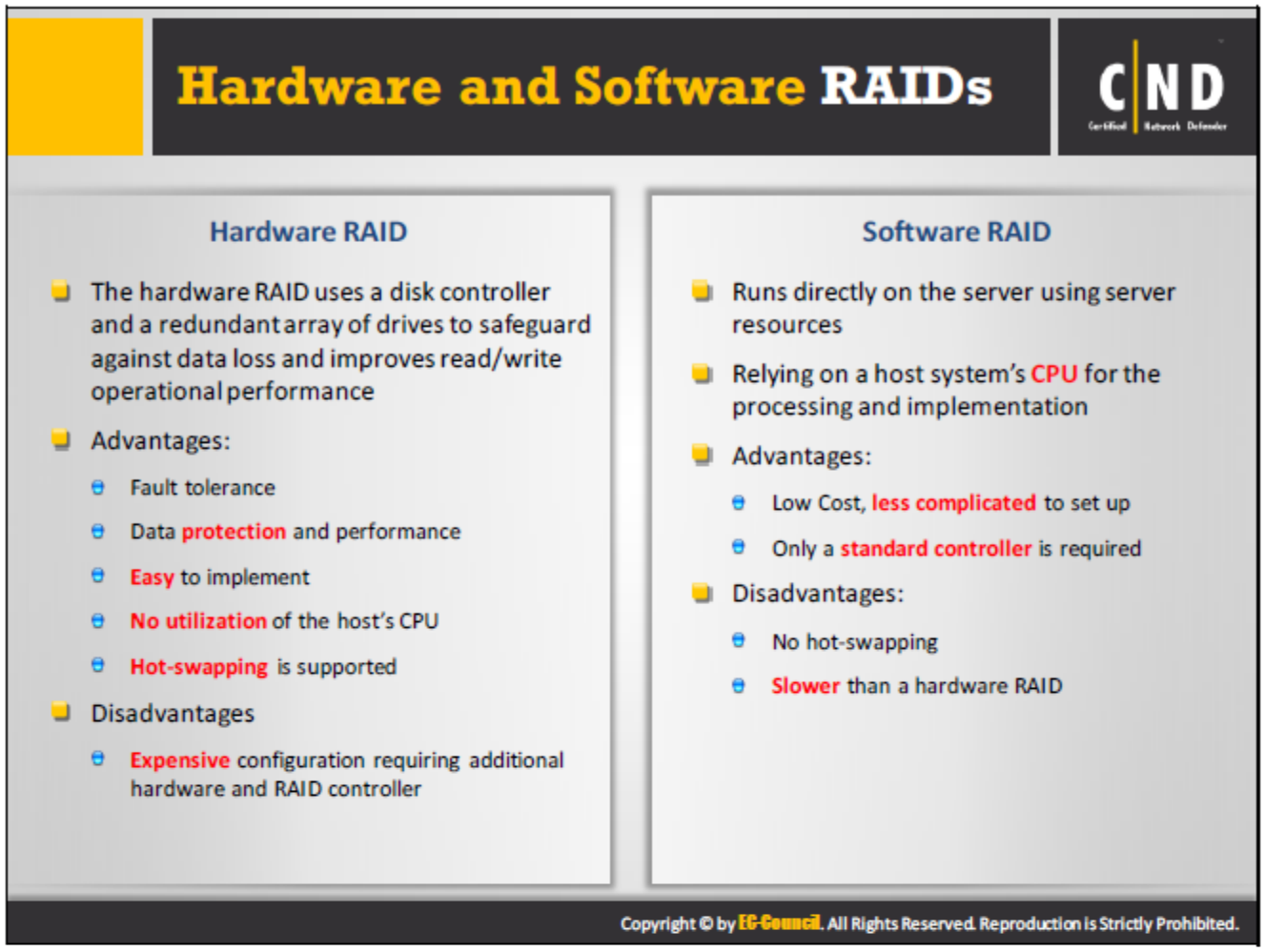
There are several points to consider while selecting RAID levels:

- **Application performance needs**: Not all RAID levels are useful for all applications and data needs. Choose an appropriate RAID level according to other factors like I/O need, storage capacity, fault tolerance etc.
- **Capacity:** Each RAID level offers different amounts of storage capacity. The choice of a RAID level depends on the capacity required. For example, if 30 drives are needed, a RAID 50 or 60 is the better choice. Three segments of 10 drives each. Could do a RAID 5 but the rebuild process would be tedious, among other problems. One drive is lost to parity for each segment. There would only be 27 drives available towards the capacity requirements. Capacity is lost but performance is gained.
- **Cost:** Both performance and capacity cost money. Weigh the options between performance and capacity. Capacity can be lost and performance gained. Losing a small amount of capacity may be worth it for the gains in performance. This all depends on the where the RAID system will be utilized. Have to strike a balance between both capacity and performance and what works best for the organization.
- **Availability needs:** Choose a RAID level that matches the availability requirements for the organization.

The following table will help you in selecting an appropriate RAID for your organization:

RAID	Disk Utilization	Fault Tolerance	Large Data Transfers	I/O Rate	Data Availability	Key Problems
Single Disk	Fixed 100%	No	Good	Good	Single drive MTBF	Data Lost when disk fails
RAID 0	Excellent 100%	Yes	Very Good	Very Good	Poor MTBF of drive	Data Lost when any disk fails
RAID 1	Moderate 50%	Yes	Good	Good	Good	Use double the disk space
RAID 3	Good – Very Good	Yes	Very Good	Good	Good	Data Lost when any disk fails
RAID 5	Good – Very Good	Yes	Good – Very Good	Good	Good	Lower throughput with disk failure
RAID 0+1	Moderate 50%	Yes	Good	Very Good	Good	Use double the disk space
RAID 1+0	Moderate 50%	Yes	Very Good	Very Good	Very Good	Very expensive, not scalable
RAID 30	Good – Very Good	Yes	Very Good	Excellent	Excellent	Very expensive
RAID 50	Good – Very Good	Yes	Good – Very Good	Excellent	Excellent	Very expensive

TABLE 13.1: Selecting appropriate RAID levels



Choosing between a hardware and software RAID depends on the requirements of the organization as well as the need of the IT infrastructure. The organization should consider their budget before selecting a specific RAID type, as hardware costs more than a software-based RAID system.

Hardware RAID

This is where the processing is done, such as on a motherboard or a RAID expansion card. In a hardware-based RAID, logical disks are configured and mirrored on the hardware. A physical controller is located on the PCI bus and it manages the application data and operating system(s). The controller prevents the drives from data loss and enhances the read-write operations.

RAID levels 0, 1, 3 and 5 are compatible with a hardware RAID. A hardware RAID provides efficient and non-stop recovery from media failure. Performance based advantages are much higher with a hardware RAID. For example, the implementation of RAID level 5 will enhance the data throughput as compared to a software-based RAID. Multiple controllers can be added in to improve the read-write performance and total storage capacity.

A hardware RAID can be implemented when there is a complex and critical setup or with large databases.

- **Advantages:**

  1. **Write-Back mode:** A typical hardware controller has a battery backup unit (BBU). The hardware RAID can work in write-back mode because of the BBU feature. If there is a power failure while writing data to a drive, the data will not be lost or deleted.

     The BBU plays a very important role in write-back mode.

  2. **Hot-swapping:** Many controllers in a hardware RAID support hot swapping. The disk can be replaced while the server is still running, this does not affect the production of the organization.

  3. **Higher throughput:** With the availability of a BBU, a hardware RAID offers higher read and write throughput, increasing the overall performance of the RAID level.

  4. **Rebuild:** Rebuilding disk sets can be easier, with the availability of a BBU. A BBU speeds up the rebuild process, decreasing the total amount of time it takes to rebuild.

  5. **Overhead:** Hardware RAID requires external hardware to function. It does not affect the overhead of the CPU or RAM on the host machines.

  6. **Boot loader:** A hardware RAID can recover from a boot loader failure.

- **Disadvantages:**

  1. **Expensive:** Hardware RAID requires an external RAID card or external hardware for the implementation. This adds to the overall cost of the implementation, making it more expensive.

Software RAID

Software RAID uses software instead of hardware for its implementation. Unlike a hardware RAID that uses a controller, software RAID uses system processors and other applications to work. Software RAID is implemented in the operating system or at the kernel level. The performance of a software RAID depends on the CPU performance. Software RAID relies on a standard host adapter and executes all I/O commands using mathematical calculations. RAID levels 0, 1 and 5 are compatible with a software RAID.

- **Advantages:**

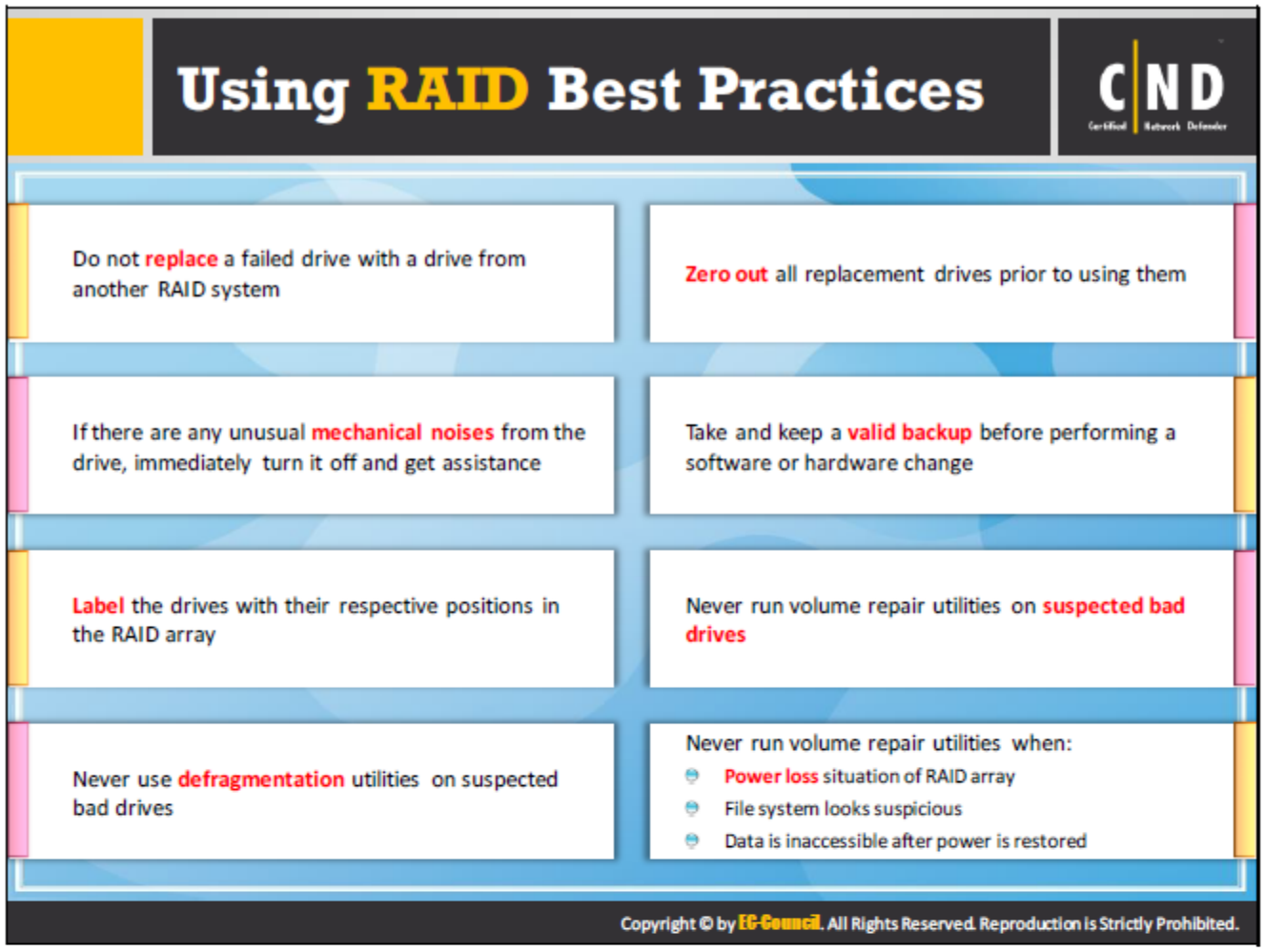
  1. **Cost-effective:** Software RAID is part of the operating system. There are no additional items needed increasing the cost for its implementation. It is more cost-effective than a hardware RAID implementation.

  2. **Simplicity:** A software RAID does not need a hardware controller. There are no complexities for its implementation.

  3. **Duplexing:** Duplexing in a software RAID requires only a standard controller for the process.

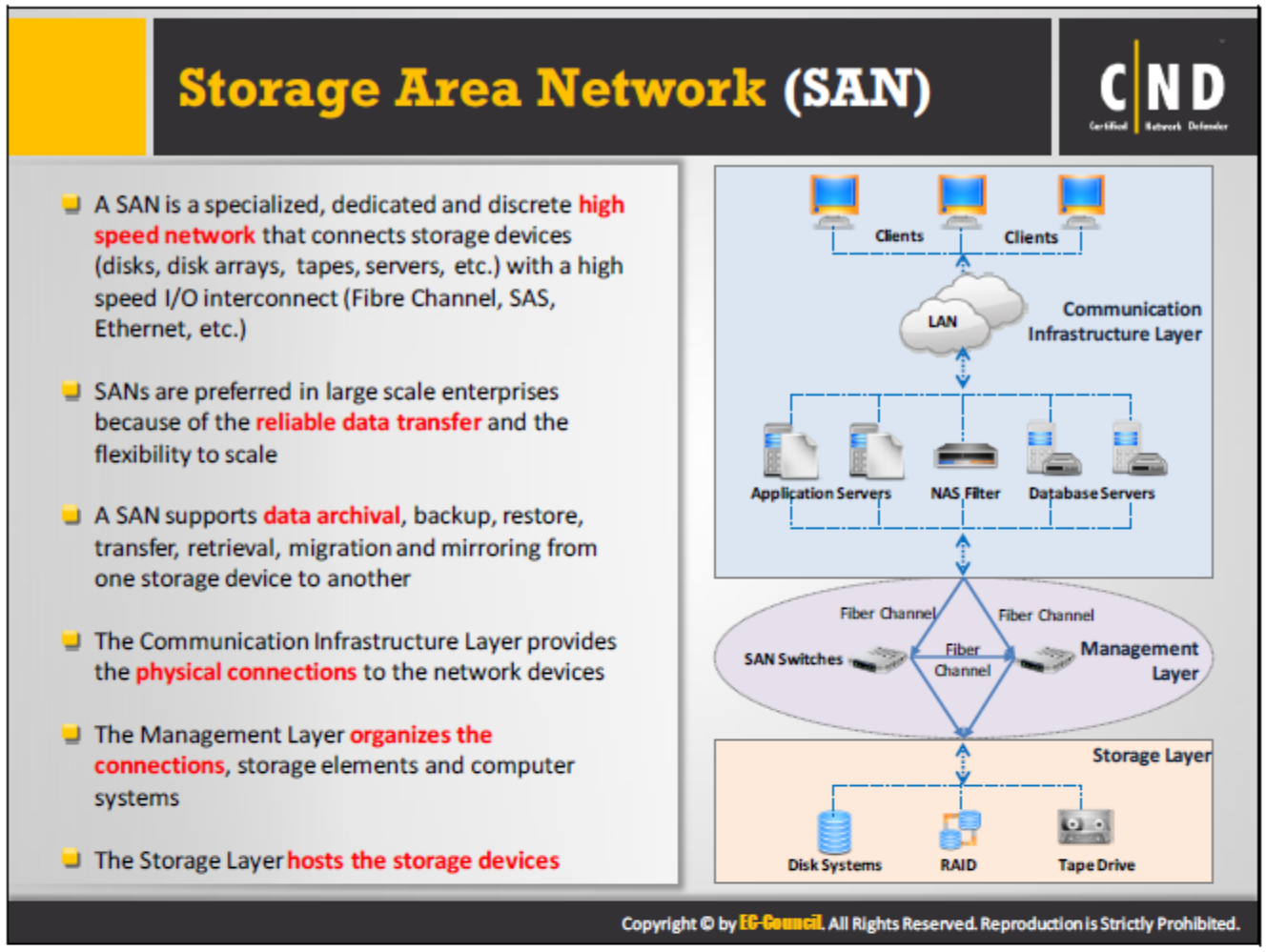
- **Disadvantages:**

1. **Performance:** The performance of a software RAID depends on the CPU usage, as it uses the CPU cycle of the host machine. The software RAID performance is lower than that of a hardware RAID.
2. **Boot loader failure:** The software RAID requires an operating system to function. If the boot loader fails it will lower disk performance.
3. **Compatibility:** Certain software and operating systems may not be compatible with the RAID levels. This causes an issue with the disk array.
4. **Advanced features unavailable:** Software RAID does not offer hot swapping or a drive swapping feature.



The following are the additional best practices for selecting and using RAID:

- Always select a RAID level that can handle the workload.
- Always be cautious about the storage capacity while selecting a RAID level.
- Do not lose the balance between cost and performance.
- Always ensure the chosen RAID level is according to the needs of the organization.
- Avoid replacing a failed drive that was a part of a previous RAID system.
- Always seek assistance if there are any unusual noises from the system.
- Label hard drives with their respective RAID array positions.
- Always select a RAID group according to logical unit numbers, accommodated by the server.
- Avoid making any changes to the data in a RAID.
- Always use hard drives of equal sizes in RAID groups.



A Storage Area Network (SAN) is a high performance network that interconnects storage devices with multiple servers. The role of a SAN is to transfer stored resources available on the common network and reorganize them on an independent and high performance network. This helps the servers to share the storage across the network. Primarily, a SAN enhances storage devices like, tape drives, disk drives, file servers, RAID, etc. Implementation of a SAN makes disk maintenance controllable and easier. The implementation of SAN needs a cable, switch and host bus adapters. Each storage system on the SAN must be interconnected and in case of physical interconnection, the bandwidth level should be such that it supports high data activities.

We know that systems in the network connect to the storage devices. But, to assure that all systems in the network should be connected to every storage device available on the network, implementation of a SAN is needed. SAN allows these systems to take the ownership of the storage devices; systems can exchange the ownership of the storage devices among themselves.

Understanding Storage Sharing

The working of storage area network depends on client server communication. Every organization has multiple servers that are connected to the systems.

Example: If computer A needs a data from computer B, it will need a copy of data from the server, to which computer B is connected to. This can be done through, file transfer, inter-process communication and backup. Even though the data is transferred from computer B to

computer A, there can be a probability that computer A may face the situation of untimely data errors, an expensive transferring process taking place between two servers or any other operational process. To resolve this issue, SAN architecture will be the perfect solution towards it. In SAN architecture, all servers are connected to storage devices like, tape drive, RAID, disk systems, etc. through a fiber channel. Thus, instead of computer A communicating to computer B for data, it can directly get a copy of it from the storage devices connected to the servers. For this process to be successful, data storage devices act as a common access point for all the servers.

SAN storage sharing eliminates the scheduling of the data transfers among the servers. It reduces the cost of data transfer among the servers. Storage devices help timely transfer of data. SAN storage offers only block level operations that do not provide file abstraction.

However, if the file systems are structured on top of storage area network, file access is provided which is known as a SAN file system.

Now-a-days, in large organizations, SAN is a storage pool for the servers that are connected via a network. The fiber channel is now replaced by iSCSI which has become the choice of many mainstream organizations. Whatever, be the size of the organization, SAN has become a consolidation of workloads in the network.

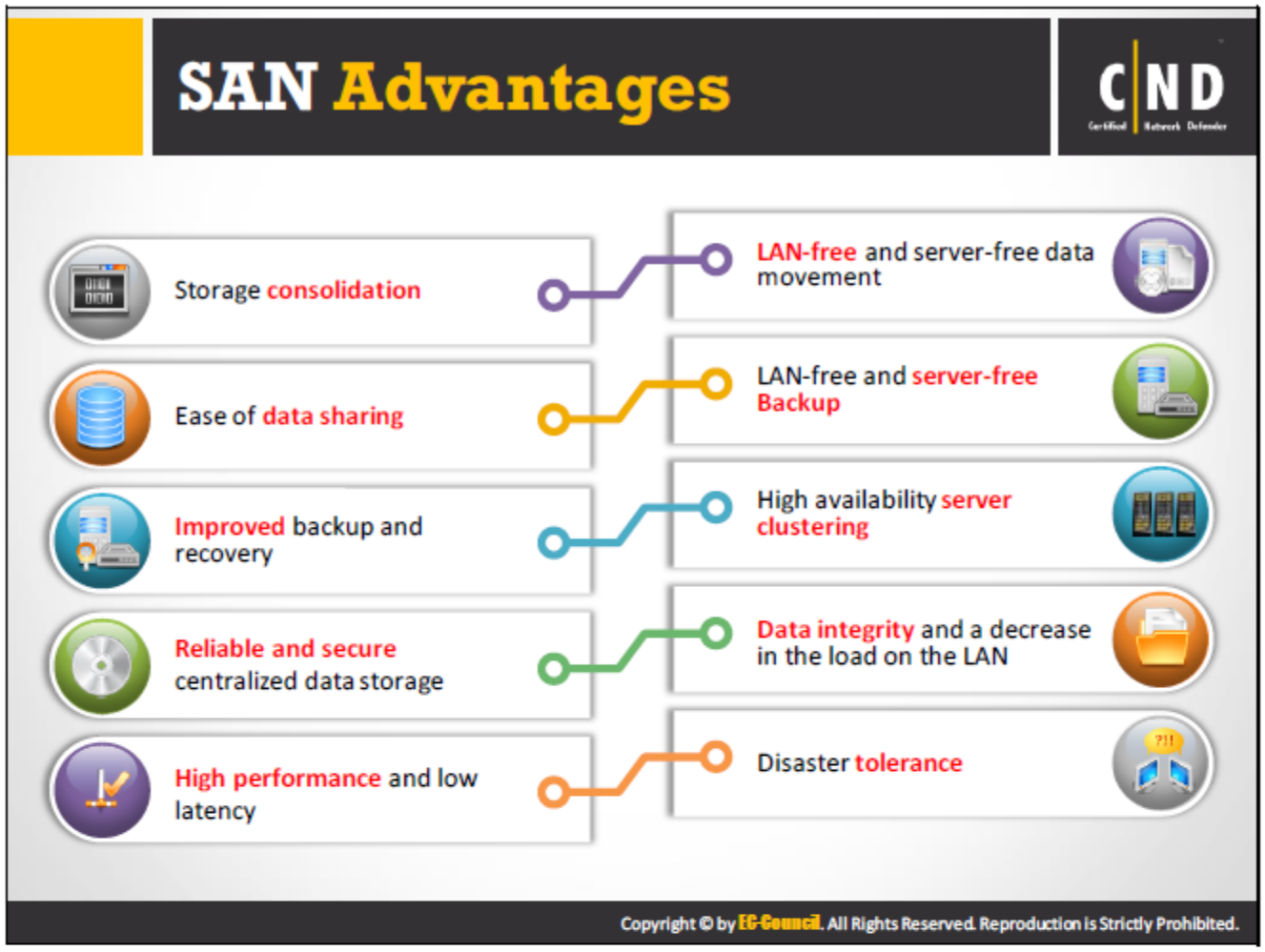
Types of SAN

1. **Virtual Storage Area Network (VSAN):** VSAN designed by Cisco is a logical partitioning that is within the physical storage area network. VSAN allows the allocation of some or entire storage network to logical SANs. VSAN is mainly used in cloud computing and virtualization environment. It can be used to build a virtual storage.

   The working of VSAN is similar to traditional SAN, since it has a virtualized environment, the addition or relocation of end users can take place. This will not affect or change the physical layout of the network. Implementation of VSAN enhances the security of the entire network.

2. **Unified SAN:** Unified SAN is also known as network unified storage or multiprotocol storage. It allows the applications and files to perform actions through a single device. It handles data storage and block based input/output operations. It merges files and block based access in a single storage network. Unified SAN is cost effective as it saves the expense of hardware requirements. Storing the combined modes in a single device, unified SAN is easily manageable. Although it is advisable to deploy the critical applications on block-based storage systems.

3. **Converged SAN:** A converged SAN uses a common network arrangement for network and SAN traffic. This reduces the cost and complexity of the SAN technology. Converged SANs depend on 10 Giga bit Ethernet and network ports.



With the rise in technology and an increase in data, organizations need a storage device that can fulfill and handle their needs. The SAN advantages below, help determine the benefits of deploying in an IT infrastructure.

SAN Advantages

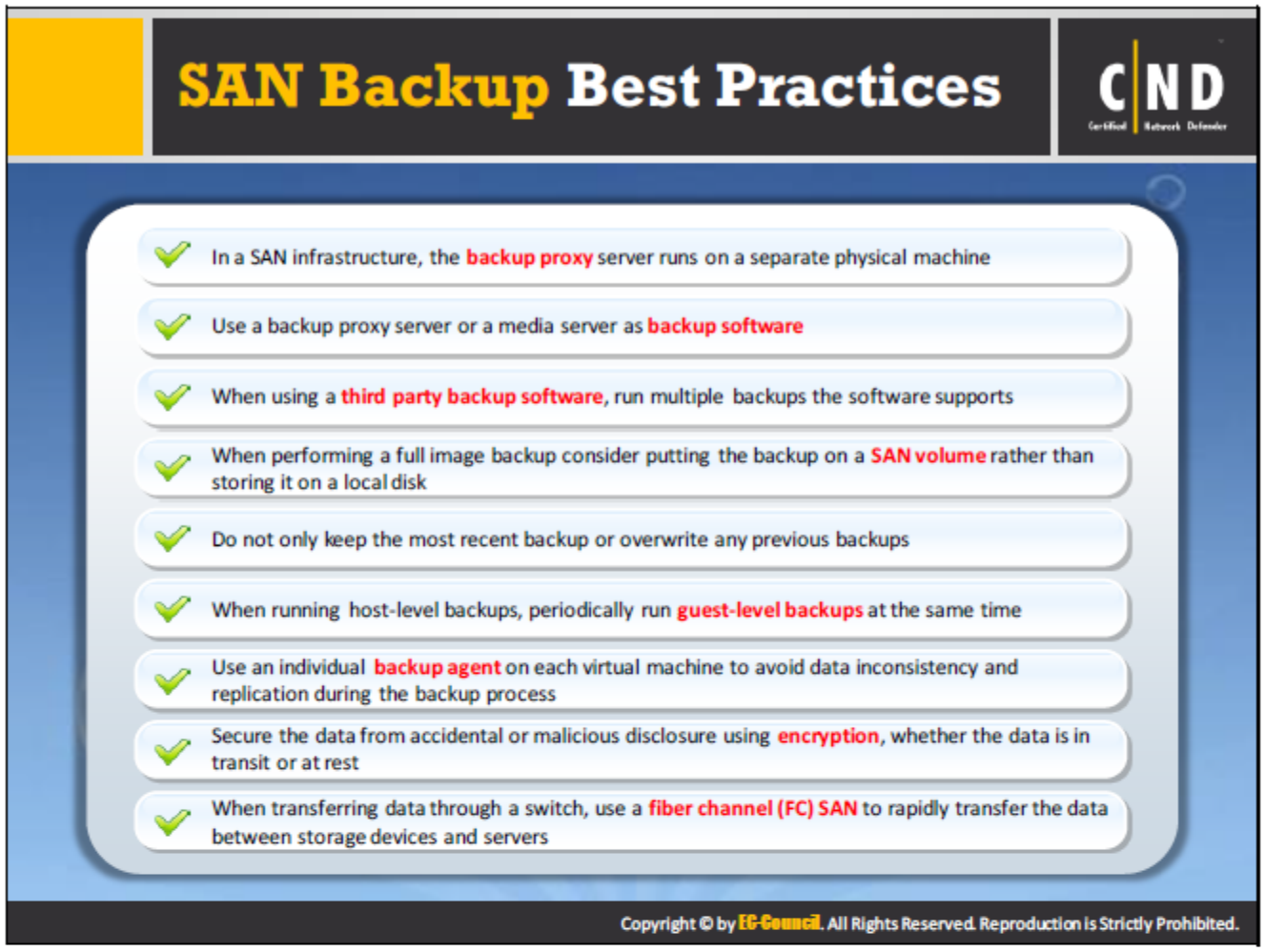
1. **Capacity:** SAN performance is directly proportional to the type of network. A SAN allows unlimited sharing of data regardless of the storage capacity. The SAN capacity can be extended limitlessly to thousands of terabytes.
2. **Easy sharing:** SAN data is easily shared between systems as it maintains isolated traffic. The traffic does not interfere with the normal user traffic, increasing data transfer performance.
3. **Security:** If a SAN is configured correctly, the data is secured. Chances of device intrusion is minimal.
4. **Productive:** A SAN is scalable, adding a new disk to the network does not stop the SAN's productivity. When adding a new hard disk, a reboot or shut down is not required.
5. **Availability of applications:** The algorithms in the SAN storage array offers data protection. This results in application availability at all times.
6. **Fast backup:** The data mirror copy can be created instantly. These mirror images can be used as a backup whenever required.

7. **Bootable:** A SAN can run a server without a physical disk and it can be booted by the SAN. This feature permits access to all the page files and applications.
8. **Distance connectivity:** For better security, plan to keep storage devices in an isolated location. A SAN has a feature where it can connect devices up to a distance of ten kilometers.
9. **Recovery:** A SAN is the most reliable data recovery option. If the servers are offline a SAN remains available.
10. **Effective utilization:** A SAN is an appropriate option for storage space compared to local disks. If a system requires more storage, a SAN dynamically allocates the space. This process is similar to virtual machines.

The implementation of a SAN is beneficial to an organization. Especially, when considering the limitations caused by budget constraints, availability and employee expertise.

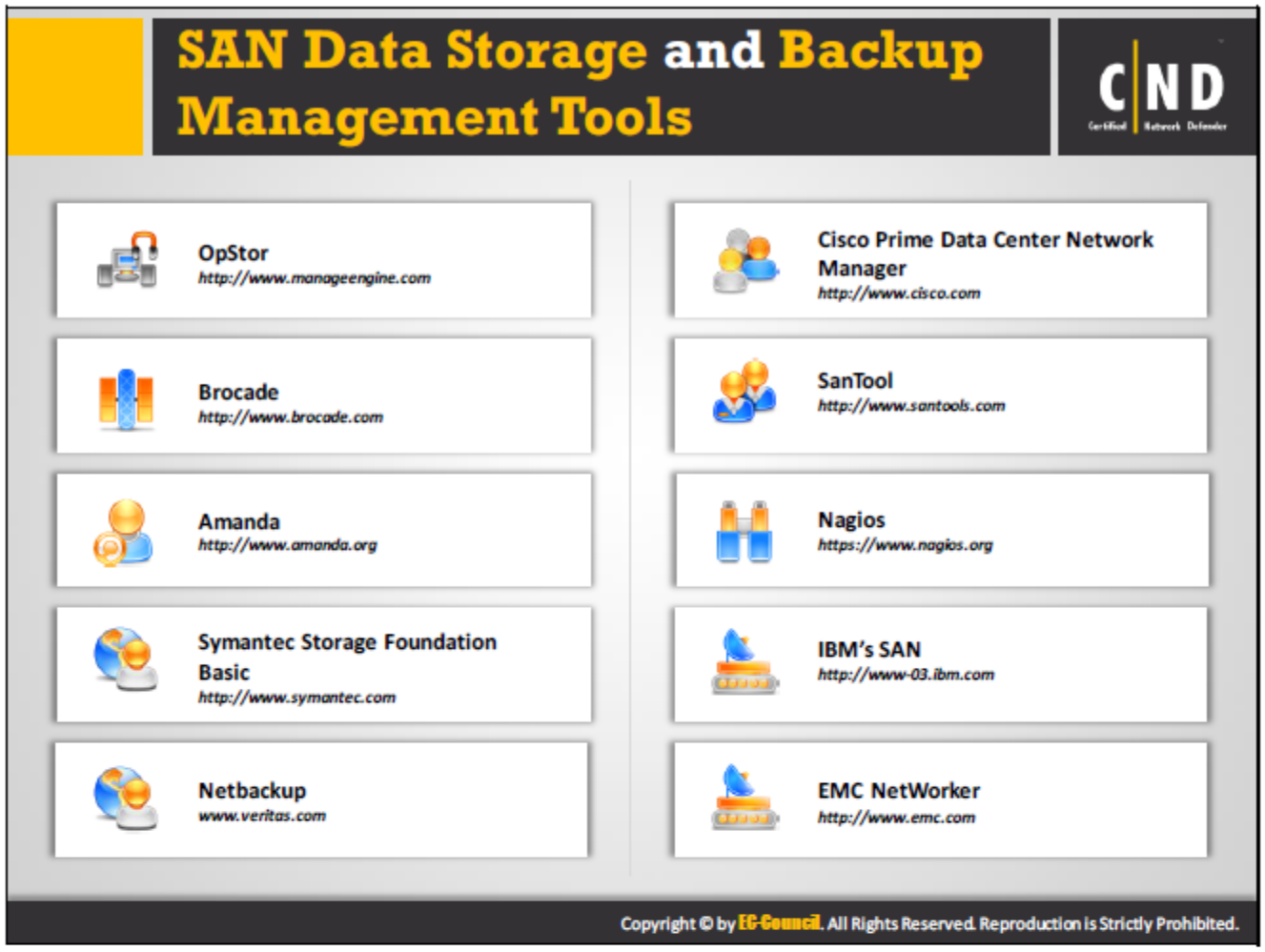
SAN Disadvantages

1. **Very costly:** The implementation of a SAN can cost more than the available budget limitations. A SAN is an investment and only implement if it meets the goals of the organization.



Additional best practices for an effective design, implementation and performance of a SAN:

- The implementation of SAN technology should incorporate future enhancements in the storage plan for the organization.
- Requires additional attention during the design phase.
- Select topologies that could enhance the performance.
- Always implement smaller SANs for better management.
- Always label the fiber switches as this makes it easier to locate and differentiate between switch types.
- Always prepare cable connection documentation for the SAN network.



Opstor

Source: *http://www.manageengine.com*

OpStor helps reduce the clutter of point products in storage by providing deep insight into backup and maintenance schedules. It also provides a detailed server, client, node, disk and plug-in report for single and multiple-node configurations of an EMC Avamar backup server.

Brocade

Source: *http://www.brocade.com*

The Brocade data center fabric supports controller-based network virtualization architectures such as VMware NSX and the Brocade BGP-EVPN Network Virtualization controller-less architecture. Brocade BGP-EVPN Network Virtualization eliminates the need for an external controller by leveraging open standards-based protocols to enable workload agility, segmentation and security within and across data centers.

Amanda

Source: *http://www.amanda.org*

AMANDA, the Advanced Maryland Automatic Network Disk Archiver, is a backup system that allows the administrator of a LAN to set up a single master backup server to back up multiple hosts to a single large capacity tape or disk drive. Amanda uses native tools (such as GNUtar, dump) for backup and can back up a large number of workstations running multiple versions of Unix/Mac OS X/Linux/Windows.

Symantec Storage Foundation Basic

Source: *http://www.symantec.com*

The Symantec Storage Foundation Basic provides a complete solution for heterogeneous online storage management. It is designed for heterogeneous online storage management of edge-tier workloads with up to four file systems, four volumes and two processor sockets per system.

NetBackup

Source: *www.veritas.com*

NetBackup reduces complexity and makes data protection as manageable as possible for limited staff. NetBackup provides a single solution for the entire enterprise, available on a converged platform and built to require minimal administration in even the largest, most dynamic environments.

Cisco Prime Data Center Network Manager

Source: *http://www.cisco.com*

The Cisco Prime Data Center Network Manager (DCNM) is designed to efficiently implement, visualize and manage the Cisco Unified Fabric. It includes a comprehensive feature set, along with a customizable dashboard that provides enhanced visibility and automated fabric provisioning for dynamic data centers.

SanTool

Source: *http://www.santools.com*

SANtools provides software and consulting services for manufacturers, OEMS and resellers of storage peripherals, subsystems and SAN and NAS appliances.

Nagios

Source: *https://www.nagios.org*

Nagios provides complete monitoring of SAN solutions – including disk usage, directories, file count, file presence, file size, RAID array status and more.

IBM's SAN

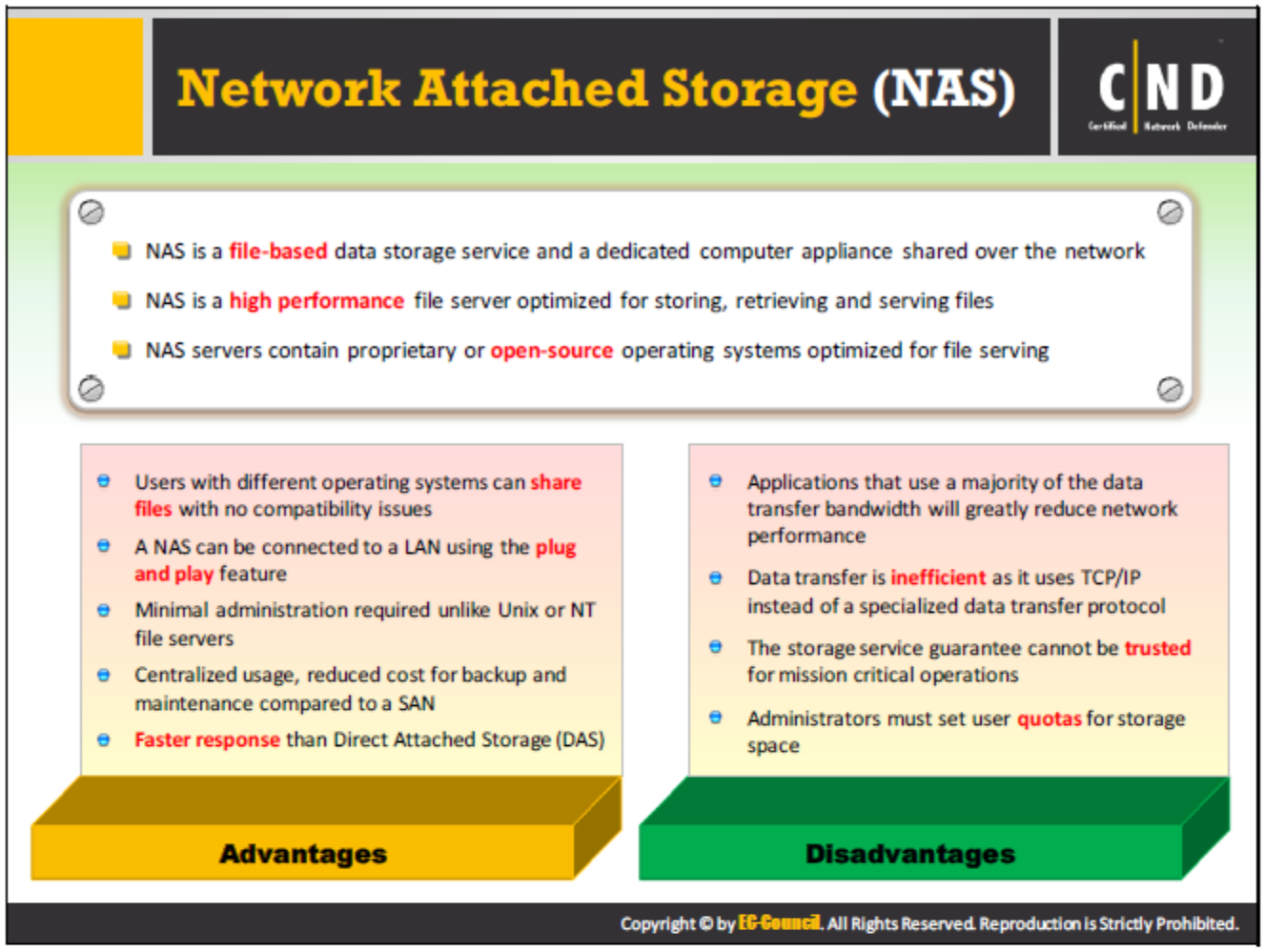
Source: *http://www-03.ibm.com*

IBM SAN products and solutions provide integrated SMB and enterprise SAN solutions with multi-protocol local, campus, metropolitan and global storage networking.

EMC NetWorker

Source: *http://www.emc.com*

The EMC NetWorker unifies and automates backup to tape, disk-based and flash-based storage media across physical and virtual environments for granular and disaster recovery.



Network attached storage (NAS) is a storage device that is connected to a network. It stores and retrieves data from a centralized location. NAS provides a dedicated shared storage space for a local area network. Implementing a NAS eradicates the server file sharing process on the network. The NAS contains one or more storage devices which are logically arranged. NAS offers file storage through a standard Ethernet connection.

NAS devices do not use an external device management and they are operated through a web-based utility. Since it resides on every node on the LAN, it has its own IP address. NAS is similar to a file server. NAS devices are scalable, vertically as well as horizontally. Implementing a NAS is accomplished using large and clustered disks.

NAS has evolved from supporting virtualization to data replication and multiprotocol access. A clustered NAS is one such example of the NAS evolution. In a clustered NAS infrastructure, access is provided to all files, irrespective of their physical location. It does not require a full source operating system like Windows. Certain devices run on the stripped down OS like FreeNAS or any other open source solutions.

NAS devices are in high demand in small enterprises due to the effective, low cost and scalable storage capacity. They are classified into three types based on the number of drives, drive capacity and scalability.

High-end or Enterprise NAS

This type of NAS is used mainly in business environments where scalability is a concern. Enterprise NAS provides the ability to increase the amount of storage space and the redundant power supply.

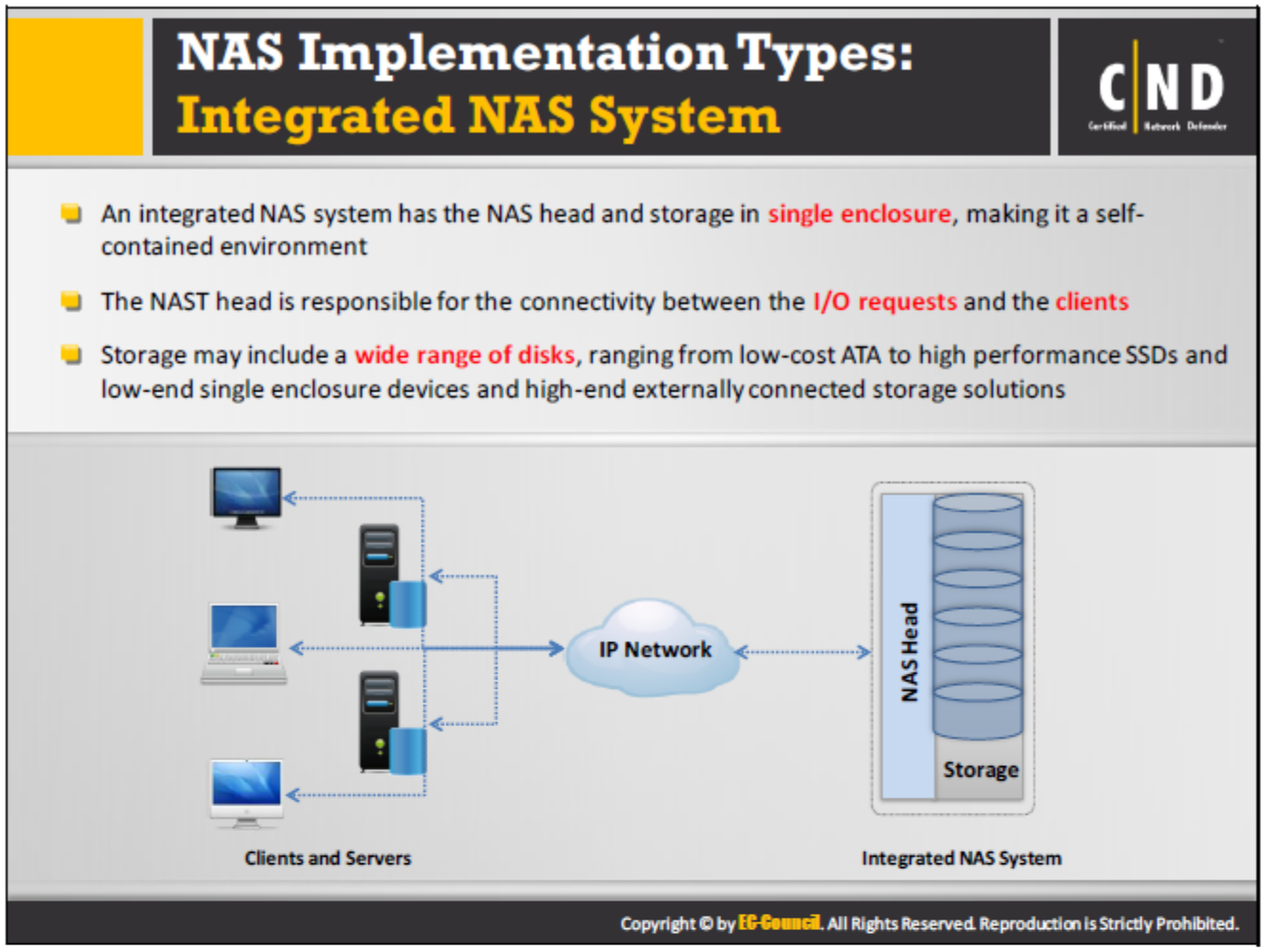
- **Small – Business Level NAS or Mid-market NAS**: Mainly used in business environments requiring one hundred terabytes (100 TB) of data.
- **Low-end or Desktop NAS**: Usually used by small business users or home users who require only local storage space.

NAS Advantages

1. **Accessibility:** A NAS system stores data as files and is compatible with CIFS and NFS protocols. Multiple users can access the files simultaneously using an Ethernet network. Computers in a shared network can access the data either through a wireless or a wired connection.
2. **Storage:** NAS deployment in the network increases the amount of storage available to the other systems. A NAS system can store up to 8 TB. NAS acts as the best source for storing large applications or video files.
3. **Efficient and Reliable:** NAS assures an efficient transfer of data and reliable network access. If a system in a network fails, the function of the other systems is not affected. A NAS server can also be created giving users to ability to access large files or applications.
4. **Automatic backup:** Certain NAS devices are configured with an automatic backup feature. The data is available on the user's system as well as on the server hard drive. Changes made on the user's system are reflected on the server hard drive as well. Automatic backup is not time consuming and is an assurance for the security of the data.

Disadvantages

1. **Consumption:** NAS shares the network with other host machines and this tends to consume a larger amount of network bandwidth. For remote NAS systems, the data transfer performance will depend on the available bandwidth. It is advisable to avoid storing databases on network attached storage, as the server response time fluctuates depending on the bandwidth.
2. **Network congestion:** During a large backup, the process can affect the function of the IP network and may lead to network congestion.



The integrated NAS system includes all the NAS components in a single frame. To provide connectivity to all clients, the NAS head connects to the IP network. An integrated NAS frame may vary from a low-end device to high-end solutions containing external storage arrays.

Low-end devices focus more on data storage rather than disaster recovery or performance. These are primarily used in small organizations where the amount of storage space available may be increased. Increasing the amount of space also increases the management overhead because of the increased number of devices being used.

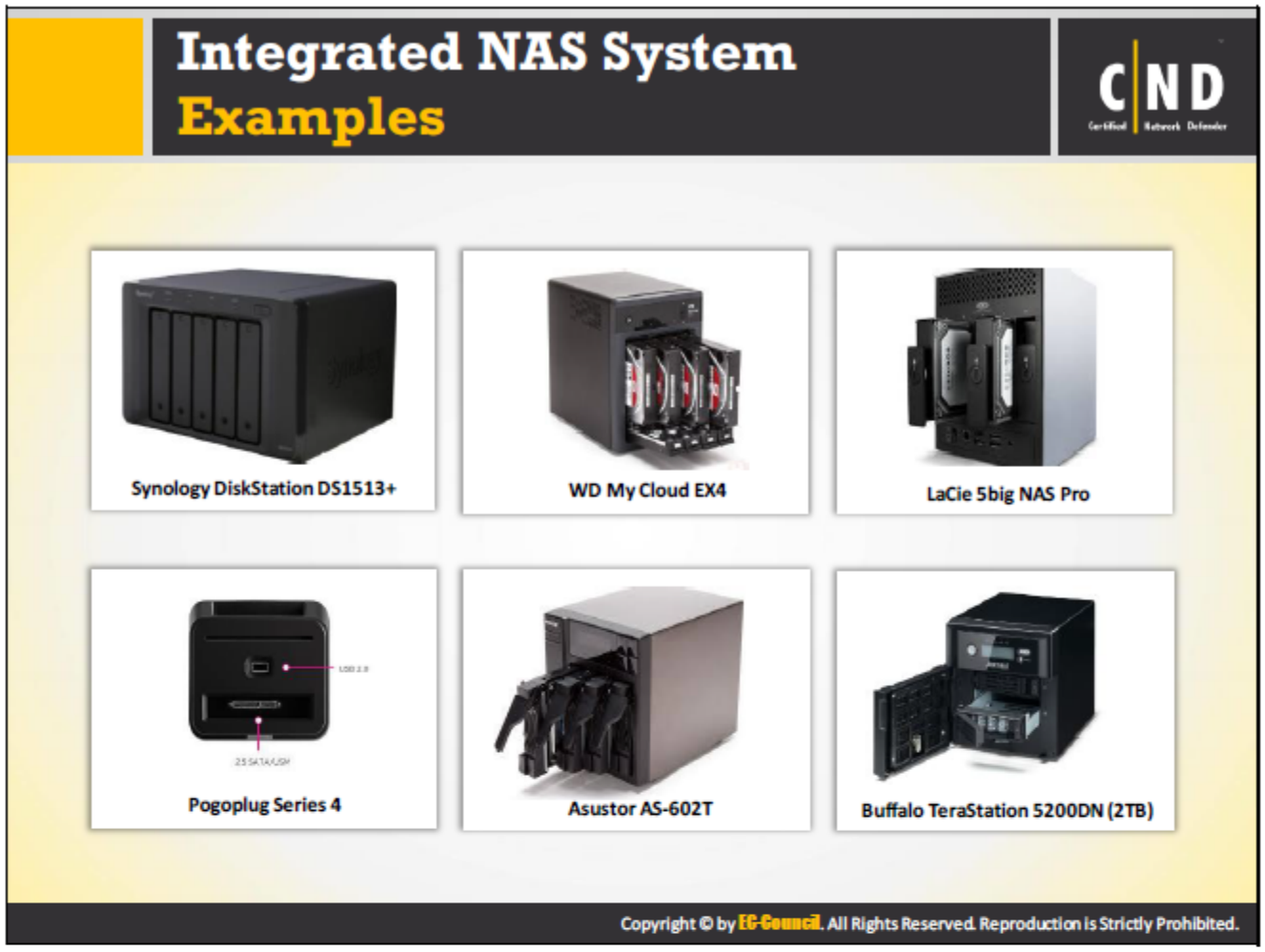
High-end devices provide additional amounts of storage space and high scalability.

Advantages

- Easy to implement
- Uses simple tools

Disadvantages

- Limited capacity and performance
- No performance upgrade



Synology DiskStation DS1513+

Source: *https://www.synology.com*

The Synology DiskStation DS1513+ offers massive dynamically scalable storage space, stellar performance, a robust Web interface and it supports a vast quantity of useful features for home, small and medium business applications.

WD My Cloud EX4

Source: *www.wdc.com*

The WD My Cloud EX4 offers data redundancy, Windows Server integration and an excellent set of personal cloud features. It is affordable and very easy to use. It is not the fastest NAS, nor does it include many advanced features, but the WD My Cloud EX4 still combines great ease of use into an affordable personal cloud system that is excellent for a connected home.

LaCie 5big NAS Pro

Source: *www.lacie.com*

The LaCie 5big NAS Pro offers super-fast performance and has an excellent drive bay design. The NAS server is also easy to use and can scale up its storage space dynamically.

Pogoplug Series 4

Source: *https://pogoplug.com*

Features of Pogoplug Series 4 include:

- Automatic, remote backup for computers and mobile devices
- Continuous backup on the go
- Access the backups from anywhere
- Powerful
- Secure, easy sharing

Asustor AS-602T

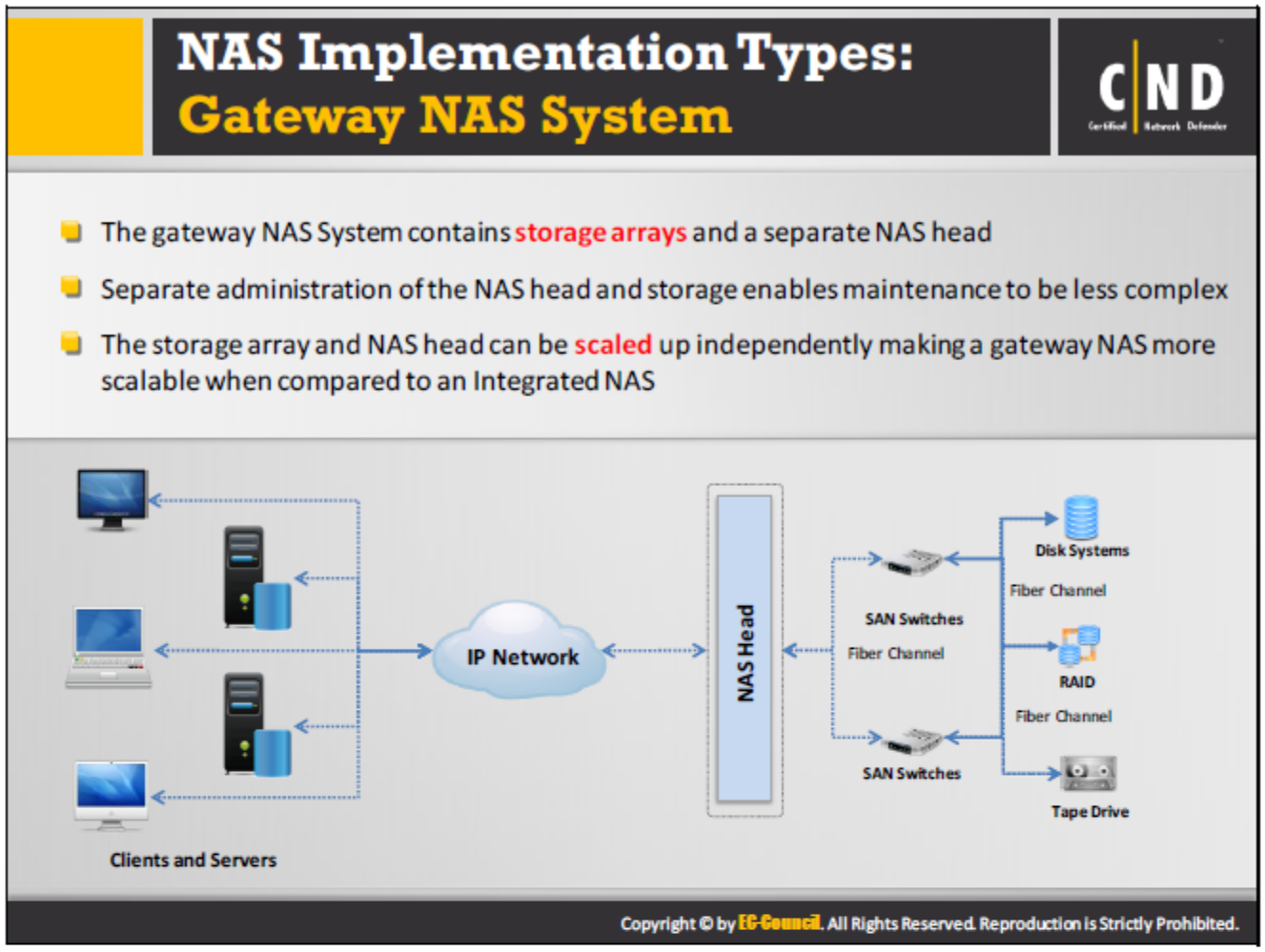
Source: *https://www.asustor.com*

ASUSTOR NAS devices provide optimal data protection through RAID technology. Support a diverse array of automatic backup solutions, guaranteeing the security of data. Seamless cross-platform file sharing allows to easily connect to the NAS device no matter what OS is used such as Windows, Mac OS or Unix-based.

Buffalo Terastation 5200DN (2TB)

Source: *www.buffalotech.com*

TeraStation 5200 is a high performance 2-drive network storage solution ideal for businesses and demanding users requiring a reliable RAID based NAS and iSCSI storage solution for larger networks and business critical applications.



A NAS gateway is considered a NAS appliance attached to an already existing SAN. In this NAS implementation, a SAN deals with the storage and a NAS gateway deals with a section of the block storage capacity. File-based storage is used in a gateway implementation.

The drawbacks of a gateway NAS implementation are:

- The NAS hardware is comparatively more costly than other file servers.
- Difficult for users to manage the block-level storage of the SAN, which is attached to the NAS's overhead.
- The NAS GUI is entirely different from that of a SAN, making it difficult for users to manage.

The gateway NAS system includes an independent NAS Head and multiple storage arrays. Gateway NAS requires additional management functions compared to an Integrated NAS. Gateway NAS provides high scalability as the NAS head and storage arrays scale up according to the requirements of the organization. A gateway NAS when combined with a SAN, provides a large amount of storage capacity.

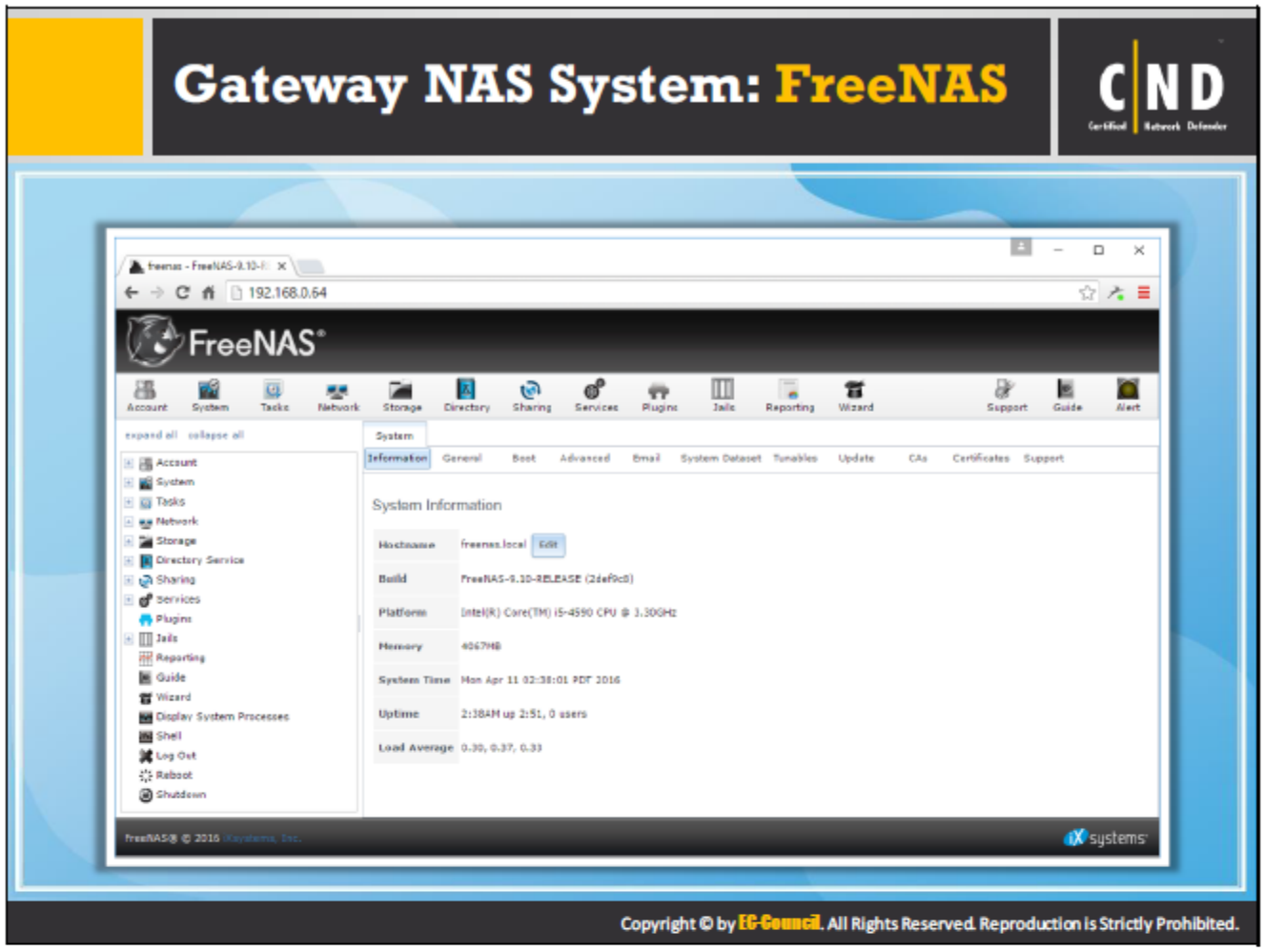
Increase scalability by adding more NAS heads, making it difficult to determine the network requirements for the gateway environment. A fiber channel SAN may be used for the connection between the gateway NAS and the storage system.

Advantages

- Ability to use available SAN storage.
- Upgrades front-end and back-end separately.

Disadvantages

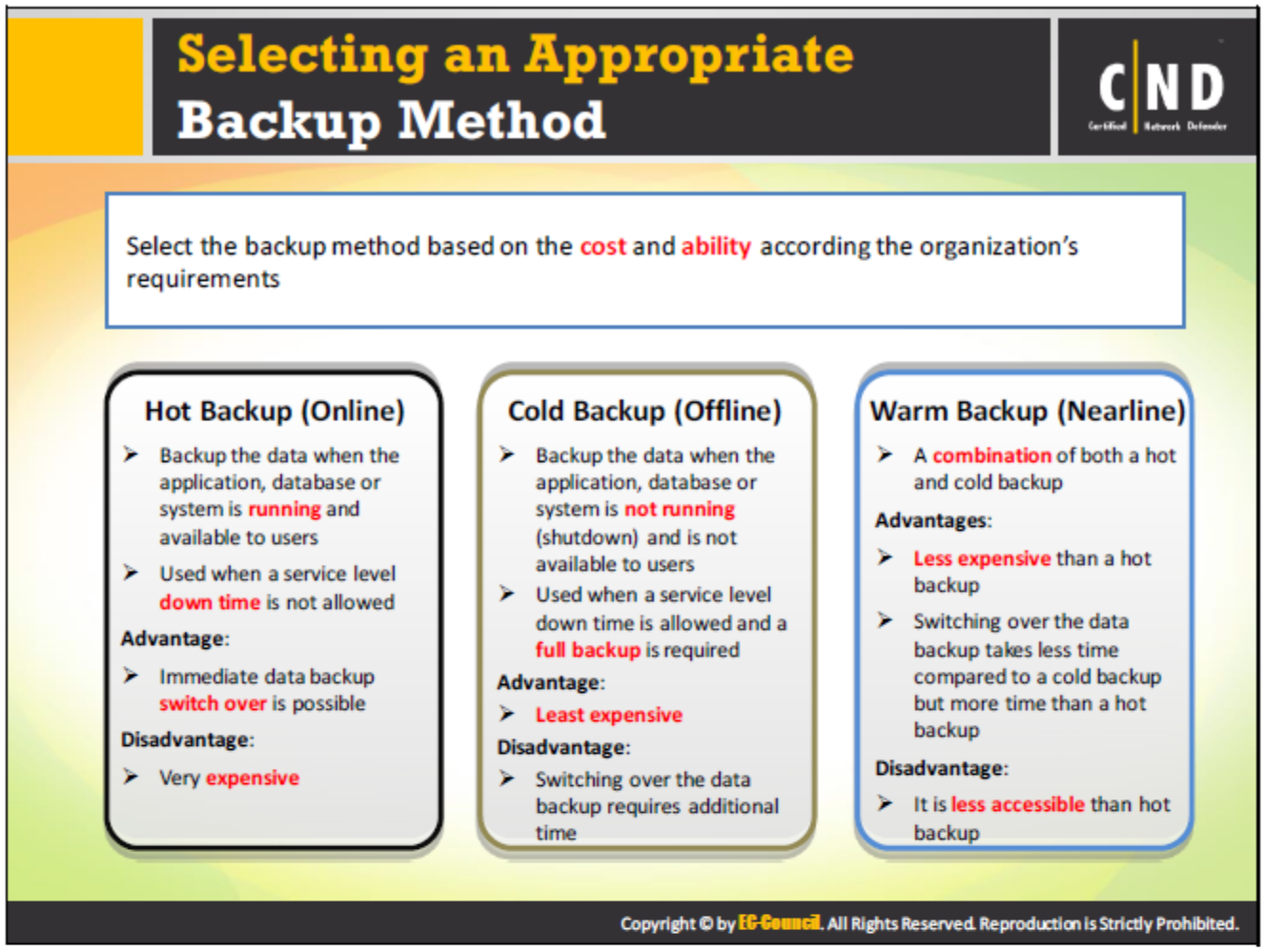
- The capacity depends on the storage space available on the NAS system.



FreeNAS is an operating system that is installed virtually on any hardware platform, to share data over a network. It is the simplest way to create a centralized and easily accessible location for data. FreeNAS with ZFS protects, stores and backups all the data. FreeNAS is used everywhere, for the home, small business and the enterprise. FreeNAS features are:

- **Web Interface**: Simplifies administrative tasks. Every aspect of the FreeNAS system can be managed from a web interface.
- **File Sharing**: SMB/CIFS (Windows File shares), NFS (Unix File shares) and AFP (Apple File Shares), FTP, iSCSI (block sharing).
- **Snapshots**: Snapshots of the entire file system can be made and saved at any time. Access files as they were when the snapshot was made.
- **Replication**: Employ the replication feature to send snapshots over the network to another system for true off-site disaster recovery.

Source: *http://www.freenas.org*



Organizations can choose any backup method depending on their budget and IT infrastructure. The different types of data backup methods are:

Hot Backup

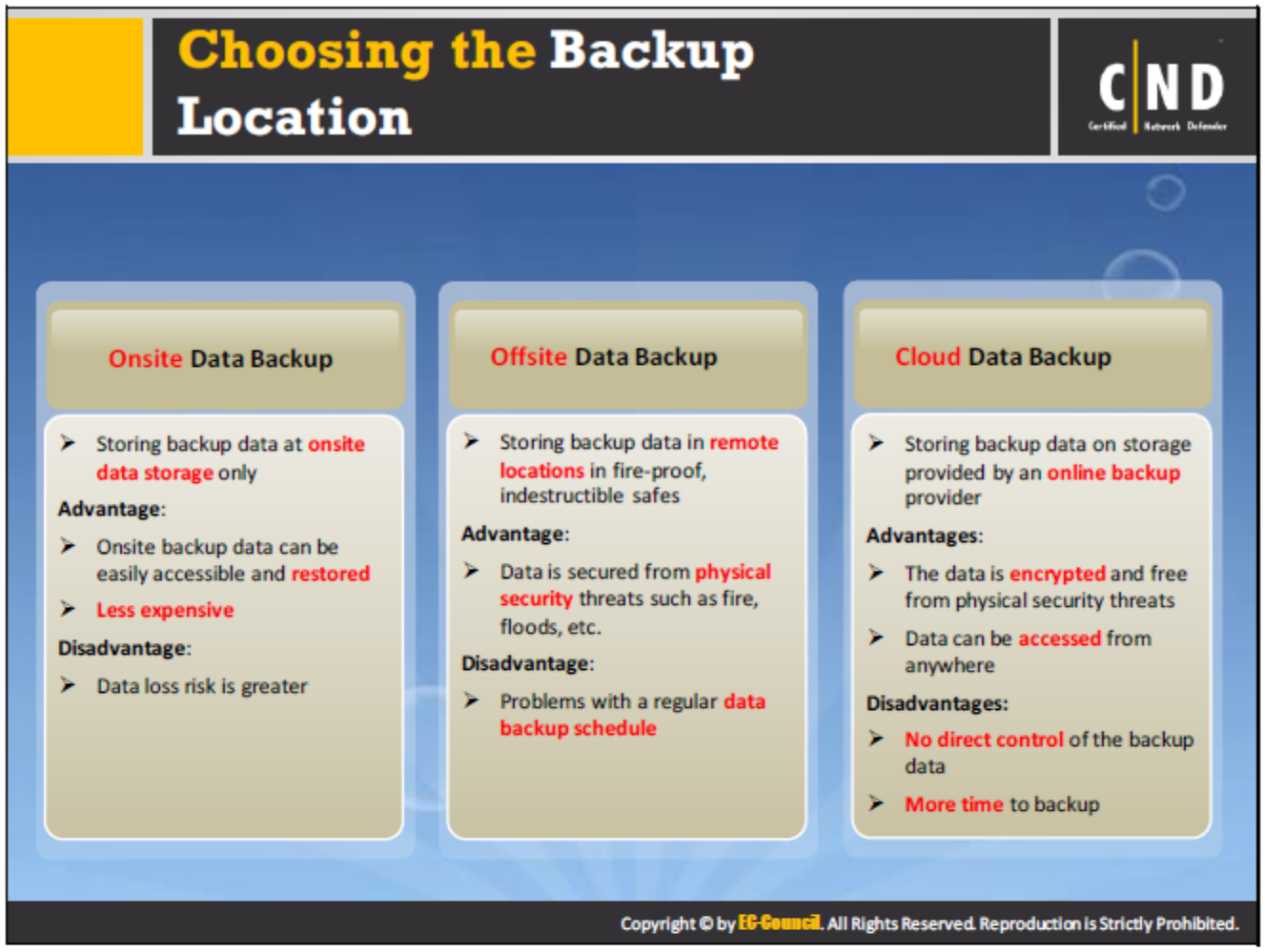
A Hot backup is a popular type of backup method used. It is also called as dynamic backup or active backup. In a hot backup, the system continues to perform the backup process even if the user is accessing the system. Implementation of a hot backup in an organization, avoids downtime. However, changes made to the data during the backup process is not reflected in the final backup file. Also, while the backup is in process, users may find the system is running slow. A hot backup is an expensive process.

Cold Backup

A Cold backup is also called an offline backup. The cold backup takes place when the system is not working or is not accessible by users. A cold backup is the safest method of backup as it avoids the risk of copying the data. A cold backup involves downtime as the users cannot use the machine until the process is back online. A cold backup is not as expensive as a hot backup.

Warm Backup

A Warm backup is also called a nearline backup. It will have connectivity to the network. In a warm backup, the system updates are turned on to receive periodic updates. It is beneficial when mirroring or duplicating the data. The warm backup process can take a long time and the process can be conducted in intervals that can last from days to weeks.



Onsite data backup

This type of backup is performed within the organization. Onsite backup uses external devices such as a tape drive, DVD, hard disk, etc. The choice of external storage will depend on the amount of data to be backed up.

- **Advantages:**
  - Provides immediate access to data.
  - Less expensive.
  - Media used for onsite backup is readily available and costs less.
  - Faster recovery.
  - Enhanced scalability.
  - Internet access is not required.
- **Disadvantage:**
  - Requires direct human interaction to perform the backup.
  - Susceptible to theft or natural disasters.

Offsite data backup

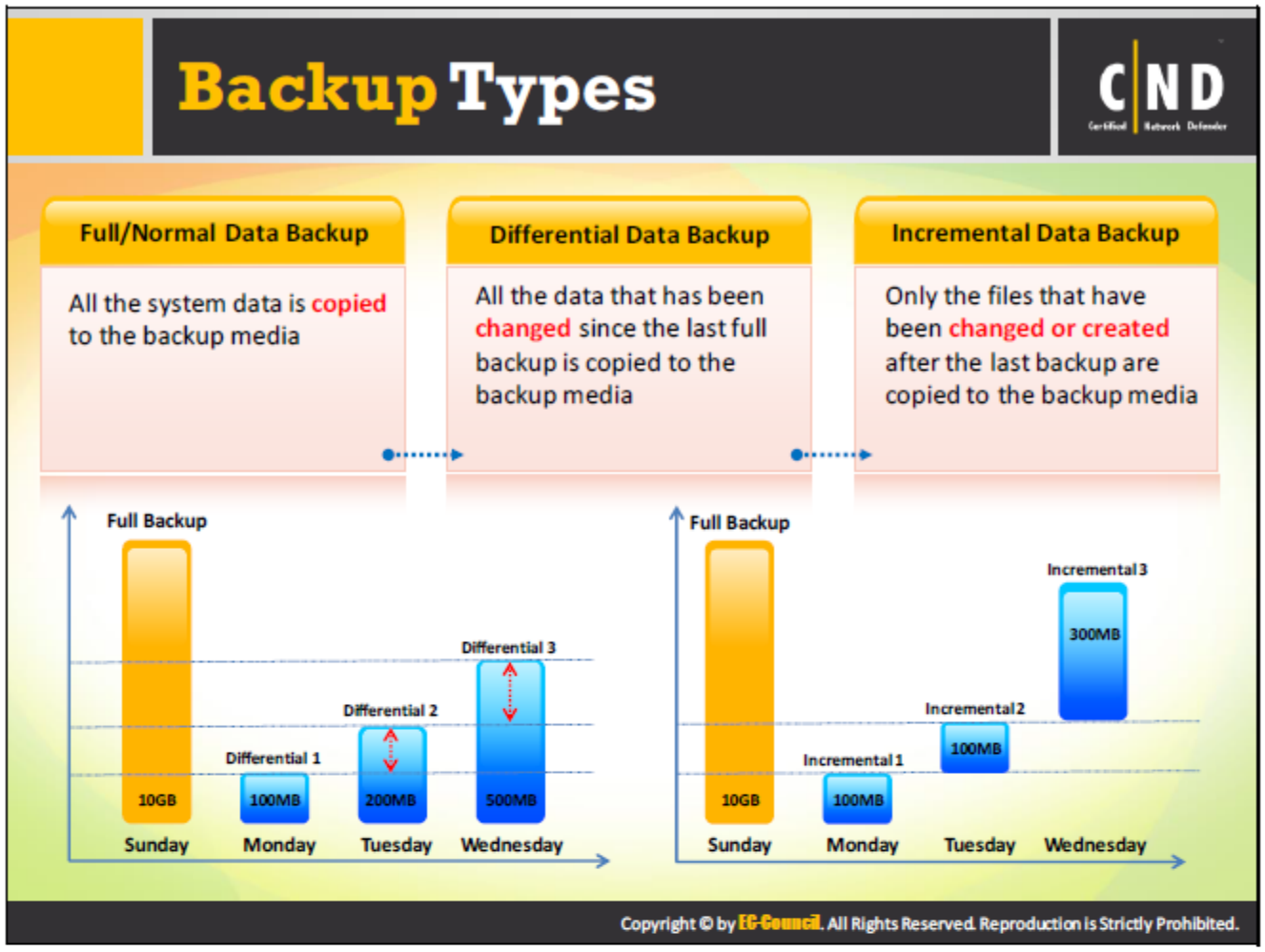
In an offsite backup, the backup is done at a remote location. It either stores the data on physical drives, online or third party backup service. Storing the data online helps have an updated data backup available.

- **Advantages:**
  - Implementing offsite backup creates multiple copies that can be stored in multiple locations.
  - Human error is minimal as the backup process is automated.
  - Data retention is unlimited.
- **Disadvantages:**
  - It is expensive, requiring a third party service.
  - Requires an Internet connection and the bandwidth consumption will be higher.
  - The process is lengthy and time consuming.

Cloud data backup

A Cloud backup is also known as online backup. It involves storing the backup on a public network or on a proprietary server. Usually a third party service provider hosts the proprietary server. The backup process in a cloud data backup works according to the requirements of the organization. If the organization needs the backup on a daily basis, the proprietary server will run a daily backup. Usually any non-critical data is archived using a cloud data backup.

- **Advantages:**
  - Cloud data backup is efficient as the technology implemented is disk-based backup, virtualization, encryption, etc.
  - Many proprietors provide data monitoring and create reports for the organization.
  - The data in a cloud backup is easily accessed and the data can be accessed through the Internet.
- **Disadvantages:**
  - Data recovery can be time consuming.
  - Cloud data backup proprietors do not give any assurances or guarantees concerning the completion of the backup. It is the responsibility of the organization to check if the backup process was successful.



An appropriate backup type is the one that does not add a major impact to the bandwidth, cost, time required and the resources of the organization. The three most common backup types are full, differential and incremental.

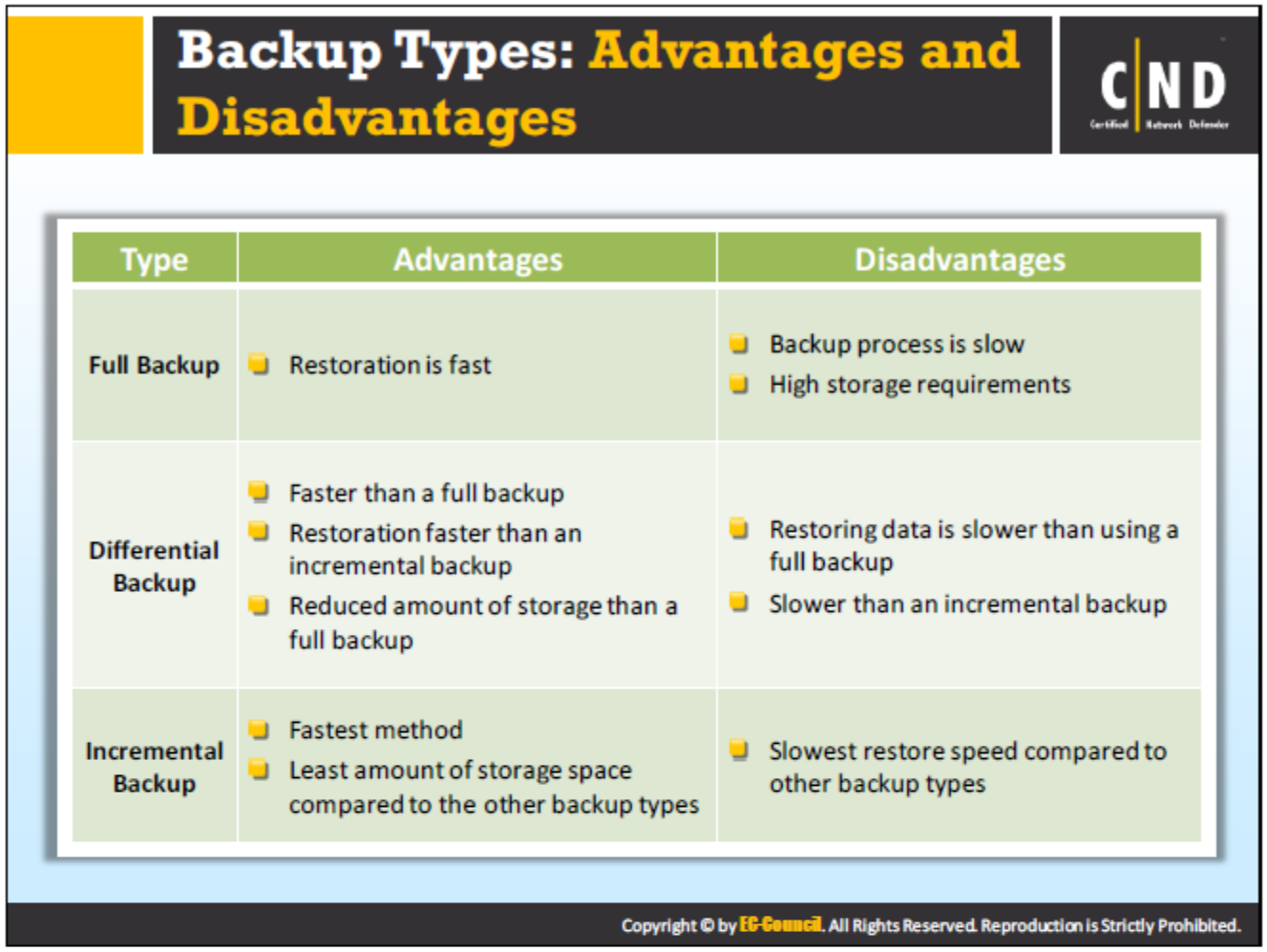
Backup Types:

- **Full Backup:** Is also called a normal backup. The full backup occurs automatically according to a set schedule. It copies all the files and compresses them to save space. A full backup provides efficient data protection to the copied data.
- **Incremental Backup:** Backups only the data that has changed since the last backup. The last backup can be any type of backup. Before an incremental backup can be performed, the system should be backed up using a full or normal backup.

  Example: Assume a full backup of a system is schedule for Sunday and from Tuesday to Saturday, an incremental backup is scheduled. Once the full backup is performed on Sunday, the incremental backup on Monday will only backup the changes that occurred on Sunday. This process will continue until Saturday.
- **Differential Backup:** Differential backup is the combination of a full backup and an incremental backup. A differential backup backs up all the changes made since the last full backup.

  Example: Considering the above example, assume full backup is scheduled for Sunday and then a differential backup is scheduled to run until Saturday. Once the full backup is

completed on Sunday, the differential backup will occur on Monday and the data that was changed will be backed up. This sounds a lot like an incremental backup. However, on Tuesday, the backup will be for the changes made on Sunday and Monday. Then on Wednesday, it will contain the changes from Sunday, Monday and Tuesday.



Compare the advantages and disadvantages for each backup type and then select the type best suited for the organization.

Full Backup

- **Advantages:**
  - It is easy to restore, the process requires a file name and a location.
  - Maintains different versions of the data.
- **Disadvantages:**
  - A time-consuming process because each file is backed up every time a full backup is performed.
  - Very large storage requirements.

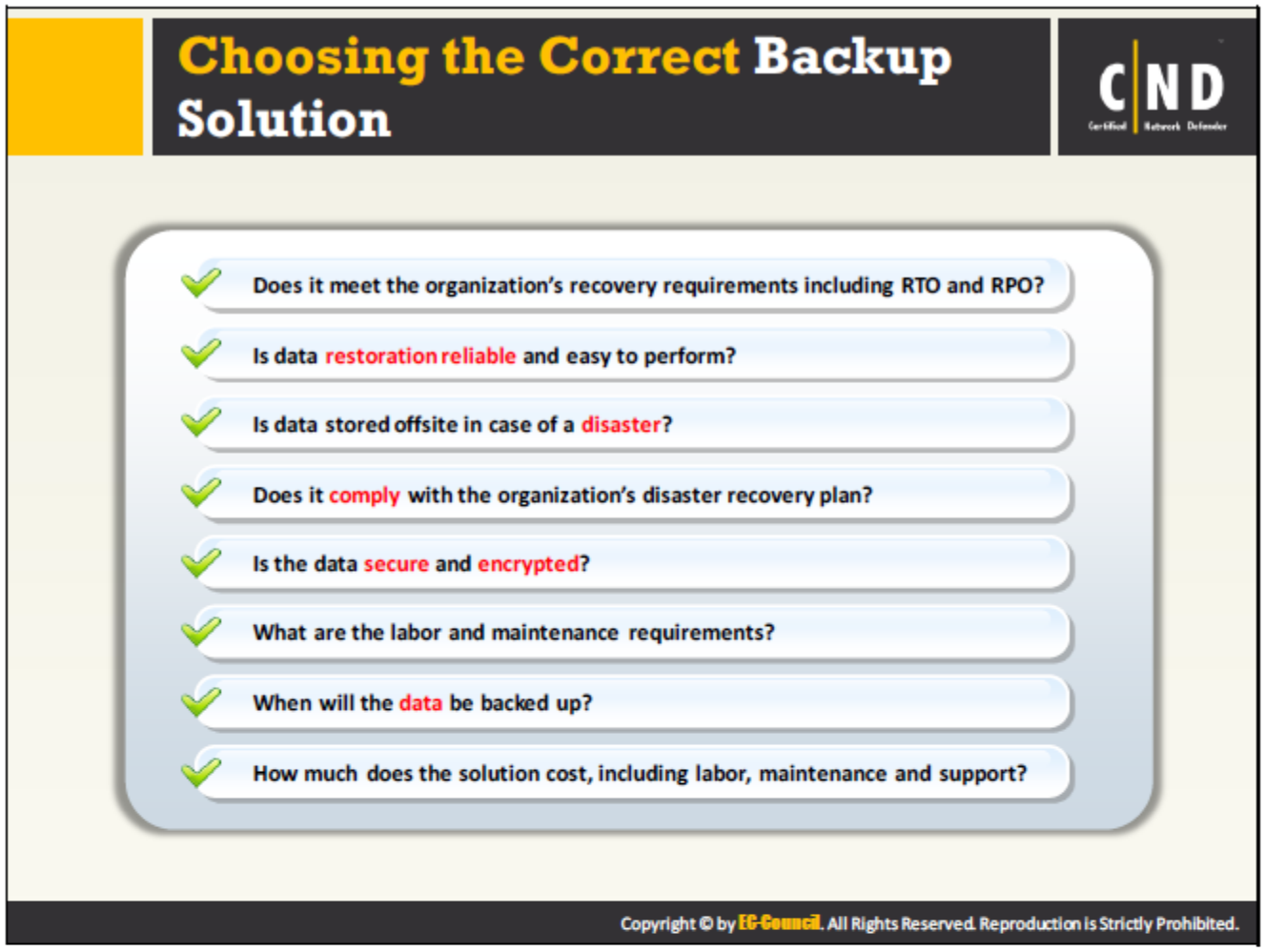
Incremental Backup

- **Advantages:**
  - Faster than a full backup.
  - Uses storage space efficiently, there is no data duplication.

- **Disadvantages:**
  - Data restoration is time consuming and a complex process, first a full backup is done of and then an incremental backup afterwards.

Differential Backup

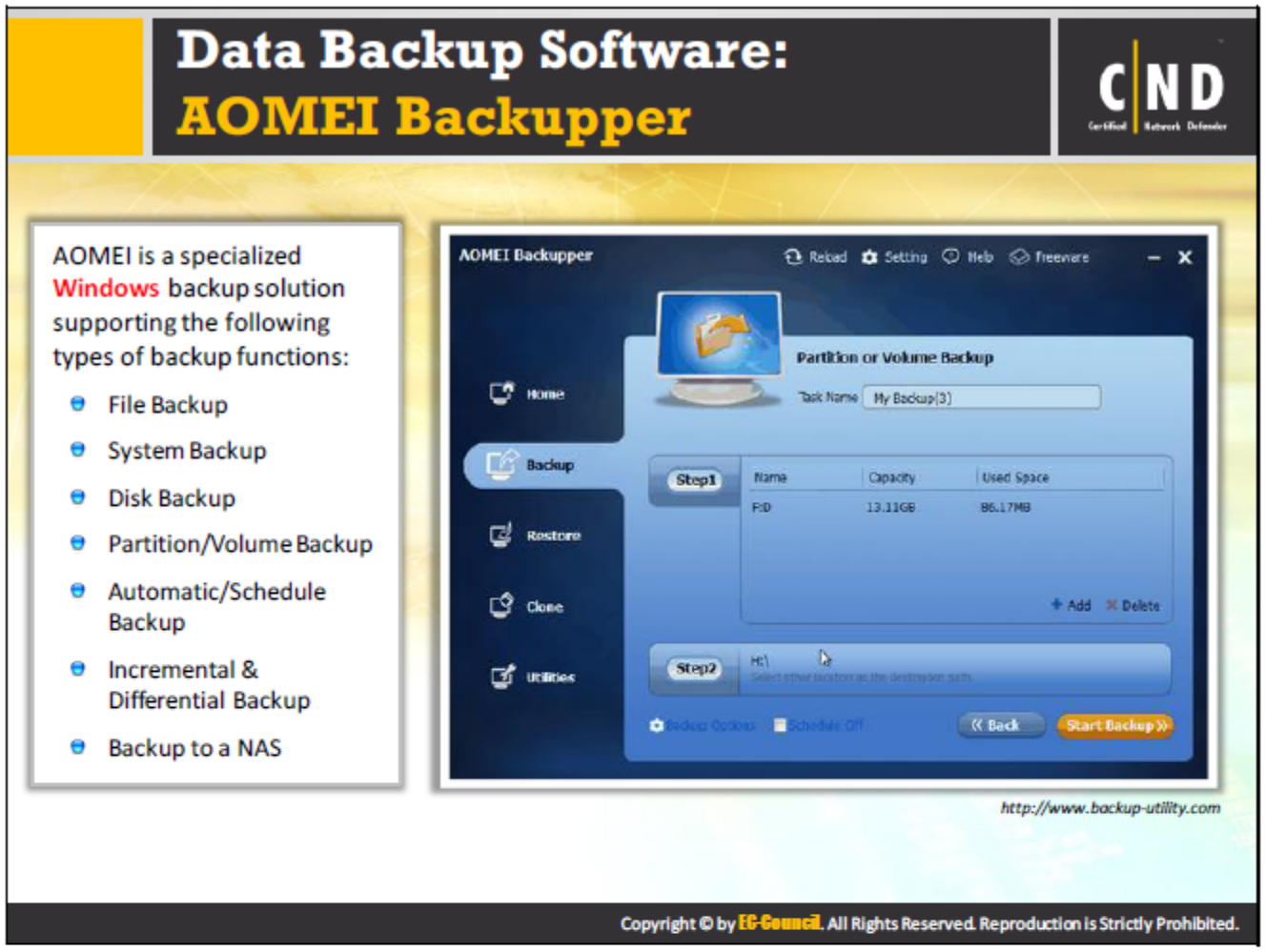
- **Advantages:**
  - Faster than a full backup.
  - Uses storage space more efficiently than a full backup, the backup only contains the changes made at regular intervals.
  - Data restoration is faster than an incremental backup.
- **Disadvantages:**
  - Slower than an incremental backup.
  - Restoration process is slower than a full backup.



Choosing an appropriate backup solution is essential for efficient and effective backups. Data loss is avoidable to an extent with excellent backup solutions.

Consider the following items before selecting a backup solution:

1. **RTO and RPO standards:** RTO and RPO should be the main parameter of your disaster recovery plan. RTO is Recovery Time Objective and is the duration required to restore the data. RPO is Recovery Point Objective and is the interval that passes before data quality is lost.
2. **Data restoration:** The data restoration process should be easy and reliable. The longer the restoration process, the higher the productive loss. Look for a backup solution that offers an efficient and quick data restoration process to your organization.
3. **Off-site storage:** It is necessary to identify if the solution stores the data off-site. If the backup solution does not offer an off-site storage solution, the security of the data is not guaranteed and the backup can get affected from unwanted occurrences.
4. **Security:** It is the responsibility of the backup solution vendor to provide proper security to the data. The solution should consist of an encryption feature, acting as add-on security to the data.
5. **Solution know-how:** Understand how the backup solution functions. Understand how long a backup takes to complete, the maintenance required, additional costs, implementation in the organization infrastructure, cost and etc.



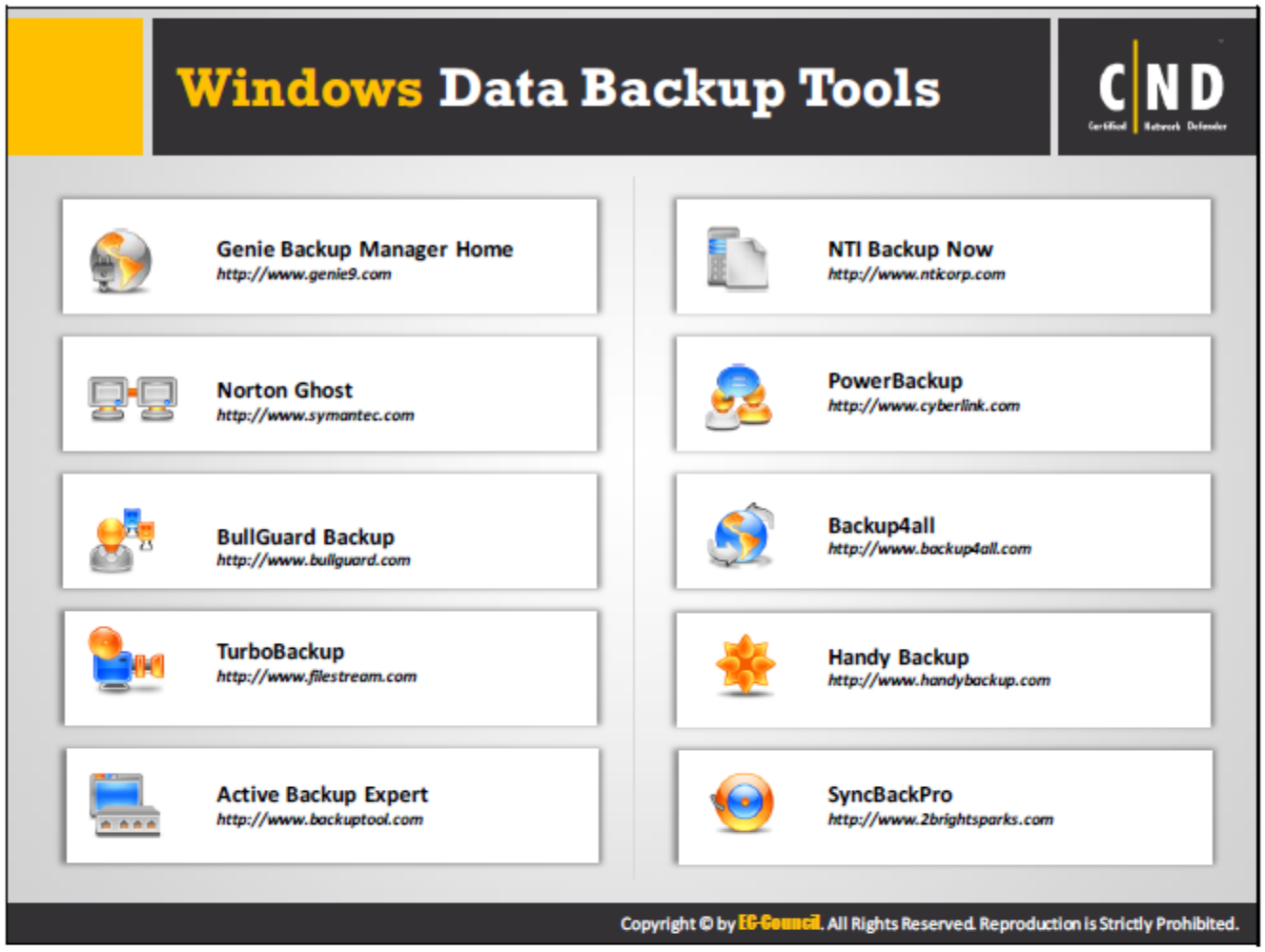
AOMEI Backupper is available backup and recovery software helping those with little to no knowledge on backup and recovery processes. The main functions of software are:

- Backup all critical data on a regular basis.
- Reduces the time required for backing up data through incremental and automatic backups.
- Backup the entire hard disk or partitions.
- Creates a system image to keep Windows and applications safe.

AOMEI backs up files, folders, hard disk drives, partitions and applications. If there is a loss of data, it will restore the files. It includes a disk imaging and cloning tool to create an exact image of the hard disk and operating system. The backup types supported by AOMEI include:

- File, System and Disk
- Partition/Volume
- Automatic/Schedule
- Incremental/Schedule
- Backup to a NAS

Source: *http://www.backup-utility.com*



Genie Backup Manager Home

Source: *https://www.genie9.com*

Genie Backup Manager Home is a tool that provides full control of backup procedures. The main features of Genie Backup Manager Home are:

- Full featured backup product
- Security
- Recover the entire system in case of a disaster
- Resource friendly
- Access backups without the need for additional software
- Full control over the backup procedure
- Track the backup anywhere

Norton Ghost

Source: *https://www.symantec.com*

Norton Ghost 15 backs up an entire system or specific files and folders while saving recovery points to offsite locations using FTP.

BullGuard Backup

Source: *http://www.bullguard.com*

BullGuard Backup is an online backup solution for keeping electronic valuables safe.

TurboBackup

Source: *http://www.filestream.com*

TurboBackup provides an option to create multiple backups of shared documents to more than one destination. It also offers the ability to back up and retain different versions of the same file to protect documents from accidental loss.

Active Backup Expert

Source: *http://www.backuptool.com*

The Active Backup Expert (ABE) is a software that backs up important files on a Windows platform.

Active Backup Expert advantages:

- Zip and Cab format.
- Hard disk, network, CD-RW, CD-R, DVD, floppy, FTP server and other device support. Can choose any drive in the system to store the backups.
- Full, Incremental and Differential backup modes.
- Basic backup projects.
- Strong encryption.
- Set-and-forget.
- Backup management.

NTI Backup Now

Source: *http://www.nticorp.com*

NTI Backup Now backs up and restores files and folders on your Windows PC.

Features:

- Enhanced performance for faster backups.
- Incremental drive image backup for a complete system backup and restore.
- Support for Microsoft Volume Shadow Copy Service (VSS).
- Customized description fields in a backup job.
- Create a bootable image restore CD/DVD.
- Restore from a particular point in time.

PowerBackup

Source: *http://www.cyberlink.com*

PowerBackup provides support for the following types of data backup:

- Full.
- Differential.
- Incremental.

Backup4all

Source: *http://www.backup4all.com*

Backup4all is a backup program for Windows that protects data from partial or total losses. It automates the backup process, compresses the data to save storage space (using standard zip format) and encrypts the backup to protect it from unauthorized use.

Handy Backup

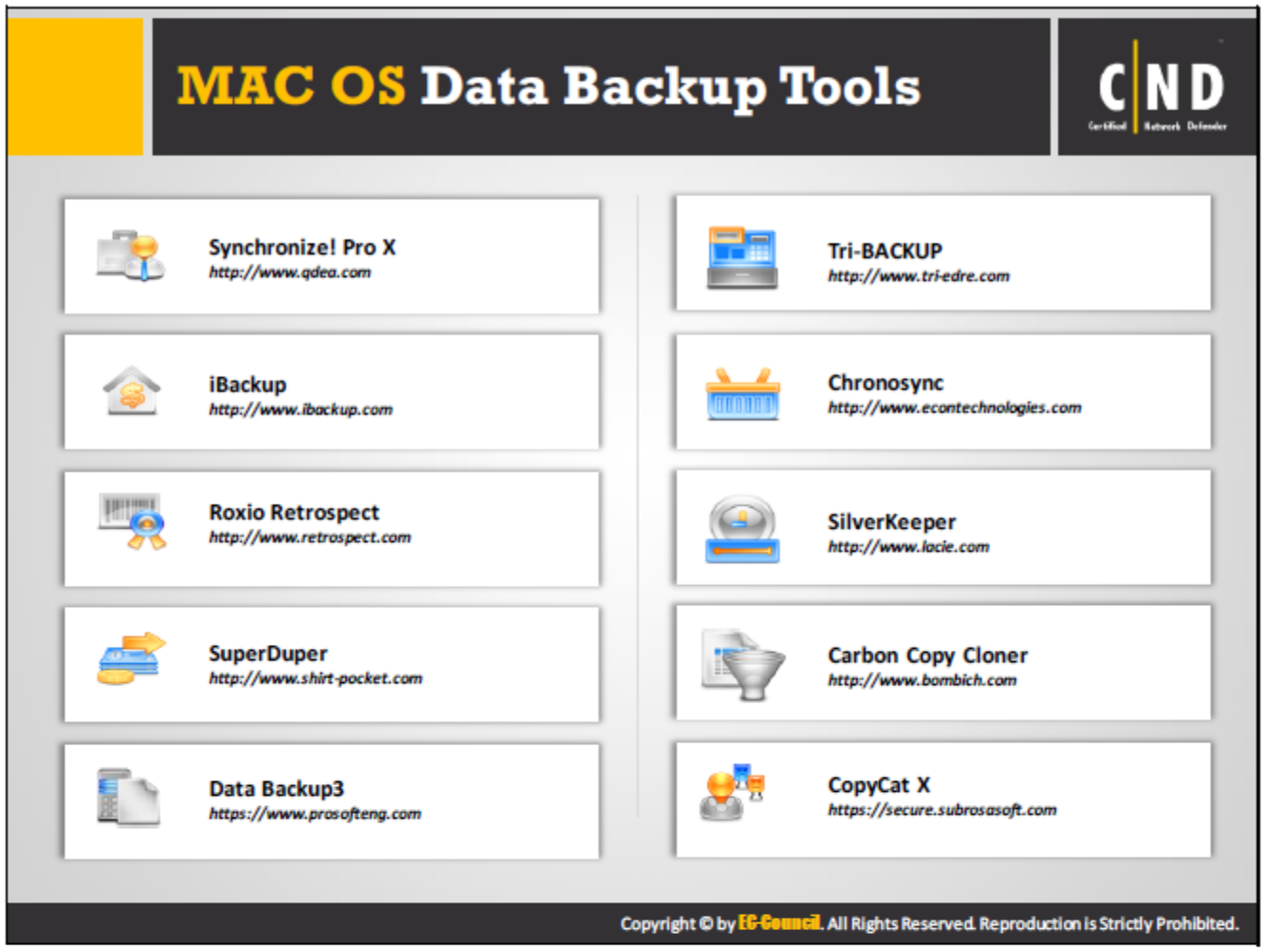
Source: *http://www.handybackup.com*

Handy Backup is a program designed for an automatic backup of critical data virtually to any type of storage media including CD/DVD-RW devices and remote FTP servers. This tool creates a reserve copy of valuable data. Special add-ons provided enable MS Outlook, system registry and ICQ files to be backed up.

SyncBackPro

Source: *http://www.2brightsparks.com*

SyncBackPro is used to backup, synchronize and restore data files. It is used by individuals, small businesses and mission critical organizations including law enforcement agencies, hospitals and government departments.



Synchronize! Pro X

Source: *http://www.qdea.com*

Synchronize! Pro is a tool for high-end server backup solutions because it can reliably handle millions of files on disks containing terabytes of data. Synchronize! Pro X actions can be scheduled when changes occur, at night or at any preset time, once or periodically, without anyone present. Passwords can be supplied automatically for file server connections.

iBackup

Source: *http://www.ibackup.com*

iBackup backups and restores user data, system and applications settings such as System Preferences, Mail, iPhoto, iTunes. It can also use third party application settings from any Mac to another Mac.

Roxio Retrospect

Source: *http://www.retrospect.com*

Retrospect backup and recovery software is mainly used at medical offices, law firms, banks, auto repair shops, restaurants, departments in large corporations, universities, government offices and many others.

SuperDuper

Source: *http://www.shirt-pocket.com*

SuperDuper has a user friendly interface to create a fully bootable backup.

Data Backup3

Source: *https://www.prosofteng.com*

Data Backup3 is a backup software solution that backs up, restores, and synchronizes important files with minimal effort.

Tri-BACKUP

Source: *http://www.tri-edre.com*

Tri-BACKUP protects the data from a single copy on an external drive to a set of actions that back up on different types of media. Each is then kept in different locations for maximum security (including backups on the Internet).

Chronosync

Source: *http://www.econtechnologies.com*

ChronoSync can synchronize backups and create a bootable backup for almost anything a Mac can be connected to: external drives, NAS drives, other Macs, PC's or anything else that can be mounted as a volume.

SilverKeeper

Source: *http://www.lacie.com*

SilverKeeper provides the use of a USB drive or FireWire to create a complete backup. This tool provides the function for verifying the backup is complete by comparing the source and destination. It keeps a status log recording the details of the backup.

Carbon Copy Cloner

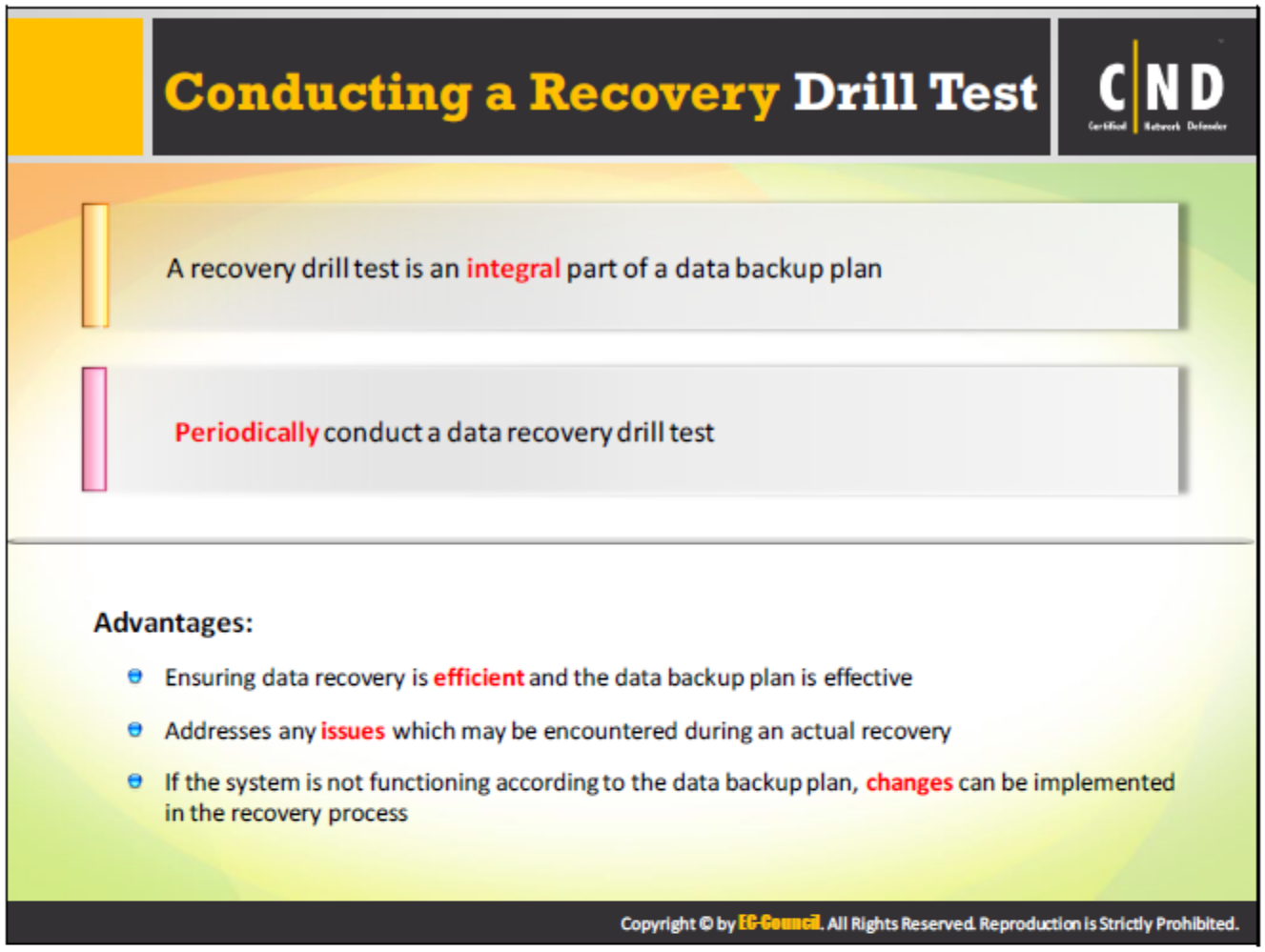
Source: *https://bombich.com*

Carbon Copy Cloner is a cloning and backup utility. With this software, the data and the operating system's data is preserved on a bootable volume.

CopyCat X

Source: *https://secure.subrosasoft.com*

SubRosaSoft CopyCatX™ is an easy-to-use and fast utility for duplicating volumes, cloning drives or recovering intermittent/mechanically unsound drives.



While 80% of organizations create a disaster recovery plan, only 40% create any plans for testing it.

The organization needs to perform these data drills often to check if the recovery process is effective according to backup plans created. These drills further help locate the areas of improvement in the recovery plans. The challenges performing these drills are:

- Whether the drills are conducted periodically.
- Whether issues found in one test is addressed and resolved by the team.
- Whether there are any changes in the recovery plans.
- Was the drill test perfect?
- Whether the right person is addressing the issues the drill test identified.

The purposes for conducting a recovery drill test are:

- Check if the recovery plans meet the company's requirements.
- Provide a level of expertise to the team who is conducting the tests for the recovery plans.
- Detect what areas of the recovery plan require improvement.

An organization performs a drill test to validate it has a foolproof and updated DR plan. It is advised to perform a recovery drill test at least once or twice a year, depending on the size of the organization.

Remember the items below for a successful recovery drill test:

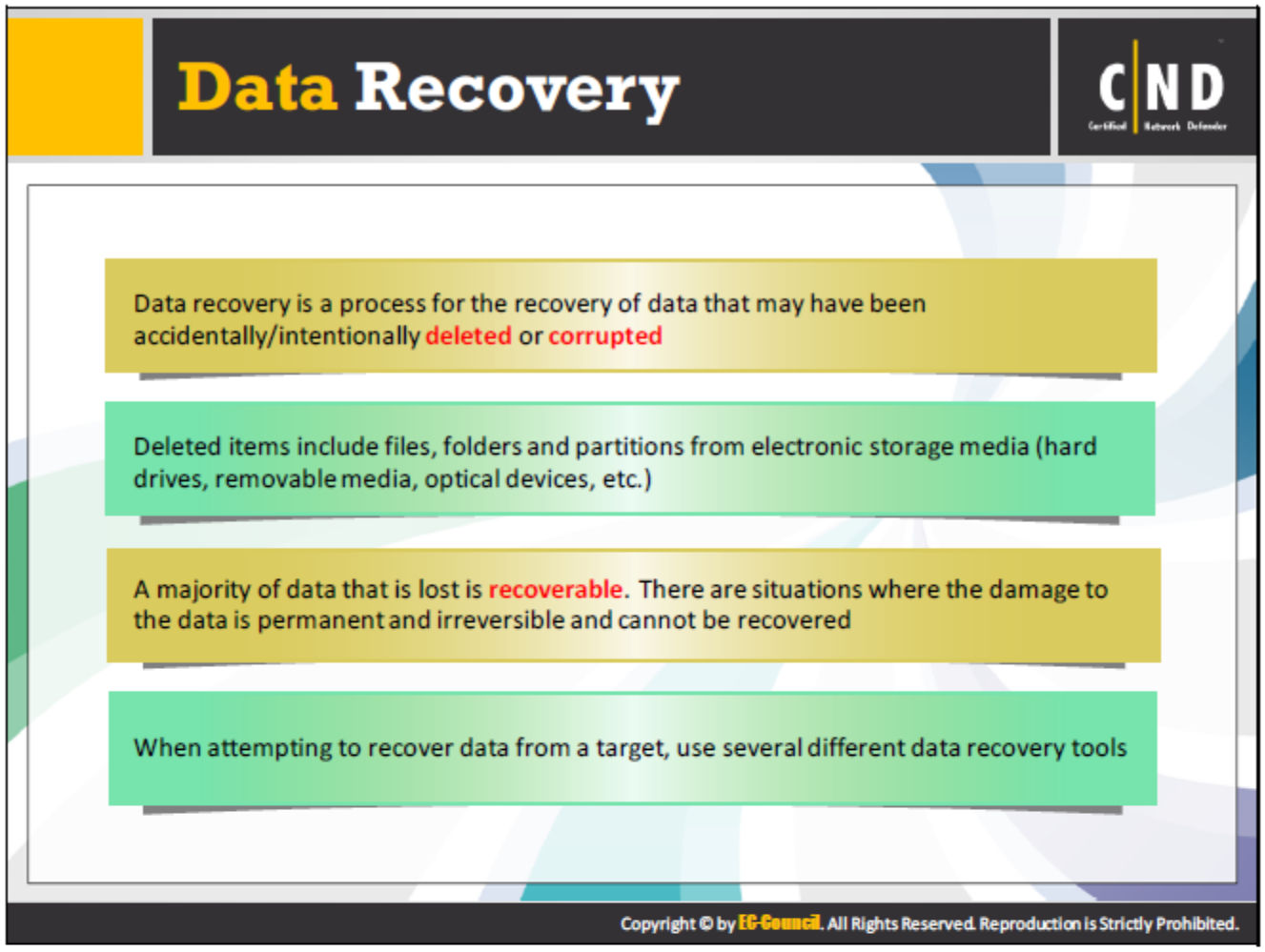
1. **Regular Testing:** For a successful DR plan, a recovery drill test should be performed regularly. Before proceeding with the test, it is important to go through the DR blueprint.
2. **Broadcasting to users:** Before performing a recovery drill test it is important to inform all employees, stakeholders and vendors of the organization. Organizations should brief employees on the necessary actions to take when there is a data breach or disaster. This is also covered in the incident response plan.
3. **Testing applications:** Apart from system testing, application and user account testing should also be performed. Any user account without a password should be immediately corrected.
4. **Pen Tester:** If a user can access the files and folders in the system without administrator privileges, it means that any user can. Organizations should have a pen tester check for any vulnerabilities in the network. If a vulnerability is detected it must be documented and a solution provided.

Performing a drill test:

Before beginning the recovery drill test, organizations should set certain goals:

1. An internal DR team or a third party can conduct the drill test.
2. Maintain a record of the analysis.
3. Reconfirm the disaster plan is realistic and is parallel to current technology.
4. The DR plan should be accessible to more than one person.

A DR plan for any organization is successful only when the drill test confirms the resources are secure and not vulnerable.



Data loss is a primary concern for any organization. Data recovery refers to the restoration of data from devices or from a backup. The process of data recovery varies depending on how the data was lost, the data recovery software and the device where the data will be restored.

Information stored on storage devices such as a flash drive, a hard disk, DVD, etc. can be recovered. Users should not write or save over any data stored on the affected media. Improperly trained users should not perform data recovery. The disaster recovery plan should mention the individual/team responsible for recovery of data in the organization. Data recovery software can assist with retrieving the data usually with great results.

The correct knowledge and the proper use of tools help in the recovery process.

Probability of recovering the data:

Data recovery will not always be successful. If a system is too corrupt and/or damaged, recovery may not be possible and fail. The probability of recovering the data depends on the cause of the loss. The common causes for data loss are:

1. **File Deletion**: If a file is deleted, it will remain in the storage space until it has been overwritten. This can happen if the OS reuses the disk space. Even if the change is minor it can make the chances of data recovery negligible. Windows operating systems have a file deletion algorithm on NTFS formatted disks and the data can be recovered using this algorithm.

2. **File Corruption:** If an operating system is corrupted, the data can be recovered using the partition table. If the partition table is corrupt, it can be repaired using data recovery software.
3. **Physical Drive Damage:** Physical damage to a hard drive or an external drive can cause a larger amount of data loss compared to a file corruption. Recovering data from a damaged device requires a specific level of expertise. When recovering from corrupt physical devices, the environment where the recovery process takes place must be free of pollutants. This process often occurs in a clean room. Dust particles can make the recovery difficult if not impossible. Having a certified clean room to recover the data is recommended. When recovering data from damaged drives, the drive is either rebuilt or a disk image is created. This process can be very expensive, depending on how extensive the damage.

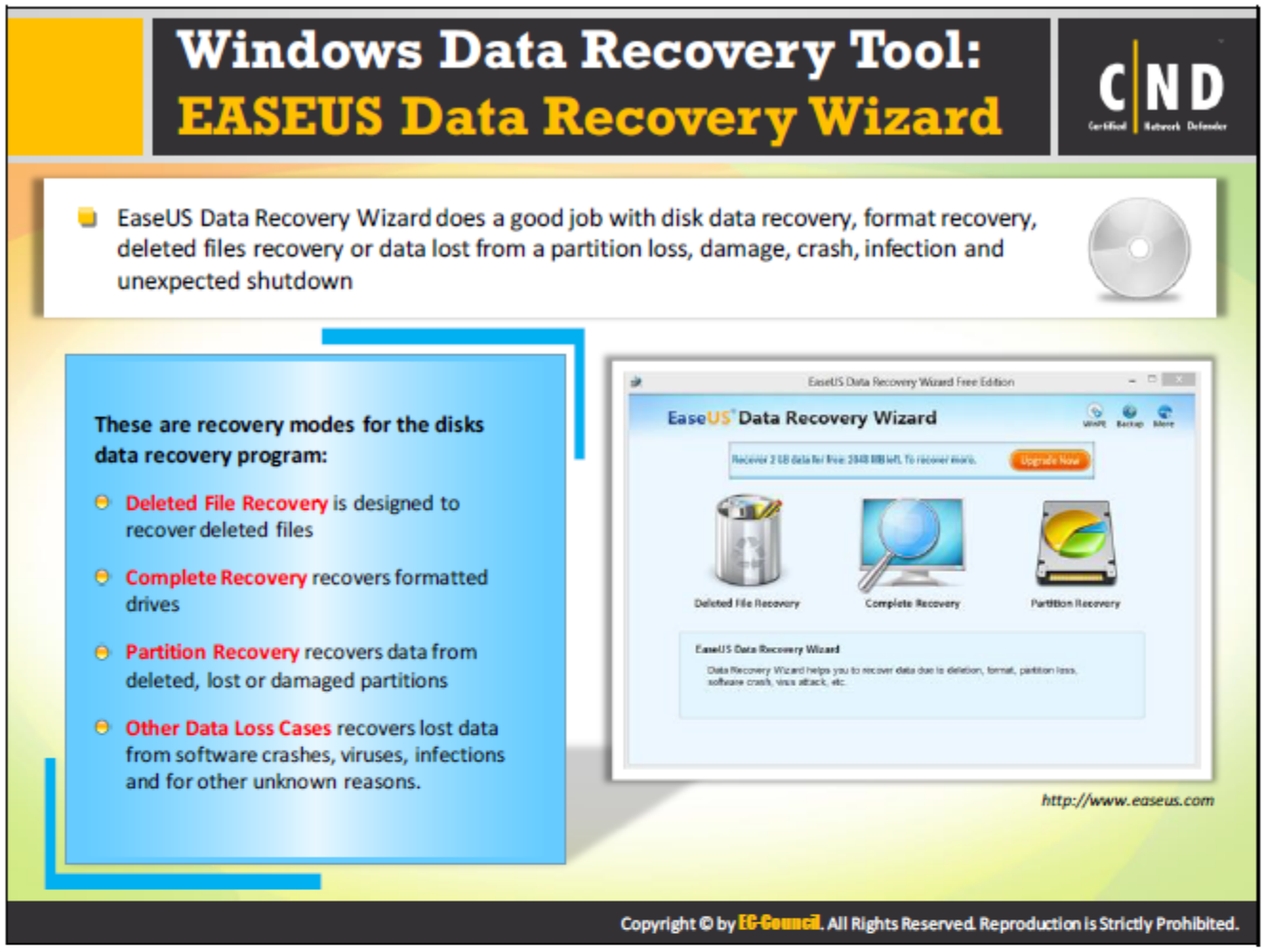
Points to remember:

1. Be cautious when plugging in an external device to the system. The device may be corrupt, which will result in corruption of the files or the system.
2. Never overwrite the data on the same storage location where the data was lost.
3. Create multiple backups and store them in different locations.
4. Data recovery is not 100% perfect every time.

Recover My Files recovery software recovers data lost from the Windows recycle bin, hard drives, files and data lost due to a virus or malware. The recovery of the data depends on the file content. The Recover My Files recovery tool uses two mechanisms:

- **Lost file:** This mechanism searches for deleted files. Unfamiliar file types cannot be added. The file name searched is found in the 'deleted files' and not in the 'lost file', as deleted files are stored on the disk and not destroyed.
- **Lost drive recovery:** This mechanism helps recover files that were stored on old drives.

Source: *http://www.recovermyfiles.com*



EaseUS data recovery wizard is a tool that recovers lost data or files from iOS, Android, removable media and hard drives in the event of an unexpected error.

EaseUS features:

- Retrieve deleted, formatted and inaccessible data.
- Retrieve all deleted files like images, documents, videos etc.
- Retrieve data from a PC, laptop, hard drive etc.
- Retrieve data from deleted, lost or hidden partitions.
- Provides technical assistance to customers.
- Retrieve data after the computer faces an issue booting.

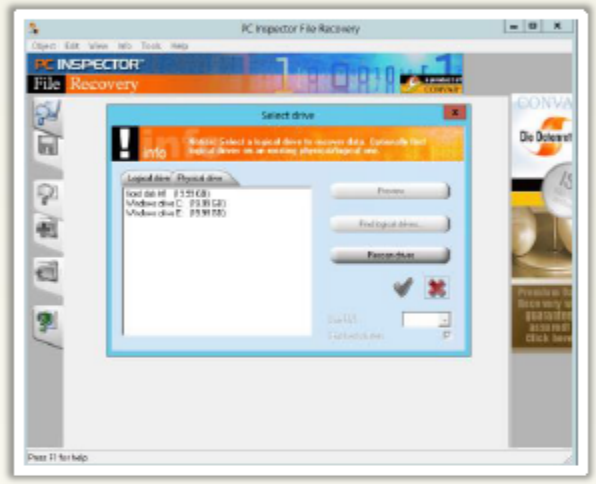
Source: *http://www.easeus.com*

Windows Data Recovery Tool: PC INSPECTOR File Recovery

PC INSPECTOR File Recovery 4.x is a data rescue program supporting the FAST 12/16/32 and NTFS files systems

Features:

- Locates drives automatically even if the boot sector or file system is damaged
- Recovers files with the original time and date including network drives
- Supports saving recovered data
- Recovers files, even when a header entry is no longer available

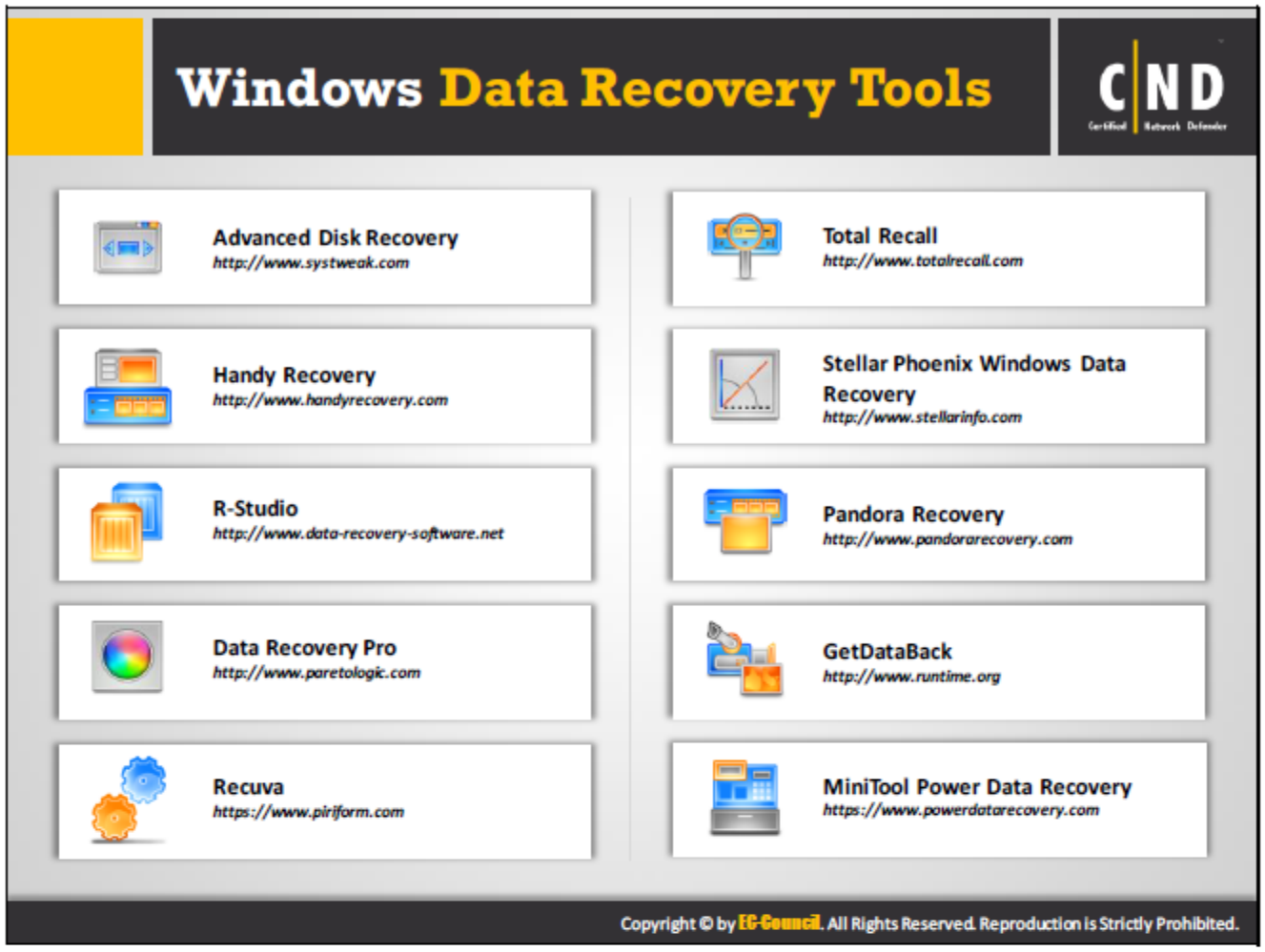


http://www.pcinspector.de

PC Inspector File Recovery deals with the recovery of data supporting FAT 12/16/32 and NTFS file systems. PC Inspector automatically locates deleted files or damaged recovered files along with the date and time. Recovers files even in the absence of a header entry.

The software supports: Files with .JPG, .TIF, .BMP, .GIF formats and many types of memory cards such as CompactFlash, SmartMedia etc.

Source: *http://www.pcinspector.de*



Advanced Disk Recovery

Source: *http://www.systweak.com*

Advanced Disk Recovery used to recover accidentally deleted data. It is possible to restore every type of file and folder stored on a Windows PC and from multiple storage devices.

Handy Recovery

Source: *http://www.handyrecovery.com*

Handy Recovery™ is used to restore files accidentally deleted from hard drives, all types of USB/eSATA devices and memory cards.

The tool recovers:

- Files damaged by virus attacks, power failures and software faults.
- File deleted by a program that does not use the Recycle Bin or if the Recycle Bin was emptied containing the file.

R-Studio

Source: *http://www.data-recovery-software.net*

R-Studio is a data recovery tool uses advanced file recovery and disk repair technology in order to recover files.

Data Recovery Pro

Source: *http://www.paretologic.com*

Data Recovery Pro scans for deleted email messages and recovers emails. It can even recover deleted email attachments and partial files due to bad sectors. It has the ability to retrieve missing files from many peripheral storage devices, including iPod Shuffle, iPod Nano, and iPod Classic.

Recuva

Source: *https://www.piriform.com*

Recuva recovers pictures, music, documents, videos, emails or any other file type lost accidently from a Windows system, recycle bin or a memory card.

Total Recall

Source: *http://www.totalrecall.com*

Total Recall Data Recovery Software obtains lost data back from hard drives, RAID, photos, deleted files, iPods, even removable disks connected via Firewire or USB is supported by Total Recall.

Stellar Phoenix Windows Data Recovery

Source: *http://www.stellarinfo.com*

Stellar Phoenix Windows recovery software recovers photos, images, songs, movies, and other multimedia files deleted or lost due to corruption or formatting of hard drives, memory cards, or external storage.

Pandora Recovery

Source: *http://www.pandorarecovery.com*

Pandora Recovery allows finding and recovering deleted files from NTFS and FAT-formatted volumes, regardless of their type. Pandora Recovery scans the hard drive and builds an index of existing and deleted files and directories (folders) on any logical drive on the system with supported file format.

GetDataBack

Source: *http://www.runtime.org*

GetDataBack software allows easy and fast recovery of data with NTFS, FAT and EXT formats.

Features of Get Data Back include:

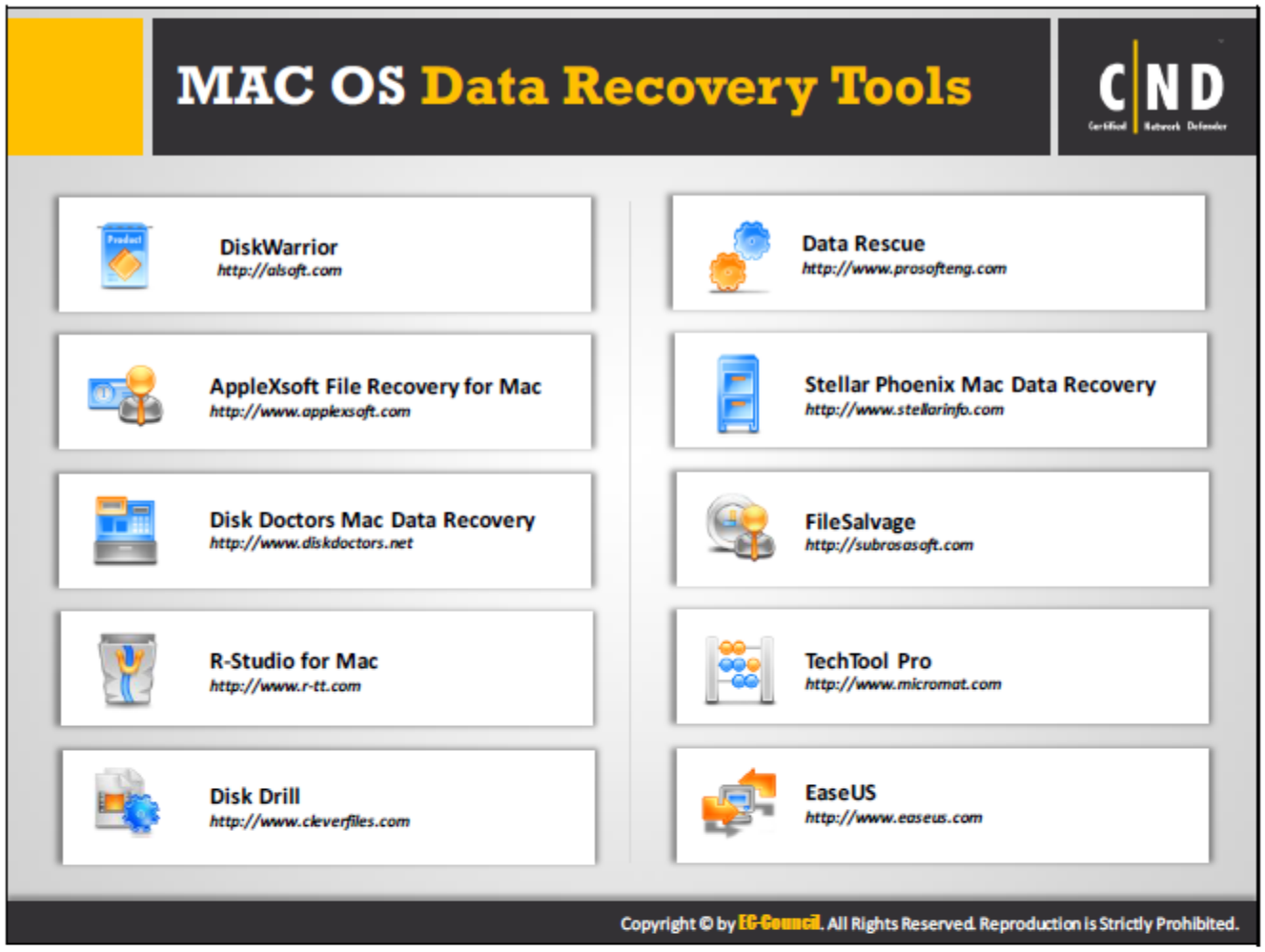
- Recover the drive's data
- Restore the file names and directory structure
- Safe, read-only design
- One easy click, it is simple, simpler, simplest

- Lightning fast operation
- Supports all hard drives, SSD, flash cards, USB
- Newly redesigned and rewritten, using the newest technologies
- Supports NTFS, FAT12, FAT16, FAT32, EXT, EXT2, EXT3, EXT4

MiniTool Power Data Recovery

Source: *https://www.powerdatarecovery.com*

MiniTool Power Data Recovery program helps recover deleted, lost and damaged files from Windows.



DiskWarrior

DiskWarrior

Source: *http://alsoft.com*

DiskWarrior will recover documents, photos, music and any other files from a Mac system.

AppleXsoft File Recovery for Mac

Source: *http://www.applexsoft.com*

AppleXsoft File Recovery scans and recovers damaged or deleted files from any type of storage drive, including all hard disks, external hard drives and SSD. It supports various digital removable media such as a SD card, CF card, CD/DVD, USB drive, etc.

Disk Doctors Mac Data Recovery

Source: *http://www.diskdoctors.net*

Disk Doctors Mac Data Recovery software recovers lost and deleted data from HFS+ and HFSX file systems on Mac OS. Disk Doctors Mac Data Recovery software helps recover lost data with simplicity matching the Mac OS.

R-Studio for Mac

Source: *http://www.r-tt.com*

R-Studio for Mac recovers files from HFS/HFS+ (Macintosh), FAT/NTFS/ReFS (Windows), UFS1/UFS2 (FreeBSD/OpenBSD/NetBSD/Solaris) and Ext2/Ext3/Ext4 FS (Linux) partitions. In

addition, raw file recovery (scan for known file types) can be used for heavily damaged or unknown file systems. R-Studio for Mac also recovers data on disks, even if their partitions are formatted, damaged or deleted.

Disk Drill

Source: *http://www.cleverfiles.com*

Disk Drill can scan and recover data from virtually any storage device - including internal Mac hard drives, external hard drives, cameras, iPods, USB flash drives, Kindles and memory cards.

Data Rescue

Source: *http://www.prosofteng.com*

Data Rescue is hard drive recovery software that can recover your photos, videos and documents from:

- Crashed, corrupted or non-mounting hard drives.
- Accidentally reformatted hard drive or reinstalled OS.
- A previous deletion, damaged or missing files

Stellar Phoenix Mac Data Recovery

Source: *http://www.stellarinfo.com*

Use Mac data recovery software to restore documents, photos, music or videos lost due to deletion from any HFS, HFS+, FAT, ExFAT and NTFS format based file systems.

FileSalvage

Source: *http://subrosasoft.com*

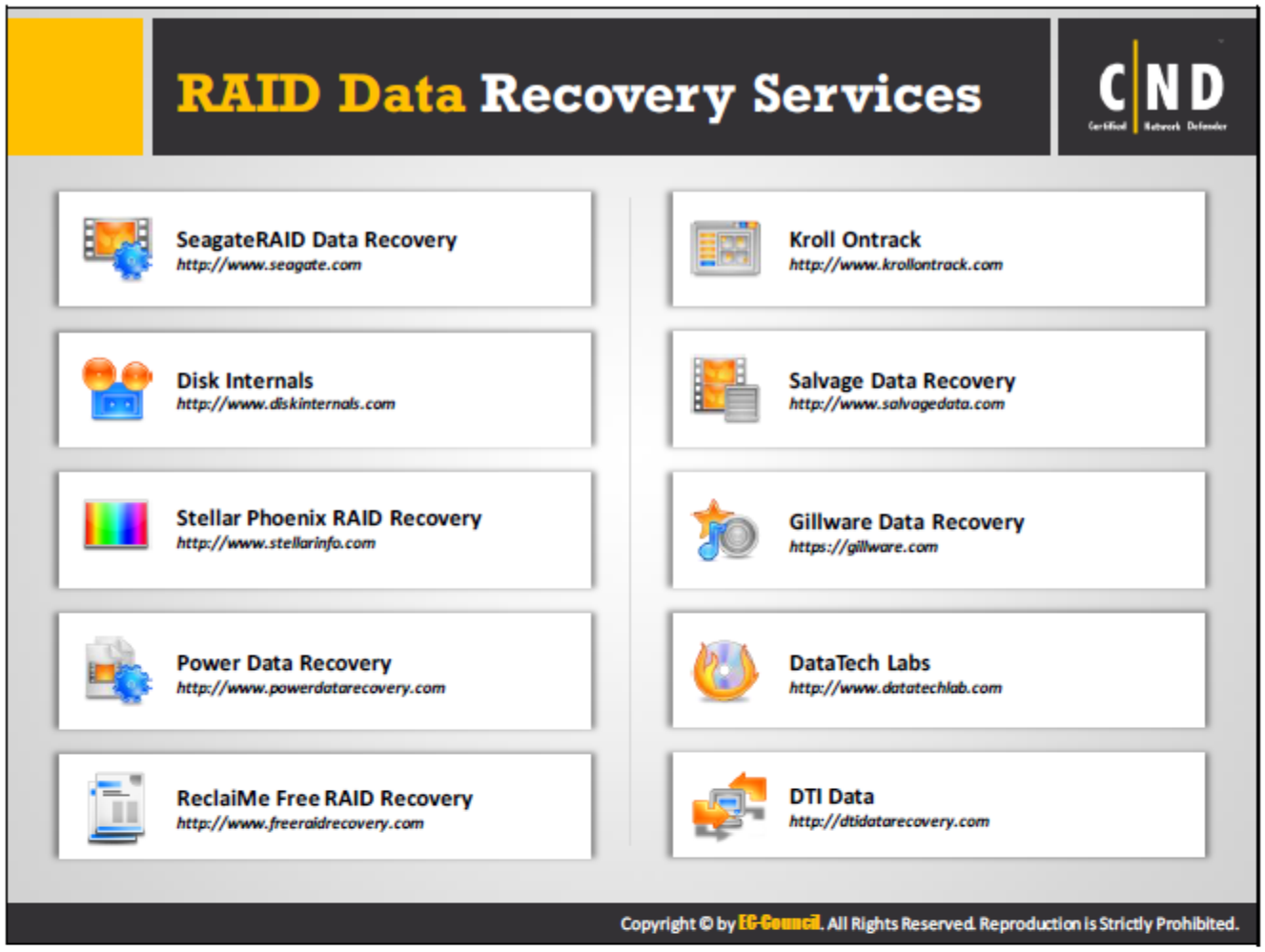
FileSalvage can recover files from a normal Mac OS hard drive, USB key, PC disk, Linux disk, FAT32 disk, FLASH card, scratched CD, Digital Camera, iPod and almost any other media or file system that can be recognized in a Mac OS.

TechTool Pro

Source: *http://www.micromat.com*

TechTool Pro's data recovery routines consist of three parts:

- Protection: Recover files/folders based on previously saved Directory Backup files.
- Drives: Recover files/folders based on scavenged directory data.
- Trash: Recover deleted files based on the Trash History.



Seagate RAID Data Recovery

Source: *http://www.seagate.com*

Seagate Recovery Services can successfully recover data from the very earliest to most recent NAS, SAN, and Server RAID configurations on the market.

Disk Internals

Source: *http://www.diskinternals.com*

Disk Internals recover all types of RAID arrays. It supports all configurations of RAID arrays, including RAID 0, 1, 5, 0+1, and JBOD (span), and supports dedicated RAID controllers and native RAID chipsets embedded into motherboards produced by Intel, NVIDIA, and VIA.

Stellar Phoenix RAID Recovery

Source: *http://www.stellarinfo.com*

Stellar Phoenix RAID Data Recovery Software recovers lost or inaccessible data from RAID 0, 5 or 6 hard drives. The tool has a full range of advanced features for recovering files, photos, videos, documents and emails from Windows hard drives, external media and RAID servers.

Power Data Recovery

Source: *http://www.powerdatarecovery.com*

Power Data Recovery is able to recover lost RAID data.

ReclaiMe Free RAID Recovery

Source: *http://www.freeraidrecovery.com*

ReclaiMe Free RAID Recovery is designed for recovering RAID configuration parameters like:

- Disk order
- Block size
- Start offset and others

Kroll Ontrack

Source: *https://www.krollontrack.com*

Krolltrack software allows recovery of data from RAID storage.

Salvage Data Recovery

Source: *https://www.salvagedata.com*

Salvage Data Recovery centers specialize in recovering all types of files and RAID servers.

Gillware Data Recovery

Source: *https://gillware.com*

RAID data recovery is done by recovering data from individual failed disks and then reassembling it based on the type of RAID system.

DataTech Labs

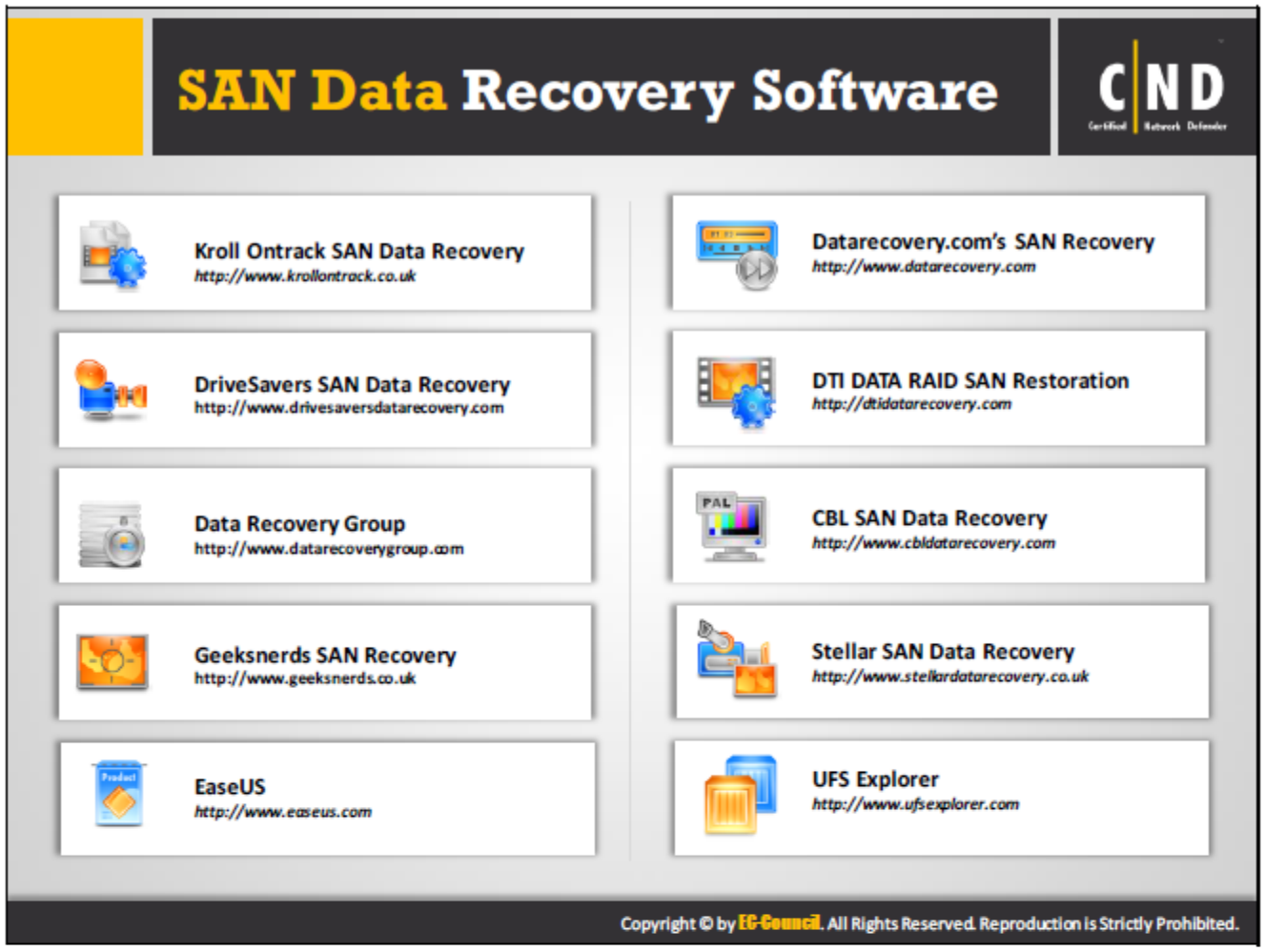
Source: *https://datatechlab.com*

DataTech Labs is a nationwide leader in professional data recovery services. This software deals with deleted files, crashed hard drives or a failed RAID.

DTI Data

Source: *http://dtidatarecovery.com*

DTI Data Recovery can restore or recover RAID 5, SAN, NAS, Snap Server and many others.



Kroll Ontrack SAN Data Recovery

Source: *http://www.krollontrack.co.uk*

The Kroll Ontrack can be used to restore the original data on a SAN's shared pool storage architecture.

DriveSavers SAN Data Recovery

Source: *http://www.drivesaversdatarecovery.com*

DriveSavers can be used to recover data from all operating systems and all types of high-capacity storage environments including SAN, NAS, RAID, tape and multi-disk servers.

Data Recovery Group

Source: *http://www.datarecoverygroup.com*

Data Recovery Group is a data recovery service used for recovering data from Desktop Drives, Laptop Drives, External Drives, Servers, Network Attached Storage Devices (NAS), Storage Area Network Devices (SAN), Flash Drives and Camera Media.

Geeksnerds SAN Recovery

Source: *http://www.geeksnerds.co.uk*

Geeksnerds offers data recovery services for SAN devices. It recovers data from almost all manufacturers of SAN devices.

Datarecovery.com's SAN Recovery

Source: *https://datarecovery.com*

Datarecovery.com's SAN services recover or restore your SAN without the expensive downtime.

DTI DATA RAID SAN Restoration

Source: *http://dtidatarecovery.com*

DTI Data Recovery can restore or recover your RAID 5, SAN, NAS, Snap and many others.

CBL SAN Data Recovery

Source: *http://www.cbldatarecovery.com*

CBL provides data recovery services for a failed Storage Area Network (SAN), disk drives in laptops, desktops, servers, RAID arrays and tape cartridges.

Stellar SAN Data Recovery

Source: *http://www.stellardatarecovery.co.uk*

Data Recovery Services by Stellar facilitates secure data recovery for all hard drives, RAID, SSDs, SAN/NAS and for encrypted drives.

UFS Explorer

Source: *http://www.ufsexplorer.com*

UFS Explorer is used for data recovery from distributed SAN systems.

DataRecoveryGroup

Source: *http://www.datarecoverygroup.com*

The Data Recovery Group routinely recovers data from:

- Single or multiple disk failure
- Failed software or operating system upgrades
- Mechanical failure (clicking and buzzing)
- Virus attack
- System crash
- Accidental deletion of data or reformat of NAS volume
- Physical damage (fire, water, smoke, etc.)
- Power surge causing physical or logical corruption
- Data could not be viewed due to security system failure

Krollontrack NAS Data Recovery

Source: *http://www.krollontrack.co.uk*

Kroll Ontrack provides data recovery services for failed and damaged DAS, SAN and NAS storage systems.

Runtime Software's NAS Data Recovery

Source: *https://www.runtime.org*

NAS Data Recovery is capable of recovering the entire content of the broken NAS. NAS Data Recovery works for all XFS or EXT-formatted single-drive, RAID-0, RAID-1, or RAID-5 NAS stations from manufacturers such as Buffalo, Seagate, Western Digital, D-Link or Iomega.

DIY DataRecovery iRecover

Source: *http://www.diydatarecovery.nl*

iRecover is used to recover data from hard disks, memory cards, RAID arrays and Network Attached Storage (NAS) devices.

UFS Explorer

Source: *http://www.ufsexplorer.com*

UFS Explorer is capable of restoring lost data from a NAS. Use UFS Explorer RAID Recovery for recovery and reconstruction of a RAID will be helpful in the event when the NAS disks are organized in a RAID system.

ReclaiMe NAS Data Recovery

Source: *http://www.reclaime.com*

The ReclaiMe software recovers data from a NAS, hard drives, memory cards, USB drives and RAID arrays.

ZAR X

Source: *http://www.z-a-recovery.com*

ZAR X NAS data recovery provides data recovery for Windows and Linux.

Uneraser

Source**:** *http://www.diskinternals.com*

DiskInternals Uneraser recovers lost data, undelete deleted files and documents and recovers entire folders. It uses a unique signature scan algorithm to locate and successfully recover supported documents (*) stored on formatted disks and memory cards.

Seagate Rescue Data Recovery

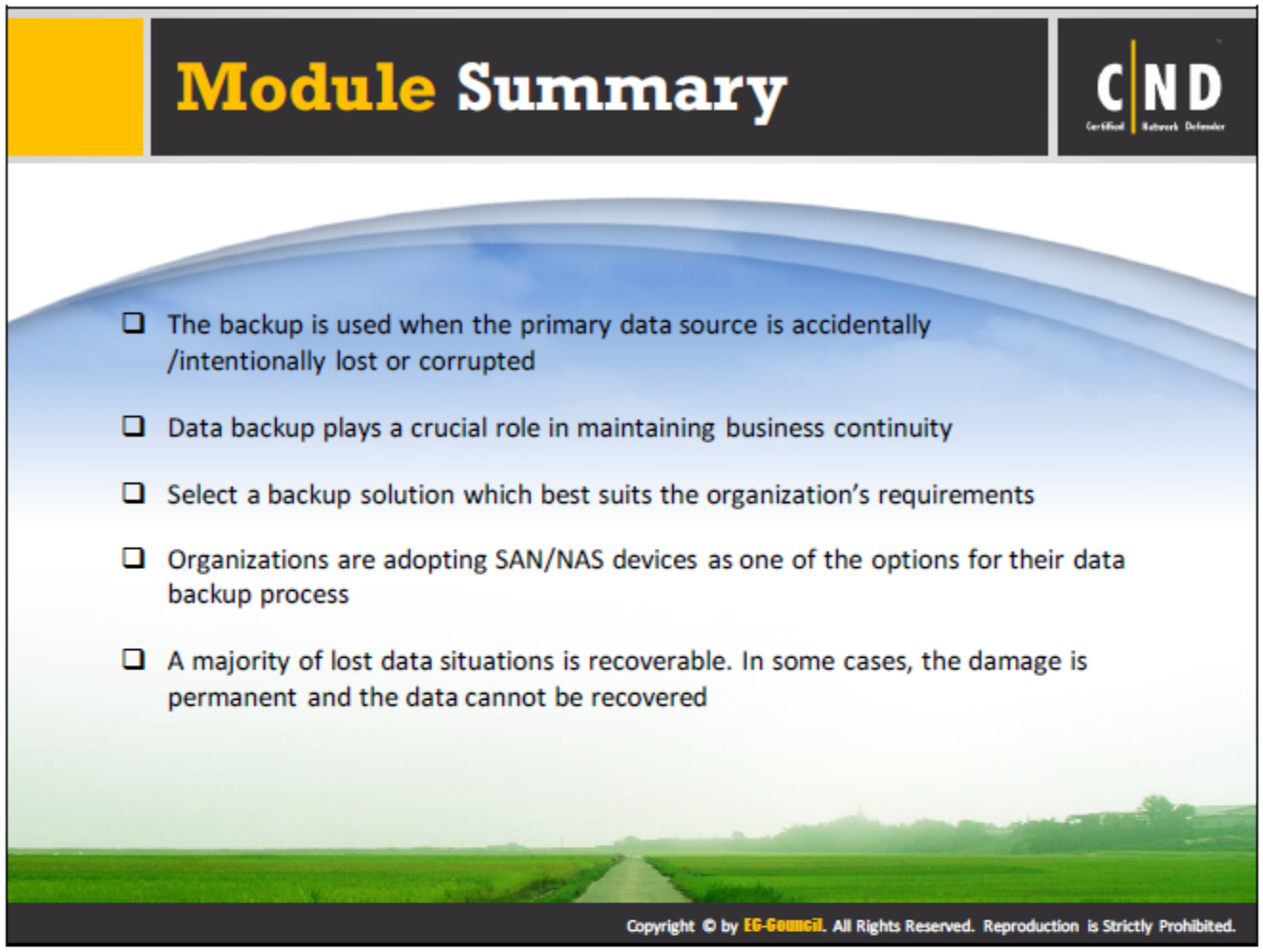
Source: *http://www.seagate.com*

Seagate Rescue Data Recovery involves recovery of a RAID controller failure, lost RAID configuration, accidental reconfiguration and re-initialization of the RAID array, missing RAID partitions, reformatted RAID partitions, virus damage, natural disaster, human error and drive failures.

DriveSavers

Source: *http://www.drivesaversdatarecovery.com*

DriveSavers recovers data from NAS devices that have failed mechanically. It provides unparalleled data recovery and digital forensic services for all NAS systems.



In this module, the importance of performing regular backups of an organization's critical data was covered. The module also talked about how to plan and execute a data backup for the organization and provided comprehensive guidelines for selecting the appropriate method, type, media and software for according to the backup plan. By completing this module, you now have the skills to effectively and efficiently design and execute a backup plan for your organization.