

MBR and EFI Disk Partition Systems

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Computer technology is constantly evolving. The hard disk drive partition system has become quite complicated in recent years because of the need to accommodate large disk drives, and to design a better system of protection for critical boot files. Today, there are two different Microsoft disk partition styles used for hard disk drives, **Master Boot Record (MBR)** and **Globally Unique Identifier Partition Table (GPT)**.

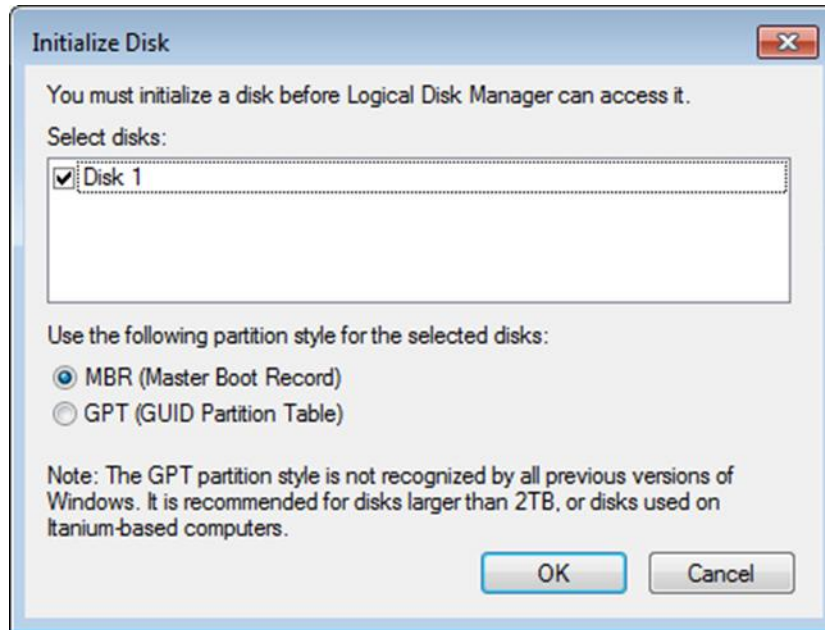
Both the MBR and the GPT are used to identify the location of the partitions on a hard disk drive. The type of partition used is directly related to the type of firmware designed to work with the motherboard. The type of partition is decided when the disk is first initialized.

Initialize Disk

When a new hard disk drive is installed in a computer, the disk is initialized. When you initialize a hard disk drive, you are selecting the type of partition you wish to use to support the file system. The two choices are Master Boot Record (MBR) or Globally Unique Identifier Partition Table (GPT.) The original disk initialization standard was MBR, and there was no other choice presented. The GPT type is more modern, and is used to overcome some of the limitations of the MBR type such location and protection of the required system boot files. Another advantage of GPT is that it can create more partitions than MBR, and also better handle large hard disk drives. The original MBR could be used to support hard disk drive up to 2 terabytes (TB). GPT is designed to support hard disk drive storage of up to 18 Exabyte (EB). An Exabyte is approximately equal to one million terabytes. GPT was first introduced with Windows XP 64-bit edition and Server 2003.

When a new hard disk drive is first installed, it must be initialized before it can be partitioned. Microsoft support site states that disk initialization writes a signature to the disk. A disk signature identifies the disk type and properties so that the Microsoft operating system can utilize the disk.

(1 of 14 pages)



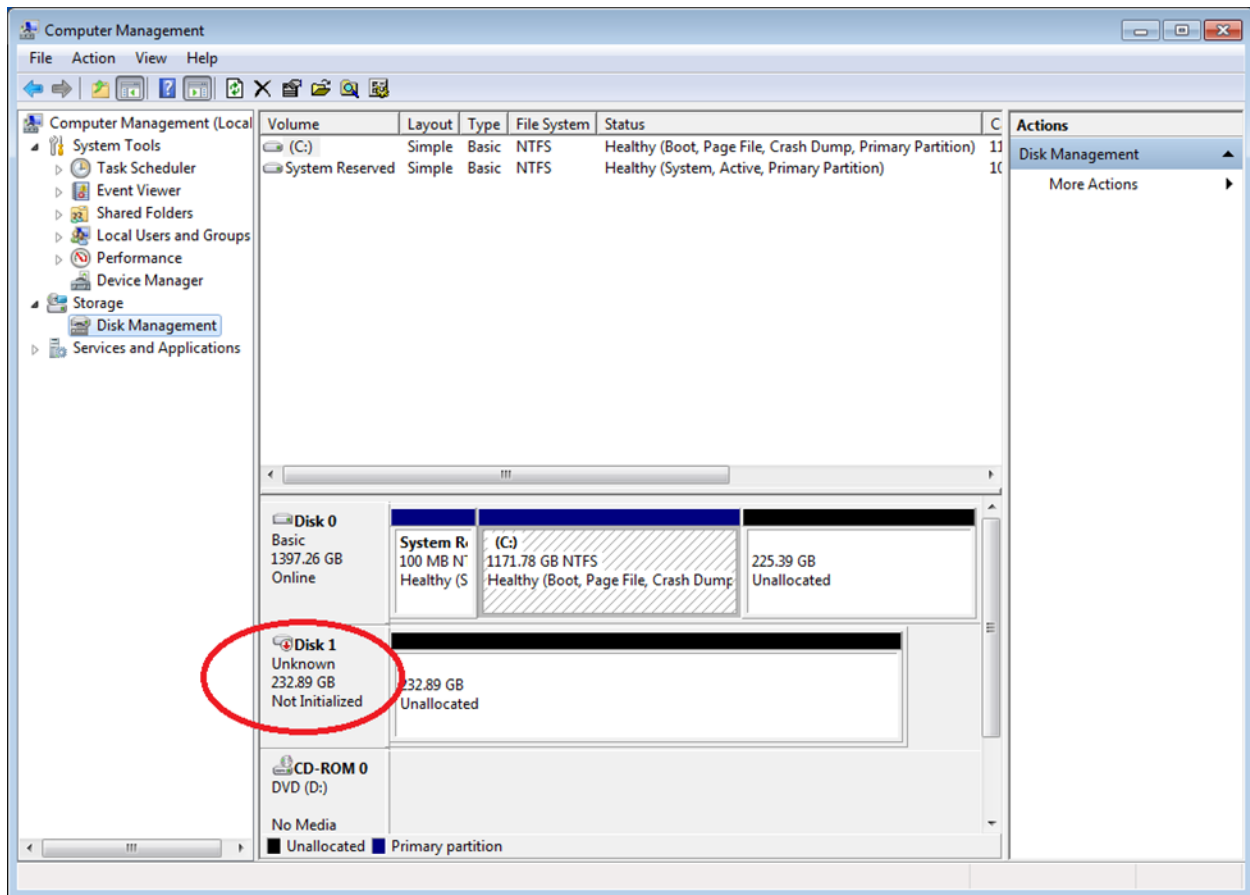
Initialize Disk

There are two choices of initialization presented in the dialog box, MBR or GPT. As the dialog box indicates the GPT partition style is not recognized by early versions of Windows and it is recommended for partitions larger than two TB.

Note: During your computer laboratory activities you will often install a hard disk that has been used one or more times by previous students. When this is the case, you will not see the Initialize Disk dialog box.

When a physical disk that has not been initialized is viewed through the Computer Management tool, it will be labeled as “Unknown” and as “Not Initialized.”

Look at the screen capture below to see an example of an unidentified disk.



Unknown disk before initialization

Also note the partition labeled “**System Reserved.**” The system reserved partition has no assigned partition letter. There will be much more about the System Reserved partition later in this section.

Note: You can convert MBR to GPT or GPT to MBR, however all data on the disk will be lost. A single physical hard disk drive cannot have both a GPT and a MBR because the system can only have one place from which to boot. You may see a “**protective MBR**” located with a designated GPT hard disk drive. The protective MBR is used to protect the GPT when legacy software tools are used to explore or repair the MBR. The legacy tools could interpret a missing MBR as an un-partitioned disk. Restoring an MBR could then render a GPT system unbootable. A computer can contain two or more physical disks, and the disk can be a mixture of both GPT and MBR type of disks.

Both Windows XP and Server 2003 can read or write data to a GPT disk but XP cannot boot from a GPT partition. Windows Vista, Windows 7 and Server 2008, can read write and boot from a GPT disk.

Quick Comparison of MBR and GPT

- MBR supports a maximum of four primary partitions
- GPT supports 128 primary partitions.
- MBR supports 2 TB partition size.
- GPT can support 19 EB (19,000,000 TB) partition size.
- MBR has no backup partition table.
- GPT has backup partition table.

To learn more about GPT and MBR check the Microsoft GPT frequently asked questions link at:

http://www.microsoft.com/whdc/device/storage/GPT_FAQ.msp

or conduct a search using the key terms “Microsoft GPT FAQ”.

To understand why a new disk initialization is needed, we must first look at some of the limitations of MBR. MBR was introduced after the FAT file system. The FAT file system used a file allocation table (FAT) to organize directories and file locations on the disk. While an excellent system at the time, it is now quite obsolete for today’s large hard drives.

Original FAT file systems are basically obsolete today, and will seldom be encountered on desktop and laptop systems. You can still encounter the FAT file system used for some Flash Memory storage devices and small electronic device storage systems. FAT is used when small storage capacity is required, because FAT has less overhead than NTFS file system. The smaller overhead makes it ideal for small storage systems. The original Fat file system has many limitations that prevent it from being a practical file system used on modern machines containing large capacity hard drives. For example, each FAT16 partition was limited to maximum 2 GB size limitation. The FAT16 could create a maximum of four primary partitions which equaled in total approximately 8 GB. This is a ridiculously small amount of storage space for today’s new computer systems. FAT32 was an improvement but also has limitations which prevent it from being used today to support large storage systems.

The default file system used today is NTFS. As storage systems evolved, NTFS has had some limitations, which are now overcome by newer technology. In this section we shall discuss two of these technologies, MBR and GPT.

There are two disk partitioning systems used for NTFS, Master Boot Record (MBR) and Globally Unique Identifier Partition Table (GPT). GPT is an updated version of the MBR

which corrects certain limitations of the MBR system. For example, MBR type of partitions can only create four primary partitions. GPT can create 128 partitions. BIOS contain the firmware that is responsible for booting a computer and initializing hardware before the operating system is loaded into memory. The BIOS method is being augmented on some motherboards with the introduction of a newer technology known as Extensible Firmware Interface (EFI). EFI uses a new partition technology known as GUID partition table (GPT).

Primary Partition

A standard master boot record (MBR) type hard disk drive can contain up to four primary partitions or three primary partitions and one extended partition. The extended partition can contain additional logical drives. The primary partition is also referred to as the active partition and the boot or system partition. Technically speaking the boot and system partition can be two different partitions but typically they are found in the same primary partition.

Extended Partition

An extended partition can only be created on a MBR type disk. As stated earlier, one of the primary partitions can be an extended partition which in turn can be used to create multiple logical partitions.

Primary ---- Primary --- Primary --- Primary

Or

Primary --- Primary --- Primary --- Extended --- Logical --- Logical ---- Logical -----

Only one extended partition can exist on a disk drive.

The GPT type partition does not have these limitations. You may create 128 primary partitions on a disk system initialized with GPT.

Extensible Firmware Interface System Partition

The **Extensible Firmware Interface** computer system (**EFI**) will create an **Extensible firmware interface System Partition (ESP)** type partition, and requires a **GUID Partition Table (GPT)**. The ESP partition is a special area of the hard disk drive intended for use solely by the firmware, and typically contains files and or data required to boot the computer system. Only one ESP partition is required per machine no matter how many physical or logical disks are installed. The acronyms EFI and ESP are often used interchangeably applied when discussing disk partitions. The ESP partition can be created by firmware or by the diskpart command tool. At this time the ESP partition cannot be created using the Microsoft Management Console. When present, the ESP

partition typically contains the required to boot files NTLDR, HAL, and Boot.txt. Additional files such as drivers may also be contained in the EFS partition.

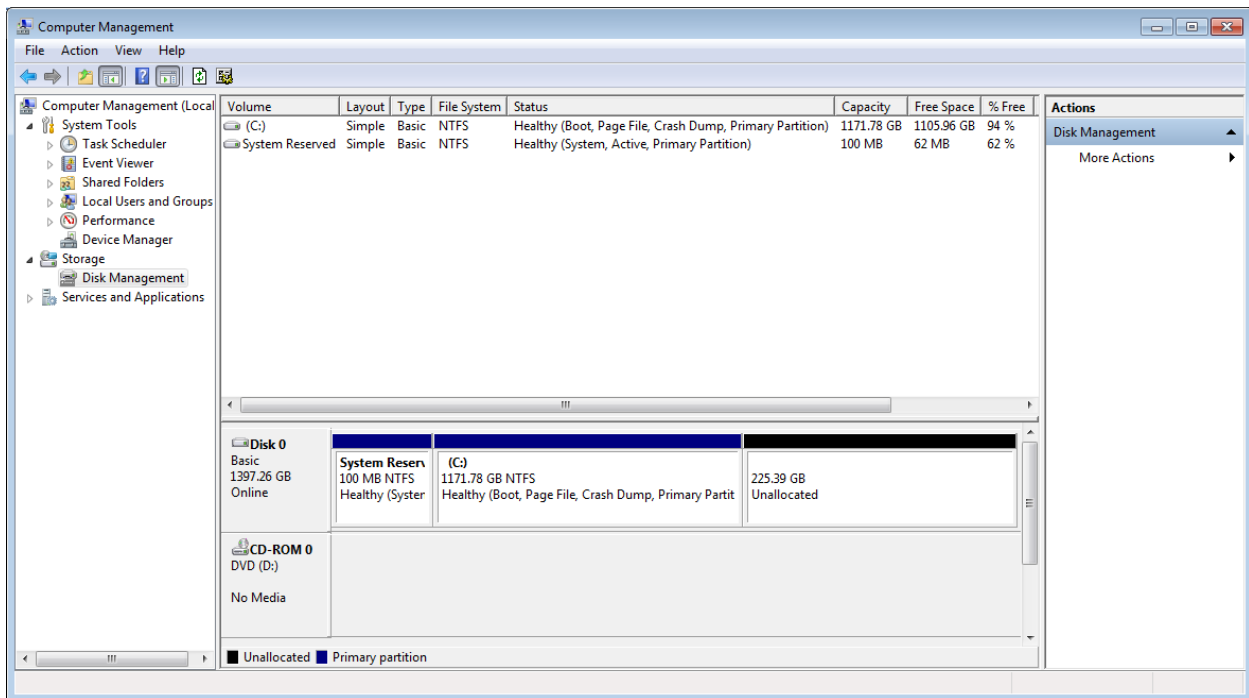
Note: The acronym EFI represents Extensible Firmware Interface and the acronym ESP represents Extensible Firmware Interface System Partition.

MSR Partition/Volume

The Microsoft Reserve (MSR) partition is required for GUID partition table disks. Microsoft Windows setup creates a MSR partition when one does not already exist.

The MSR partition is required for GUID partition table used for GPT type disk.

Look at the screen capture below, and you can see how a MSR partition appears in the Disk Management tool. The MSR partition is labeled “**System Reserved**”.



Notice that there is no partition letter assigned to the MSR partition which is identified as the “System Reserve” partition.

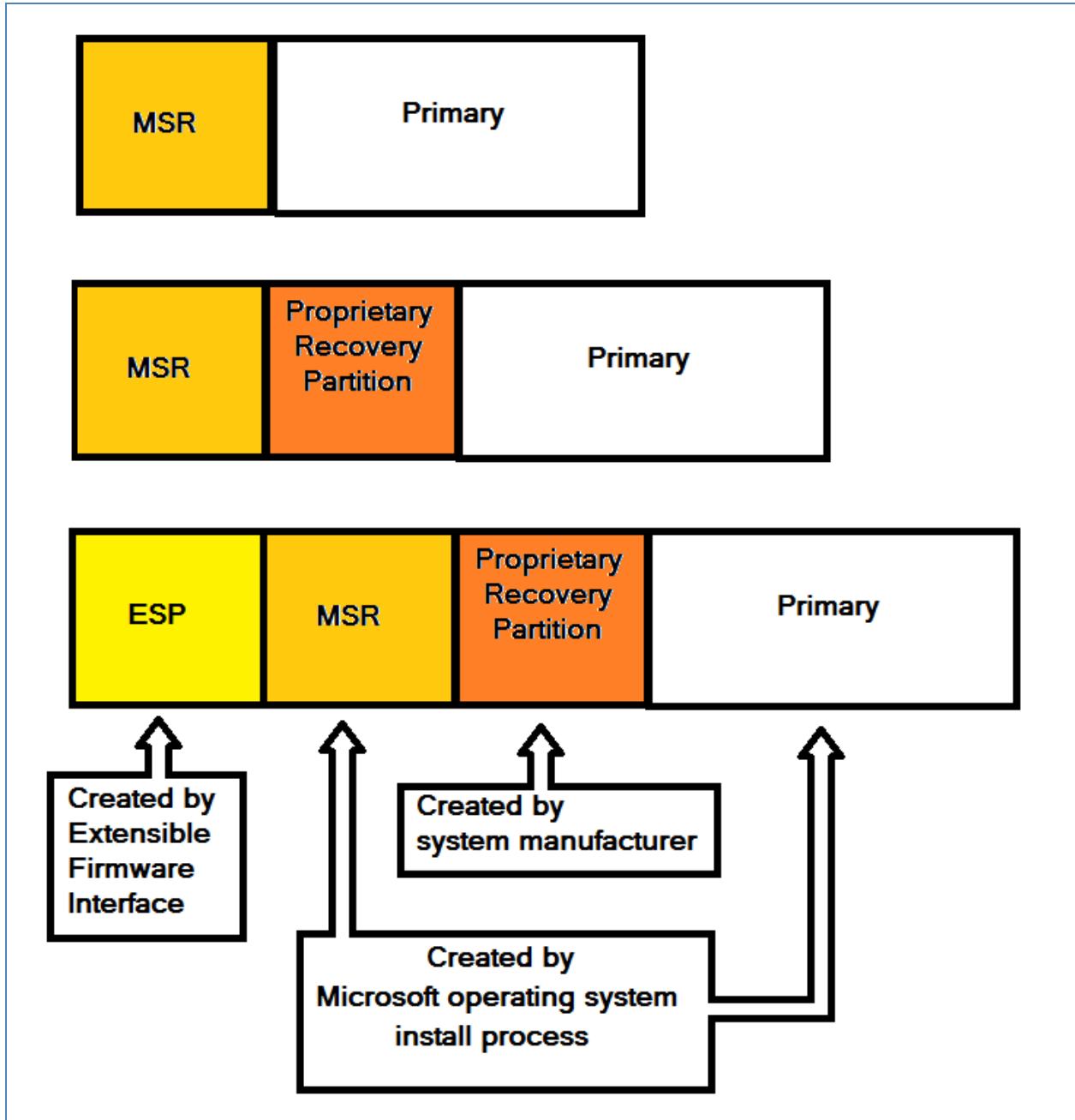
When an EFS partition is created it takes priority over both, the MSR partition and the primary partition it is required for booting the computer.

In the illustration below, you can see some common partition arrangements that you may encounter involving the MSR, EFS, and primary and proprietary recovery partitions.

The ESP partition is typically 100 MB, the MSR partition is typically 128 GB.

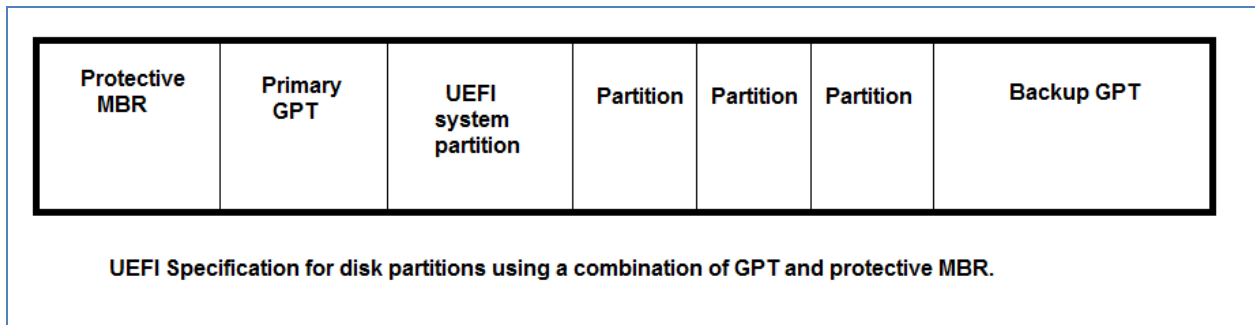
Multiple Partition Arrangements

Below is an illustration of some possible partition/volume arrangements you may encounter.



Multiple Partitions

The partitions are arranged in Microsoft's recommended sequence, but the exact order may vary according to where the system-manufacturer places the proprietary recovery partition. Generally, the ESF is a hidden partition can only be viewed using the extensible firmware interface software created utilities. The Proprietary Recovery partition may be hidden as well but not always.



UEFI Spec

The UEFI standard calls for the master boot record to be located first on the hard disk drive followed by the Primary GPT. The GPT primary partition is used by 64-bit systems to identify the system partitions. The GPT is essential to the identification of the GPT type partitions and a backup of the GPT partition information is stored in a separate partition called the Backup GPT.

The partition designated UEFI system partition is used to contain the boot loader program. After completing the POST, the control of the computer is passed from the firmware (BIOS) to the boot loader program. The boot loader program starts the proprietary operating system such as Windows or Linux, and then loads the remaining portions of the operating system.

After the UEFI system partition, there is one or more partitions used to contain operating system files required to run the program as well as data files.

As you can see, there is conflicting terminology used to identify and explain the function and purpose of the disk partition system. This is quite common in computer related fields when a new technology is released, especially before a standard is adopted by all parties. During the transition you will encounter hybrids of the new and older technologies mixed together. ***The terminologies will conflict because of different sources of information emerging at the same time.*** Also, be aware that companies sometimes create their own terminology and present the information in a manner that will lead you to believe that they invented it first. This is a typical marketing technique used by software, as well as hard ware companies.

Unfortunately, not all hard disk drives conform to this arrangement, nor do all manufacturers of hardware and software use the same terminology as presented in the standard. As a result of lack of strict standard adoption, you will encounter several variations of partition arrangement. The variations are caused by the desire of OEMs to install a recovery partition to support system recovery for their computer operating systems. Another main factor for the various partition arrangements that do not adhere to the UEFI standard is the fact that many OEMs released computer systems into the market place before the standard was fully adopted by all major OEMs.

You will encounter this lack of total uniformity to a specific standard time and again in the computer industry. In the free market place, manufacturers are always rushing to introduce their own improved technology, rather than wait for a standard to be fully adopted. As a result, you will encounter many systems that are hybrids of the standard and the legacy technology.

ESP/MSR Partition Creation

The EFS partition is created by Extensible Firmware Interface firmware or by using the DiskPart command tool. The MSR partition is created when a new Windows operating system is installed and the hard disk drive is partitioned. The MSR partition is not created when Windows is installed on an existing hard disk drive that was already partitioned. The Primary partition is also created by the Microsoft operating system during the installation process.

The Proprietary Recovery Partition is an optional partition created by the system or original equipment manufacturer (OEM.)

Note: You can only boot from an EFI type of firmware system to a GPT type disk when using the 64-bit versions of Windows XP, Vista or 7 operating systems. The EFI to GPT is not an available option for 32-bit operating systems at this time.

Primary Partition

All hard disk drives must contain at least one primary partition used to contain operating system and boot files as well as data files. The primary partition can contain the system files or the boot files or a combination of both. When the Primary partition and the Microsoft System Reserved partition are present, the Primary partition will contain the Boot files and the MSR partition will contain the System files. The Microsoft terminology of system files and boot files can be confusing. The Microsoft system files are used to start the computer, the Microsoft boot files are used to run the operating system after the boot sequence is completed.

Removal of the EFS or the MSR partition can result in boot failure. The failure is directly related to the fact that the partition table, as well as required boot files will be missing.

Proprietary Recovery Partition/Volume

The Proprietary Recovery Partition also known as the Original Equipment Manufacturers (OEM) partition is a special optional partition created by the computer system builder. The partition usually contains recovery tools and a copy of the operating system files as well as any other program files that the equipment manufacturer selects as necessary to completely recover a machine from a catastrophic failure. For example, all Windows operating system files used for installing the operating system might be placed in the recovery partition. The recovery partition may also contain software applications files, copies of hardware drivers, and anything else necessary to completely restore the computer to its original condition at time of purchase. The recovery partition is used to recover a computer system by the computer owner either through a tech support conversation, email, or with an on line message textbox displayed at time of failure. The user simply selects a key such as F12 to start the automated recovery process without the need for user intervention. This type of recovery often, but not always, results in the loss of all user files such as documents, pictures and music.

Note: The recovery partition is identified as the PQSERVICE partition on some computers. Using the DiskPart list command identifies the partition as “Recovery” and running the Diskpart “volume” command list the same partition as the “PQSERVICE” volume.

Intel has information about the Intel version of EFI located at <http://www.intel.com/technology/efi/>

The Microsoft TechNet website provides detailed information about disk management at a technician level. Look at the following link for information about disk drive troubleshooting in the Microsoft Windows environment. [http://technet.microsoft.com/en-us/library/cc787481\(WS.10\).aspx](http://technet.microsoft.com/en-us/library/cc787481(WS.10).aspx)

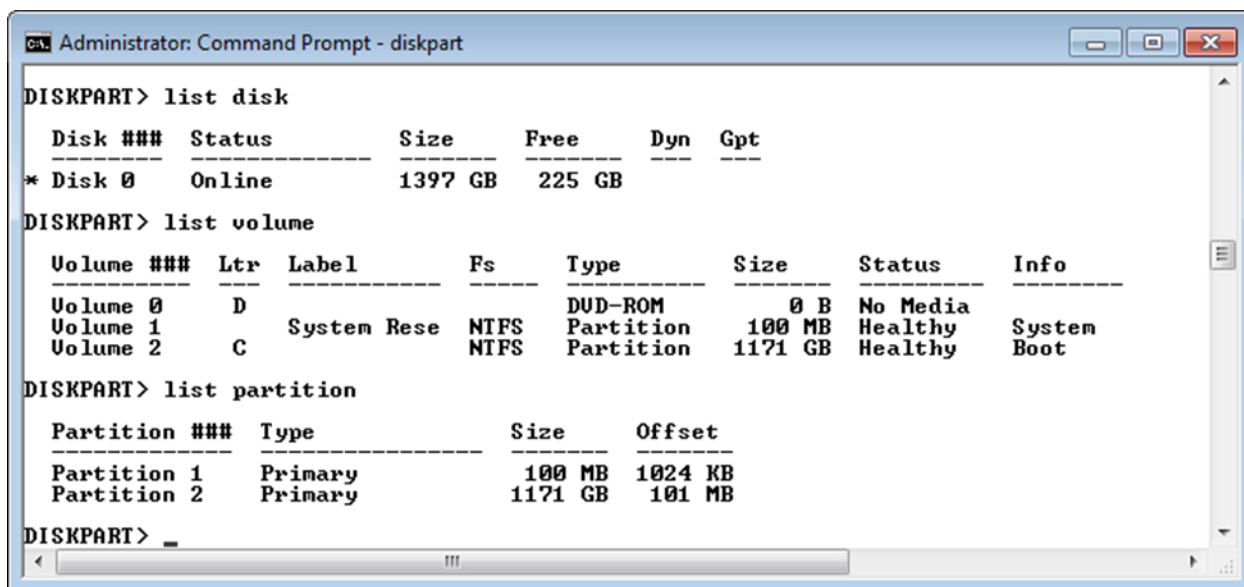
You may also conduct a Google search using the key terms “TechNet cc787481 (WS.10)”

Microsoft FAQ for GPT type partitions is located at the following link: <http://msdn.microsoft.com/en-us/windows/hardware/gg463525.aspx>

Technical specifications for UEFI are located at the following link. <http://www.uefi.org/specs/>

You may also conduct an Internet search using the key terms “UEFI specifications”.

Comparing volume and partition information as it is reveal using the diskpart commands list disk, list volume and list partition. A screen capture showing the results of these three commands is below.



```
Administrator: Command Prompt - diskpart
DISKPART> list disk

   Disk ###  Status         Size         Free         Dyn  Gpt
   ---
* Disk 0     Online         1397 GB      225 GB

DISKPART> list volume

   Volume ###  Ltr  Label          Fs          Type          Size         Status       Info
   ---
   Volume 0    D    DUD-ROM        DUD-ROM      DUD-ROM       0 B          No Media
   Volume 1    C    System Rese    NTFS         Partition     100 MB       Healthy      System
   Volume 2    C    System Rese    NTFS         Partition     1171 GB      Healthy      Boot

DISKPART> list partition

   Partition ###  Type          Size         Offset
   ---
   Partition 1    Primary       100 MB       1024 KB
   Partition 2    Primary       1171 GB      101 MB

DISKPART> _
```

Compare volume and partition

The first command “**list disk**” provides basic information about “Disk 0” the first and only disk in the system. The second command “**list volume**” identifies three volumes that exist on Disk 0. Notice that volume 1 does not have a drive letter assigned, and has been identified or “**labeled**” as the “**System Rese**” or system reserve disk. The system reserve disk contains the required boot files used to boot the computer after POST and then load the remaining operating system files located in “Volume C”. The fact that the “Boot” files required to start the operating system are located in the “System” Volume 1 and the remaining operating system files are located in the “Boot” volume 2.

Key Points

- There are two choices of partition styles identified during disk initialization, MBR and GPT.
- MSR partition is created when a new Windows operating system is installed and the hard disk drive is partitioned.

- The MSR partition is not created when Windows is installed on an existing hard disk drive that was already partitioned.
- A disk initialized as a GPT disk must contain a MSR partition.
- When there are both ESP and MSR partitions, the ESP takes primary control of the boot operating.
- The ESP partition typically contains the required boot files NTLDR, HAL, and Boot.txt
- GPT partition style is not recognized by previous versions of Windows and it is recommended for partitions larger than two TB.
- BIOS systems boot from a MBR type disk, EFI systems are designed to boot from either MBR or ESP type partition.
- To boot from a GPT type disk, the computer must support EFI.
- GPT type disk use a primary and backup partition tables for redundancy. MBR does not have a redundant feature.
- Master Boot Record (MBR) is the original disk initialization system that maintains a master boot record to locate.
- A standard master boot record (MBR) type hard disk drive can contain up to four primary partitions or three primary partitions and one extended partition.
- Removal of the ESP or the MSR partition can result in boot failure.
- The Microsoft System Reserved partition or simply the System Reserved partition.
- The proprietary recovery partition contains recovery tools and a copy of the operating system files and may contain other software as well.
- The recovery partition is identified as the PQSERVICE partition on some computers.
- Using the DiskPart list command identifies the partition as “Recovery” and running the Diskpart “volume” command list the same partition as the “PQSERVICE” volume.
- The proprietary recovery partition contains recovery tools and a copy of the operating system files and may contain other software as well.

Review Questions

1. What does the acronym MBR represent?
2. What does the acronym MSR represent?
3. What does the acronym EFI represent?
4. What does the acronym ESP represent?
5. What does the acronym GPT represent?
6. What is the acronym used to identify the partition created by the Extensible Firmware Interface?
7. Which two partitions are created by the Microsoft operating system during the install process?
8. What is responsible for creating the ESP partition?
9. Which optional partition is created by the OEM?
10. Of the four partition types identified in this article, which is the only one with a drive letter assigned?
11. Approximately how many terabytes are in an Exabyte?
12. What files are typically located in the ESP partition?
13. What is the purpose of the PQSERVICE partition?
14. What is the maximum number of primary partitions identified by a standard master boot record (MBR) type hard disk drive?
15. What is the maximum number of primary partitions identified by a GPT?
16. What partition or drive letter is used to identify the system reserved partition?
17. What is the largest partition size supported by MBR?
18. How is the first physical disk identified when the "list disk" command is issued from the diskpart tool?
19. What diskpart command is used to list the partitions located on the disk?
20. What drive letter is assigned to the system reserve partition?

Review Question Answers

1. What does the acronym MBR represent? **Master Boot Record.**
2. What does the acronym MSR represent? **Microsoft System Reserved.**
3. What does the acronym EFI represent? **Extensible Firmware Interface.**
4. What does the acronym ESP represent? **Extensible firmware interface System Partition.**
5. What does the acronym GPT represent? **Globally Unique Identifier Partition Table.**
6. What is the acronym used to identify the partition created by the Extensible Firmware Interface? **ESP or the EFI System Partition.**
7. Which two partitions are created by the Microsoft operating system during the install process? **The MSR and the Primary partition.**
8. What is responsible for creating the ESP partition? **The Extensible Firmware Interface (EFI) program.**
9. Which optional partition is created by the OEM? **The Proprietary Recovery Partition.**
10. Of the four partition types identified in this article, which is the only one with a drive letter assigned? **Only the Primary partition.**
11. Approximately how many terabytes are in an Exabyte? **An Exabyte is approximately equal to one million terabytes.**
12. What files are typically located in the ESP partition? **When present, the ESP partition typically contains the required to boot files NTLDR, HAL, Boot.txt and additional files such as hardware drivers.**
13. What is the purpose of the PQSERVICE partition? **It is used as the recovery partition by some of the computer manufacturers.**
14. What is the maximum number of primary partitions identified by a standard master boot record (MBR) type hard disk drive? **Up to four primary partitions or three primary partitions and one extended partition.**
15. What is the maximum number of primary partitions identified by a GPT? **128 primary partitions.**
16. What partition or drive letter is used to identify the system reserved partition? **The system reserved partition has no assigned partition letter.**
17. What is the largest partition size supported by MBR? **MBR supports 2 TB partition size.**
18. How is the first physical disk identified when the “**list disk**” command is issued from the diskpart tool? **Disk 0**
19. What diskpart command is used to list the partitions located on the disk? **List volume.**
20. What drive letter is assigned to the system reserve partition? **None.**