UNIT 1 CASE STUDY - WINDOWS 10

Structure

1.0 INTRODUCTION

An operating system is set of programs that act as an interface between user and hardware. It is a type of system software that provides various low level functionalities like process management, memory management, I/O management, file management, scheduling. Examples of popular operating system are Windows, Linux, Unix, Android, iOS, Mac.

Operating system is used to perform two major activities-

- Interfacing user with hardware
- Management of Resources

Windows 10 is one of the most popular and latest operating system of Microsoft. It is introduced with the concept of "Universal apps", which provides apps designed to work for multiple platforms like personal computers, smartphones, Xbox One consoles, laptops and other compatible devices. It is designed for various platforms.

Windows is widely used operating system for desktop users. The various reasons for its popularity among users are-

- Easy to use interface
- High availability of compatible software
- Provides support for new hardware
- Provides Plug and Play feature

Although it is popular among desktop users, it has several disadvantages over other operating systems.

- It is proprietary
- It is closed source
- It is susceptible to virus hence not secure
- Lacks good technical support
- Resource requirements are high

In this unit, we will study about the features, evolution, process management, memory management and file management in Windows 10 Operating System.

1.1 OBJECTIVES

After going through this unit, you should be able to:

- Know about the features of Windows 10
- Understand various editions of Windows 10 operating system
- List various components of Windows
- Describe about Process and memory management in Windows 10
- Describe how files and disk are managed
- Know about the compression used in Windows 10

1.2 FEATURES OF WINDOWS 10

Windows 10 have all the traditional features of other windows version with a wide variety of new features added to it. Features of Windows 10 are:

1.2.1 Multi user – it can be accessed by multiple users simultaneously.

1.2.2 Multi tasking – can perform multiple tasks at the same time.

1.2.3 Resource sharing – files, folders, drivers etc can be shared.

1.2.4 Different versions are available for different types of devices.

1.2.5 Universal apps – designed to run on multiple compatible Microsoft products.

1.2.6 Cortana – a voice controlled digital assistant included in desktop

- Xbox app – can capture and share Xbox games
- Microsoft web browser
- Continuum tablet mode – for touch sensitive devices
- Task view – a desktop management feature
- Windows Hello Face, Hello fingerprint, Hello PIN, security key, picture password sign-in options available.
- Dynamic lock – locks your PC when paired device goes out of range.
- DirectX 12 – used for handling multimedia tasks.
- New builds are available to users at no additional cost.

1.3 EVOLUTION OF WINDOWS 10

It's been over 35 years, since Windows 1.0 was released, and now Microsoft released Windows 10.

It all started in November 1985 when the first version of Windows, **Windows 1.0** was made available. It required two floppy disks and 192KB of RAM to install and was essentially a front-end for MS-DOS, creating a graphical environment for the platform and capable of summoning certain functions.

Windows 2.0(in the year 1987) built on its predecessor by adding more sophisticated keyboard shortcuts, overlapping windows and support for VGA graphics and introducing features that have become staples of the Windows experience. These include the control panel, the terms *minimise* and *maximise* and support for the first Windows versions of Word and Excel. Windows 2.0 was also the last version not to need a hard disk to install.Six months later, **Windows 2.1** was released to take advantage of new Intel processors, while a further update in 1989 made minor changes to memory management, printing and drivers.

The third major release of **Windows 3.0** (in the year 1990) was arguably the first successful one, with a revamped UI, better memory management, 256 colour VGA mode and enhanced multimedia options such as support for sound cards and CD-ROMS. Notably, Windows 3.0 also separated files and applications into a list-based manager for the former and an icon-based manager for the latter.

At this point, although Microsoft didn't plan for it, the Windows line divided into the NT and 9x families. The business-focused NT 3.1, the first in the line, was built from scratch as a 32-bit operating system made to have the same aesthetics as the 16-bit Windows 3.1. It was released in July 1993 in workstation and server editions, and received an incremental update in the form of **Windows NT 3.5**. **Windows NT 4.0** (right) followed three years later, boasting a similar interface to Windows 95, although NT 4.0 was considered much more stable than its consumer counterpart.

Windows 95(in the year 1995) was originally meant to be based on NT architecture but Microsoft abandoned these plans amid fears an NT-based consumer operating system wouldn't run on low-end hardware and would take too long to develop, opening up a gap in the market that could be seized by others. This need to reach the shelves quickly resulted in the Windows 9x family, the first entry of which was Windows 95.

Backed by a huge marketing campaign, Windows 95 came with a significantly enhanced user interface which introduced the start button and taskbar. It also added simpler plug and play features and although the kernel itself was 32-bit, much of the code remained 16-bit because it was recycled from 3.1.

Windows 98 (in the year 1998) a follow-up was released three years later and was considered to be more stable than Windows 95, with easier support for plug and play devices, larger disk partitions, more robust USB functionality, networking improvements and new system tools.

Windows ME was intended as a stopgap release between 98 and XP and it showed. It became notorious for instability and unreliability, but at least it introduced the 'system restore' feature to give users a fighting chance of getting any work done. Many of the new features had already been made available to Windows 95 and 98 users through updates and many enterprise functions were absent as Microsoft attempted to make a clear distinction between the consumer-facing ME and business-focused Windows 2000.

Later on **WINDOWS XP** was released in the year 2001, **Windows Vista** in 2007, **Windows 7** in 2009 and **Windows 8** in 2012. **Windows 10** is an operating system of Windows NT family developed by Microsoft Corporation. It was released in 2015 as a successor to Windows 8.

1.4 WINDOWS 10 EDITIONS

For various devices, windows 10 have total 12 editions with different set of features. Some are available only through volume licensing. Some of the major editions are-

Windows 10 Home

It is designed for PC, tablets, 2 in 1 PCs. It includes features like- Universal Windows app, Cortana assistance, Continuum tablet mode, Xbox, Microsoft edge browser, biometric sign-in.

Windows 10 Pro

It has all the features present in Windows 10 Home along with additional features like –Remote desktop, Bit Locker encryption, Hyper-V, group Policy, support for active directory, windows update for business.

Windows 10 Enterprise

It provides all the features of Windows 10 Pro along with advanced security and management needs like- Resilient file system, windows defender credential guard, application guard and advanced threat protection.

Windows 10 Education

It provides features similar to Windows Enterprise but provides tools explicitly for academic purpose.

Windows 10 Mobile

It is designed for smart phones, tablets, touch screen devices but later Microsoft discontinued this due to customer dissatisfactions.

This edition is specially designed for IoT (internet of Things) devices. It provides security, manageability to Iot devices along with windows ecosystem and connectivity with cloud.

1.5 WINDOWS OS COMPONENTS

Windows operating system has two modes for its operation – kernel mode and User mode. User applications run in user mode and system operations runs in kernel mode. Applications that run in kernel mode shares single virtual address space while a different private virtual address space is allocated to each application in user mode.

When an application is started in user mode, a process is created by windows and a private virtual address space is allocated. Since the address space is private, applications cannot access or modify data belonging to other applications. Similarly they also cannot access virtual address reserved for operating system. Also if due to some reason an application crashes, operating system and other application will not be affected.

On the other hand, single virtual address space is shared by processes running in kernel mode. It means that processes are not isolated by each other. Drivers are usually run in kernel mode. Internal components of windows operating system is shown in figure 1.

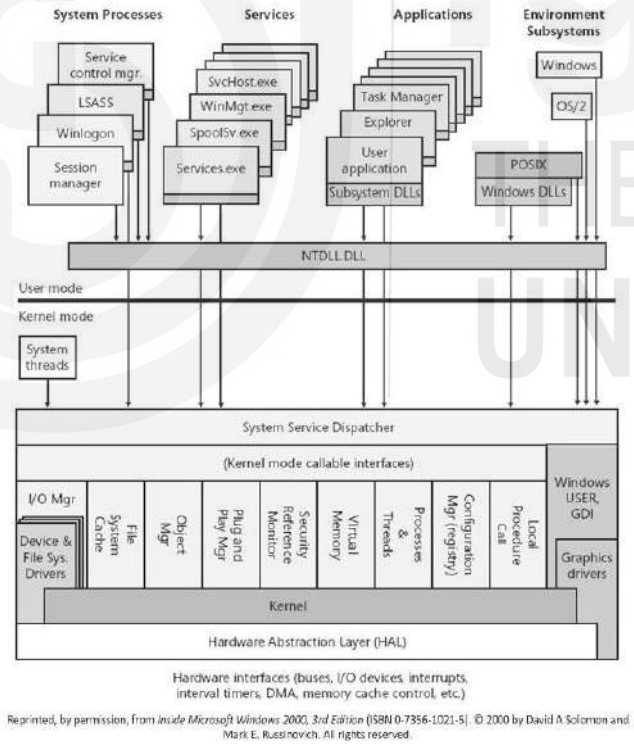

Fig 1: Windows Components (*Source: docs.microsoft.com*)

Universal Windows Platform Apps

Universal Windows Platform (UWP) is introduced in Windows 10. It is common platform that can be used for different types of devices that runs windows 10. In this same core API is used for all devices. The apps are written in C++/WinRT or C++/CX and can access Win32 API which is implemented by all window 10 devices. For user interface DirectX, XAML or HTML is used. If apps need to be designed for taking advantage of specific device than extension SDK can be used to call specific APIs.

Fig 2: Windows 10 Universal Apps Platform (*Source: docs.microsoft.com*)

1.6 PROCESS MANAGEMENT IN WINDOWS 10

1.6.1 Processes and Threads

A program in execution is called a process. A process contains information like- unique process identifiers, virtual address space, priority, environment variables, working set size, executable code and security context. Initially process starts execution with a single thread, known as primary thread but later additional threads can be created by *primary thread*. Every thread maintains information like unique thread identifier, priority, local storage, data structure to save thread context and security context. Thread context contains user stack, kernel stack, and set of registers. All threads of a single process shares system resources and virtual address space.

In windows multiple threads belonging to different processes can be executed simultaneously and creates the effect of simultaneous execution for single processor system. Hence it is called multitasking. Also windows follows preemptive approach of scheduling hence time slice is allocated to each thread. After the time slice elapses, switching is done to another thread and system saves the context of preempted thread. Context of new thread is loaded for execution.

1.6.2 Scheduling

Scheduling decides the order in which threads will be executed. Scheduling of threads is done by giving priorities in range the between 0 to 31, where 0 represents minimum and 31 represents maximum priority. Threads with same priority are treated as equal. Time slices is assigned to thread in round-robin fashion to high priority threads. Factors to determine priority of thread are:

1. Priority class of process – process can belong to any of the class - IDLE_PRIORITY_CLASS, BELOW_NORMAL_PRIORITY_CLASS, NORMAL_PRIORITY_CLASS, ABOVE_NORMAL_PRIORITY_CLASS, HIGH_PRIORITY_CLASS, REALTIME_PRIORITY_CLASS

2. Priority level of thread – priority levels of thread within a process can be any one of the following- THREAD_PRIORITY_IDLE,
   THREAD_PRIORITY_LOWEST
   THREAD_PRIORITY_BELOW_NORMAL,
   THREAD_PRIORITY_NORMAL
   THREAD_PRIORITY_ABOVE_NORMAL,
   THREAD_PRIORITY_HIGHEST
   THREAD_PRIORITY_TIME_CRITICAL

Priority of a thread is formed by combining these to priorities- priority class of process and priority level of thread. This is called **base priority** of thread.

Priority Boosts

When threads of higher priority gets execute every time, the system can suffer form the problem of starvation. To solve this problem Windows uses the concept of dynamic priorities. Initially priority of each thread is initialized with base priority. The system can later change the priority of threads so that no thread gets starved. The threads having base priority between 0 to 15 can receives priority boosts. Each time when a thread completes a time slice, its priority is reduced by one level by the scheduler until thread gets its base priority back. Once the base priority is reached, the priority is not changed further.

User mode scheduling

Applications can also schedule their own threads using user mode scheduling mechanism. In this application can switch from user mode and gain control of processor without involving system scheduler. It is used for applications that require high performance to execute threads concurrently. This service is available only for 64-bit versions. Here the scheduler component must be implemented by the application

1.6.3 Interprocess Communication

Interprocess communication is the mechanism which facilitates communication and sharing of data among processes or applications. Here applications requesting for a service can be called client and the application serving the request can be called server. Also applications can act as both client and server. The various IPC mechanisms available in windows are:

i. Clipboard

It is a loosely coupled medium for sharing of data. All the application needs to agree on common data format. Whenever a cut or copy operation is performed on data, it is put on clipboard which can then be used by other applications.

ii. COM

Software that uses component object model (COM) can access and communicate with variety of components. It allows one application to be embedded or linked with other components. Applications that use OLE make use of this.

iii. Data Copy

This allows sending of information from one application to another using windows messaging. The receiver must be able to identify the sender and the format of information.

iv. DDE

Dynamic data exchange is a protocol that allows variety of data formats to be exchanged. It is extension of clipboard. Unlike clipboard it continues to function without need of further interaction after one time data exchange.

v. File Mapping

In this, file is treated as block of memory that can be shared by processes. Processes that want to share this file gets a pointer to its memory location

through which they can access or even modify file contents. Processes must provide a synchronization mechanism to prevent corruption of data.

vi. Mailslots

Mailslots are used to send messages (one way) over network. Process that creates mailslot is called mail slot server. The client writes or appends the message in maislot and sends it to mail slot server. For two way communication multiple mailslots can be created. They can also be used to broadcast message across computers in network domain.

vii. Pipes

Two types of pipes can be used – anonymous or named.

- Anonymous pipes are generally used for transfer of data between related processes like parent child. Read write pipes should be created by each of the processes to share data.
- Named pipes are used between processes on different systems or to transfer among unrelated processes. Server creates pipes and communicates it to clients. Data can be exchanged once both get connected to pipe.

viii. RPC

Remote procedure call is a mechanism used to call remote functions which can be between processes of same or different machine. It also allows data to be converted for different hardware architectures. It is used for high performance applications that are tightly coupled.

ix. Windows Sockets

It is an interface used for communication between sockets. It enables data to be transmitted independent of network protocol and hence it is called protocol independent.

1.7 MEMORY MANAGEMENT IN WINDOWS 10

For efficient management of tasks in a system, proper utilization of memory is necessary. Hence memory management is one of the prime tasks performed by an operating system. The system is composed of two types of memory– Physical and Virtual memory.

(i) Physical Memory

Physical memory is also known as RAM. All the programs and data during execution along with the kernel of operating system are stored in RAM. Elements stored in this memory are directly accessible by the processor. Addresses that belong to physical memory are called physical address space. It can be further divided into user address space where user's data or program can be stored and kernel's address space where kernel is stored.

(ii) Virtual Memory

Virtual memory is capability of using hard disk as additional memory when RAM does not have sufficient capacity to store the data or programs. Data or programs stored in RAM are also mapped to virtual address space by operating system. Operating system

has a program called virtual memory manager which uses method of paging to map virtual to physical address space. If physical memory is able to accommodate the processes, then virtual addresses are directly mapped to physical address but if physical memory is not able to store processes together then virtual memory manager allocate memory to processes one by one till all the processes complete using technique disc paging and **demand Paging**.

Disc paging is space on the hard disk also called page file which is used as extension to RAM. When RAM has not enough space to keep a process it is placed in this location. However, retrieving process from this location degrades the performance. In Demand paging only the task which are currently needed, is placed in RAM.

1.7.1 Memory Representation

Physical memory used by a process is called **working set**. For each process this working set is composed of – private and sharable working sets. Private working set is the memory used by a process for dedicated tasks. Sharable working set is the memory used by tasks which are shared with tasks of other processes. All the system resources like drivers, DLL are shared resources whereas all the tasks performed through executable processes are private working set with sharable resources.

Commit memory for a process is the amount of memory reserved by operating system which is usually equal to the page file size required by a process. This memory is not allocated until it is necessary to page out a process's private working set from RAM to page file. Virtual memory required by the system from page file is hence equal to the sum of all process's commit memory. However windows allows user to modify page file and virtual memory size.

During bootup process, operating system creates two dynamic pools in physical memory for kernel components. These pools are paged and non-paged pools.

- **Paged pool** –this is the physical memory allocated for kernel components that can be later written to disk when not required.
- **Non-paged pool** –this is the physical memory allocated for kernel components or objects that should always remain in physical memory compulsorily but can optionally stored in disk.
- Allocations to both these pools can be viewed in task manager.

1.7.2 Physical memory organization

Physical memory or RAM is Windows 10 is composed of following sections:

- *Hardware reserved* - it is the memory not handled by memory manager and is locked. It is reserved by hardware drivers.
- *In use* – it is the sum of working sets of all running processes, non-paged kernel pool, drivers and applications.
- *Modified* –modified pages which remains idle for long time are removed from working set and shifted to this memory. If the size of this memory goes beyond the threshold limit, memory manager removes pages from this memory and writes it to page file.

- *Free* – it is the memory that can be allocated when demand for memory arises. Also the previously allocated memory which is no longer required are also returned to this memory by memory manager is available for reuse.
- *Standby* – this memory acts as a cache used to hold recent files. Unmodified files from working set of recently completed process are shifted to this memory by memory manager. This improves the performance of system by reducing the time required to fetch these pages if they will be required again by the system in near future.
- When a page is requested by a process, memory manager checks the availability of page in standby memory. If found, it is repurposed i.e. returned as working set. If not found in standby, the page is loaded from the hard disk to free memory and used as working set. If sufficient memory required by a process is not available in free memory than standby memory can be used for memory allocations. Priority is associated with each page in standby and the pages with low priority can be removed and allocated to needy process.

1.7.3 Virtual Memory organization

In windows 10, virtual address space is limited by the system architecture. Increasing memory beyond the limit will not improve performance. It also disallows processes to directly access primary memory and hence they are unaware of memory used by other processes. This feature provides security to the system.

Memory request made by processes are handled by Virtual Memory Manager (VMM). It allocates virtual memory in units called Page. Pages are initialized by location of hard disk where file in stored initially which is later changed to physical memory address where the file gets placed for execution. Hence virtual address can be allocated to all the processes irrespective to physical memory size. Page frames are memory units in physical memory used to store processes. Size of page frames is same as that of pages in virtual memory but they are distributed randomly across memory. Set of page frames belonging to a process forms a working set. Page tables are maintained by operating system for each process which maps pages in virtual memory to frames in physical memory if available otherwise store disk address. It is an array of addresses where index stores the virtual address and page table entries stores frame address. It also stores process control information having control bits like – Valid bit, modified bit and protection bit, which tells about the state of process.

For 32-bit architecture, maximum addressable units can be 2^{32}-1 i.e. 4GB. This is independent of physical RAM installed in system. If the RAM installed is more than 4GB then extra RAM will is added to Physical Address Extension (PAE). They are 36 bits long hence are capable of addressing 64GB physical memory. Since the instructions are created specific to architecture, process must run in 32 bit virtual memory mode for 32-bit system. Operating system will read and write from lowest 4GB RAM in 32 bit mode called active region and the region outside 32 bit is called passive which is usable in 36 bit mode. Processes are relocated from active to passive region by operating system when it ends by changing physical page number (PPN). Therefore adding more RAM only adds the capacity to cache more data which can lead to reduced disk paging.

For 64- bit architecture, maximum addressable units can be 2^{64}-1 which forms 16 Exabyte address space. Hence it allows more processes to be executed without the need of disk paging.

Memory management concepts like demand paging can be applied to both the systems since it is independent of architecture and RAM installed in system.

1.7.4 Demand Paging

For each process a process control block (PCB) is maintained by operating system kernel. In physical memory, the starting address of a page table is called Page table base address. For storing the address of page table, CPU maintains a special register called **Page table base register (PTBR)**. Process control block does the mapping between process id and page table base address. Whenever switching between processes is needed, operating system simple changes the page table base address in page table base register.

CPU maintains a register called Program Counter (PC) which is used to hold the address of next instruction to be executed in a process. Address stored in PC register is divided into two parts- higher order bits stores virtual Page number (VPN) and lower order bits store offset of element within a page. Memory management unit (MMU) first checks the address of page table from page table base register and then uses VPN of PC register as index into page table to find corresponding physical page number (PPN). PPN once found is concatenated with the offset part of PC register and the resulting address is stored in memory address register (MAR). CPU can then fetch the next instruction from the address stored in MAR and execute it. Later on the offset part of PC register is incremented by one to point to the next location.

A page table is created by operating system by mapping virtual address of processes to physical address. Pages that are required to be loaded in memory at initial stage are marked by valid bit=1. Pages that are not required initially are marked with valid bit=0. Page frames are created for initially required pages in physical memory contents are loaded into them from disk. Physical address of pages in page table is then replaced by the page frame address (PPN –physical page number). The process of bringing page into page frame or physical memory only when it is required or demanded is called **demand paging**. MMU maps virtual address to physical address only when the valid bit =1. If MMU does not find a frame number corresponding to a virtual address than Page fault is generated. This mean that the page is not loaded from the disk yet. In this case page handler is invoked to check the existence of the desired page and the page if exists is loaded from the disk into a new page frame. The frame address is then updated into the page table entry and the page is marked as valid.

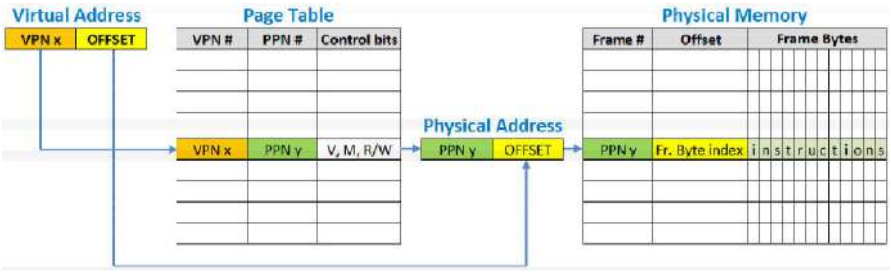

Fig 3: Mapping Virtual address to Physical address (Source: answers.microsoft.com)

1.7.5 Memory Compression

Windows 10 memory manager performs memory compression by compressing infrequently used memory pages instead of writing them on disk. This reduces number of reads and writes and improves response time. Also compressing memory makes

room for more processes to be kept in memory and hence allowing more tasks to be executed simultaneously. As compared to previous versions windows 10 writes to disk only 50 % of the time. Windows 10 also performs simultaneous decompression of data in parallel to reading data by using multiple CPU cores. This happens because of reduced number of reads and writes. The amount of memory compressed by the system can be checked in task manager.

1.8 FILE SYSTEM MANAGEMENT IN WINDOWS 10

File system enable data or files to be stored and retrived from storage locations. Naming conventions, formats for paths are also specified by file system. Storage components in windows file system are – files, directories and volumes. A file is a group of related data. A directory is collection of files and directories stored in hierarchy. A volume is also a collection of files and directories.

1.8.1 Directory Management

The number of files in a directory is limited by the size of the disk where directory is stored. The link between the directory and files within directory is implemented as **directory entry table** by NTFS file system. One or more entries are created in this table for each file in directory. Additional entries created for a file (more than one) are called hard links. Any number of hard links can be created for a file. Whenever a file is created, its entry is added into table. Similarly when a file is moved to directory, its entry is created as moved file. When a file is deleted, its entry is also deleted from table.

1.8.2 Disk Management

A hard is divided into one or more partitions, which are logical regions and created when user formats hard disk. Multiple partitions makes file management easy. In storage types there are two types of disk- basic and dynamic disk.

(i) Basic disk : Basic disk contains primary partition and logical drives. It supports Master Boot Record partition style (like older windows versions) and GUID partition table. In the traditional MBR scheme, four primary partitions or three primary and one extended can be created. Also one or more logical drives can be created in extended partition. The extended partitions should be contiguous. The partitions are formatted to create volume. One or more volumes can be created with a single partition. Partitions which are not formatted cannot be used for storage.

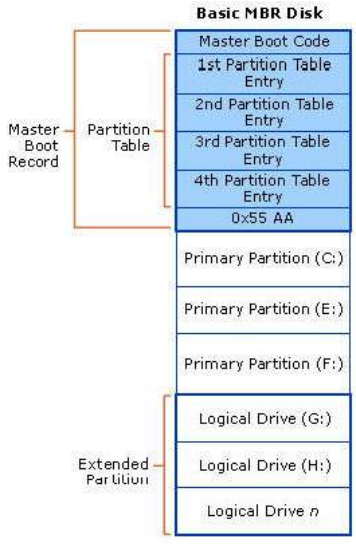

Fig4: Basic MBR Disk (Source: docs.microsoft.com)

Globally unique identifier (GUI) can be used with MBR Partition. This style allows upto 128 primary partitions to be created hence extended partitions are not needed. It allows more than 2TB partitions to be created and also applied CRC protection and replication to partitions. It is used along with MBR for backward compatibility.

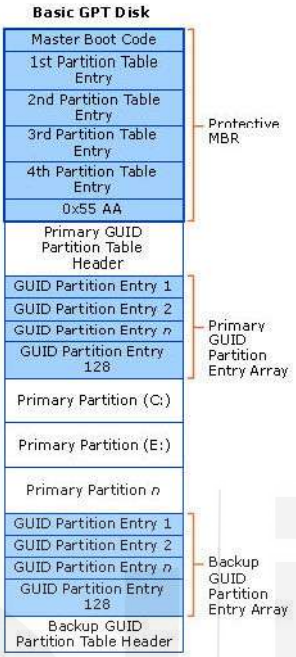

Fig 5: Basic GPT disk (Source: *docs.microsoft.com*)

(i)) **Dynamic Disks:** Similar to basic disk it can use MBR and GPT partitioning but it allows added features like- it allows volume to be spanned across multiple disks and create fault tolerant volumes. Volumes created in dynamic disk are called dynamic volumes. Information of dynamic volumes is maintained in a database. It allows volume to be created on one or more physical disk noncontiguously. It makes use for logical Disk manager (LDM) and Virtual Disk service (VDS). For converting basic disk to dynamic disk atleast 1 MB of unused space is required in disk for LDM database requirements.

1.8.3 File Management

In windows 10, all directories, files, system code are stored by NTFS file system in a file. This help in easy access and maintenance and can also be protected by security descriptor unlike other file system which stores this data in regions of disk external to file system. Group of sectors called a cluster is the fundamental storage unit of file system. The disk data can be administered by disk controller independent of the sector size.

Files are managed in windows through file objects, file pointers and file handles.

1. A file object maintains contents written to file and other attributes maintained by kernel like- file name, current offset, share mode and others. Hence it creates a logical interface between file data and process of kernel and user mode.

2. File handle is associated with a file when a process opens the file. It remains associated with the file until the process ends or the handle is closed. They are unique and private to a process.

3. File pointer is an offset value that specifies the next byte to be read or written from a file. It is created by the system and placed at the beginning of file (offset 0) when it is opened. It progresses through the file with number of reads and writes.

1.8.4 File compression

Compression of file is supported by NTFS file system. It uses a lossless compression algorithm called Lempel-Ziv compression to compress files. This allows data to be decompressed without any loss of information. Compression of files larger than 30 GB may not be successful. Applications cannot access compressed data but can only operate on those files with assistance of file compression library .

☞ **Check Your Progress 1**

1) List the important new features of WINDOWS 10 Operating System.

.....

.....

.....

.....

2) Describe the security features in Windows 10.

.....

.....

.....

.....

1.9 SUMMARY

In this unit a case study of Windows 10 is presented. The various operating system functions like- Process management, memory management and file System management are discussed in details. Also various features newly added in Windows 10 operating system and various available versions introduced are also mentioned. In this unit, we also discussed several theoretical concepts on Windows 10 in detail, often useful in your lab for practice.

1.10 SOLUTIONS/ANSWERS

1) Some of the new features and enhancements that will allow you to benefit from WINDOWS 10 are intelligent security, simplified updates, flexible management, and enhanced productivity. Apart from these following are the new features in WINDOWS 10:

   - Theme aware tiles in Start
   - Microsoft Edge
   - Improved Notifications

- Tablet Experience
- Refresh Rate of Display
- Mobile Device Management
- Windows Autopilot (for HoloLens, Co-Management etc.)
- Defender Application
- Latest Cumulative Updates (LCUs) and Servicing Stack Updates(SSUs) combined into a single cumulative monthly update via Microsoft catalog
- Secure Biometric Sign-on
- Cortana
- Universal Print
- Virtual Desktop
- MS Tunnel Gateway
- EndpointAnalysis
- Microsoft 365 Apps
- Productivity Score

2) Windows 10 includes Windows Security, which provides the latest antivirus protection. Your device will be actively protected from the moment you start Windows 10.

- Windows Security continually scans for malware (malicious software), viruses, and security threats. In addition to this real-time protection, updates are downloaded automatically to help keep your device safe and protect it from threats.
- Windows Security is built-in to Windows 10 and includes an antirvirus program called Microsoft Defender Antivirus.
- Virus & threat protection: Monitor threats to your device, run scans, and get updates to help detect the latest threats. (Some of these options are unavailable if you're running Windows 10 in S mode.)
- Account protection: Access sign-in options and account settings, including Windows Hello and dynamic lock.
- Firewall and network protection: Manage firewall settings and monitor what's happening with your networks and internet connections.
- App and browser control: Update settings for Microsoft Defender SmartScreen to help protect your device against potentially dangerous apps, files, sites, and downloads. You'll have exploit protection and you can customize protection settings for your devices.
- Device security. Review built-in security options to help protect your device from attacks by malicious software.

- Device performance and health: View status info about your device's performance health, and keep your device clean and up to date with the latest version of Windows 10.
- Kids Online Activity Protection: Keep track of your kids' online activity and the devices in your household.

1.11 FURTHERREADINGS

1. Andy Mince, WINDOWS 10 Made Simple, Kindle Edition, 2020.
2. Katherine Murray, My Windows 10, Second Edition, Que, 2018.
3. Andy Rathbone, Windows 10 for Dummies, 4th Edition, Wiley, 2020.
4. docs.microsoft.com