Systems Commands
Professor Gandham Phanikumar
Department of Metallurgical and Materials Engineering
Indian Institute of Technology, Madras
Managing Storage

Let us look at the storage related aspects that are the advanced aspects of Linux. You may not have any live demo as part of this particular section, because these are all one time activities; and one should not be messing around with these commands. But, I want to mention them here, so that you can read about them; and when you have a new machine that you want to configure. Your awareness about these may help you also identify the right kind of a configuration.

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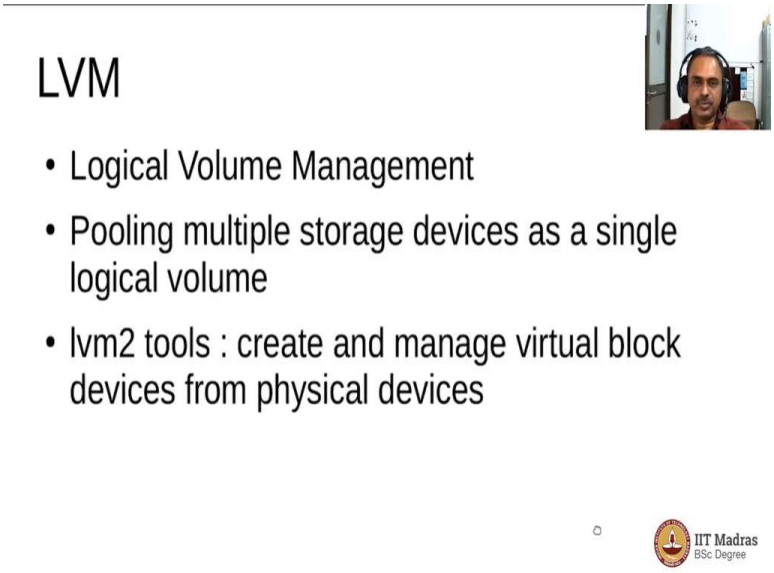

So, there are two things that we need to learn about the first thing is the logical volume management; which means, that if you have multiple physical disks, they can actually be considered as a single logical volume by the Linux operating system. So, it means, for example, you may have several disks of a particular size; but the partition that you would like to have needs a lot of space.

And there is no hard disk that will come in that particular size. Now, what do we do? So, you can actually define a logical volume, which spans over all those disks; so, that the volume is shown to you as if it is at a higher capacity; though individual disks maybe at a lower capacity. Now,

that is something that is very convenient, so that we are not limited by the availability of for that particular size of the hard disk.

So, pulling multiple storage devices as a single logical volume, is something that is very much well established in the Linux. And there are a whole bunch of tools that come under the package lvm2, where we can create and manage virtual block devices from physical devices. And what are mounted in the Linux operator system by the file system are actually the virtual block devices, which are mapped over to multiple physical devices.

So, that we do not have to worry about which piece of data is written to which disk, we are looking at as a continue continuous segment of a logical volume.

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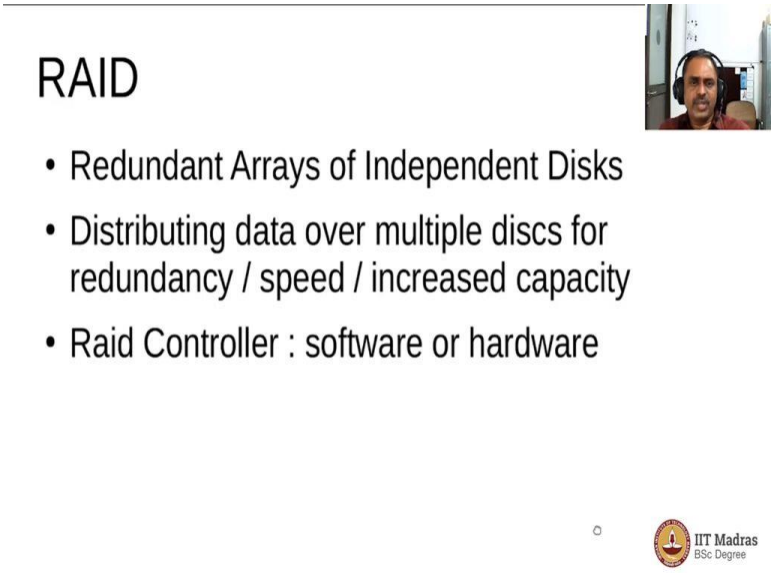

And RAID is another concept that we must be familiar; it expands to redundant arrays of independent disks. And this is basically for multiple purposes, essentially to have higher speed and for redundancy. So, that if any of the disks fail, the storage box would not go out of its usage; but you are able to recover the data, and go on to continue using the rest of the disks, by replacing the damaged disk with a new one. And the data should get rebuilt by itself.

So, some of those advanced features are very much possible today. And what is done in this particular action namely writing the data to multiple disks and making two copies of some of the data in two different disks. And and also to ensure that when a new disk has been replaced, then writing the data onto it correctly. So, all these are done by what is called a RAID controller. And

RAID controller can be a software or hardware; today hardware RAID controllers are not very expensive.

So, if you are buying a workstation, you can buy one with a RAID controller; so that you have the ability to have multiple hard disks which can be combined as a single storage.

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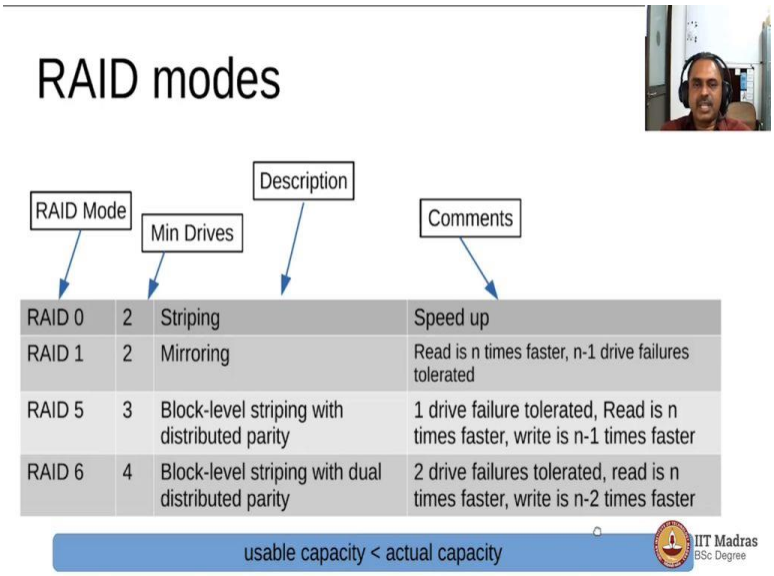

Now, there are various RAID modes that are available. So, these come in continuous sequence from 0 to 6; but I am giving you here what are more popularly used. So, RAID 0 is for striping, which means that if you are going to use two disks; you can think of the two disks as one. So, where half of the files are written in both the disks, so that they are like two stripes and the capacity is now double.

So, where does it help? It basically helps in doubling up the speed of access of a file; and RAID 1 mode is for mirroring. That means any piece of the file is written to both the disks, so that if one of them fails, you have the other copy ready. And in this case what happens is when you are reading the file, it is twice as fast; but when you are writing it is only as fast as n minus 1, so, mirroring is also one reason.

Hard disks which are SATA type will have a moving component; so they may get damaged over a period of time. So, it is not about if a hard disk fails, usually to be called as when the hard disk fails; because it will sure definitely will fail. And so it has been a good practice to have the

storage in RAID 1 mode for operating system. So, that if one disk fails, other one is still serving you; the probability of both the disks failing at the same time is very very low.

And therefore, if you invest in the second disk for OS alone, then your mission can be up and running without any problem caused by the hardware failure. RAID 5 is when you have more than three disks, so that you have an ability to have the data written to more than one disk for every file. So that off the disk, if one disk fails, you have not lost any file. Now, that kind of a distributed parity is very useful, because you can have large amount of storage; because you are writing to multiple disks. At the same time if one disk fails, you have not lost anything.

And you can have that parity over two disks if you opt for RAID 6. And that means that two disks can fail and you still have not lost any data. Now, this actually gives a very good security for your storage box, so that your services to offer the storage based data transfer can be seamless and you do not have to worry if any disk fails. Because most of the modern hardware supports hot swap; that means if disk is failed, you can plug it off, and put a new one on the fly. And this server need not be shut down and the storage need not be shut down; and everything just works quite smoothly.

So, in situations of these namely, when you do mirroring or RAID 5 or RAID 6, the usable capacity is less than the actual capacity. So, that is something that we have to accept because we are taking the benefit of parity. Therefore, we have to lose something and that is basically the usable capacity. So, more the number of discs, more is the usable capacity. But, it will never be equal to the actual capacity except when you do the striping in which case parity is absent.

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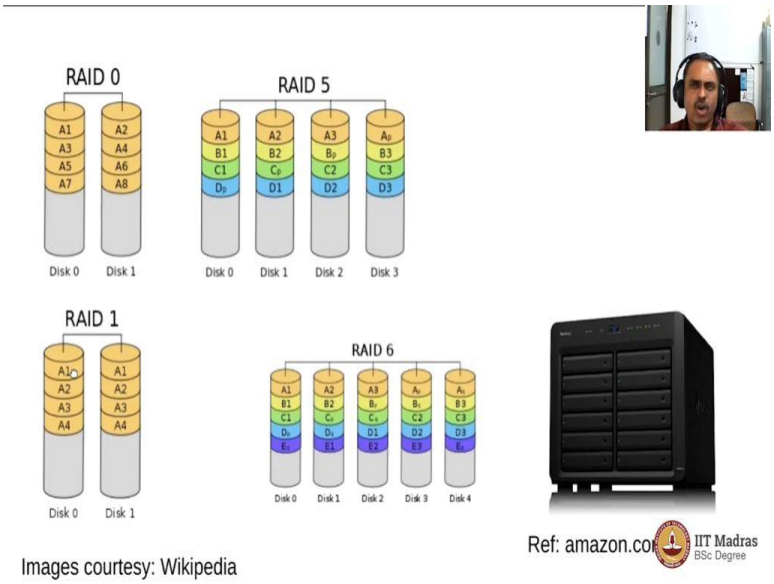

So, here are some images from the Wikipedia, which show you the philosophy. So, RAID 0 is striping only; so, which means that the A1, A2, A3, A4. So, you can see the bits and pieces of the file are written to both the disks; so they are writing in speed 2. And when you are reading also, it will be speed 2. Only thing is that if one disk fails, then you have lost the data, so it is not a good idea; only for speed it is good, but not for the disk failure.

RAID 5, you can see that A1, A2, A3 and then Ap; where p is a number, you can choose depending upon which part of a file. So, which means that you can write one third of a file to a second disk, and you write to the other one third of the next segment to the second disk. And the second disk will be shifted from 0 to 1, 2 to 3. So, that way what happens is that in a RAID 5, if one disk completely fails, the other three will contain all the three parts of every file.

And therefore, you can rebuild the disk 3 again when you put a fresh one there. Similarly, RAID 6 also will allow, only thing is there if you fail two disks, you still have the redundancy available. RAID 1 is where you have got exact copies in two discs, which is good; if one disk fails, other one will continue to run. So, for operating system alone, people tend to use RAID 1; for the home directory storage, people tend to use RAID 5 or RAID 6.

So, here is an image of Synology in NAS box from Amazon; so, here you can have like a number of disks. So, you can have a 30 terabyte or 70 terabyte kind of storages, which can be mounted as a single partition in Linux; and all these then will be configured as a RAID. And the

rest of the work is taken care of by the driver. So, you are looking at just as a partition and you can access all the storage directly.

So, let us look at that demo by looking at storages which are humongous; and you will realize from the size that it ca not be from one disk, it has to be from RAID; so let us look at that as an example.

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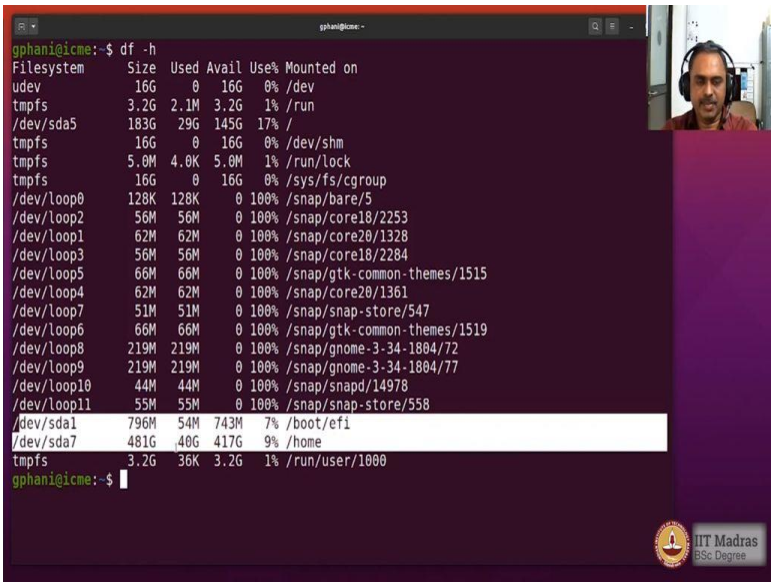

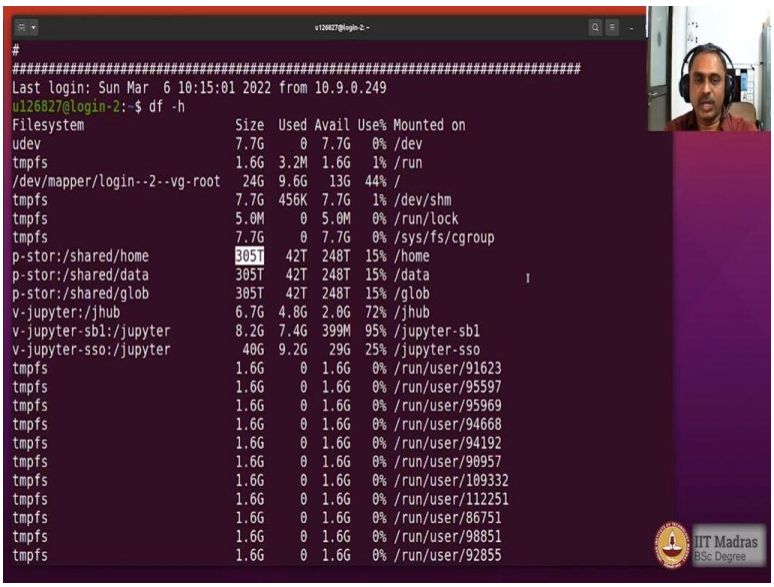

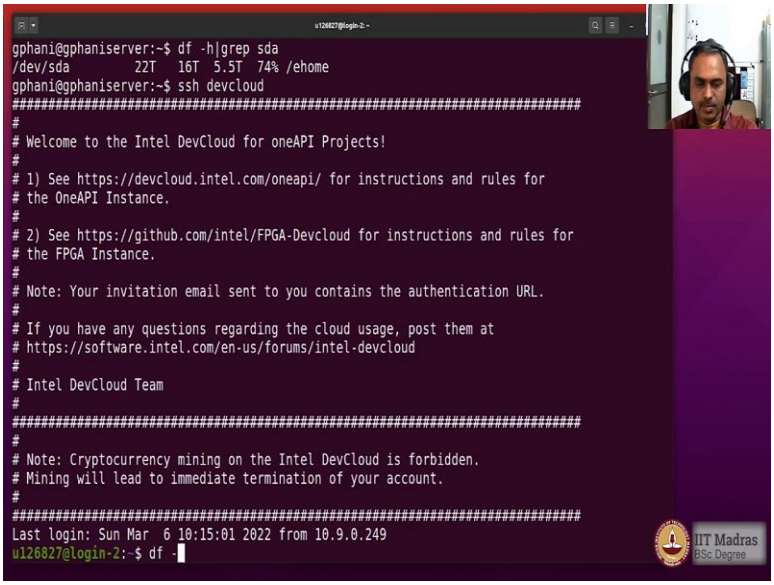

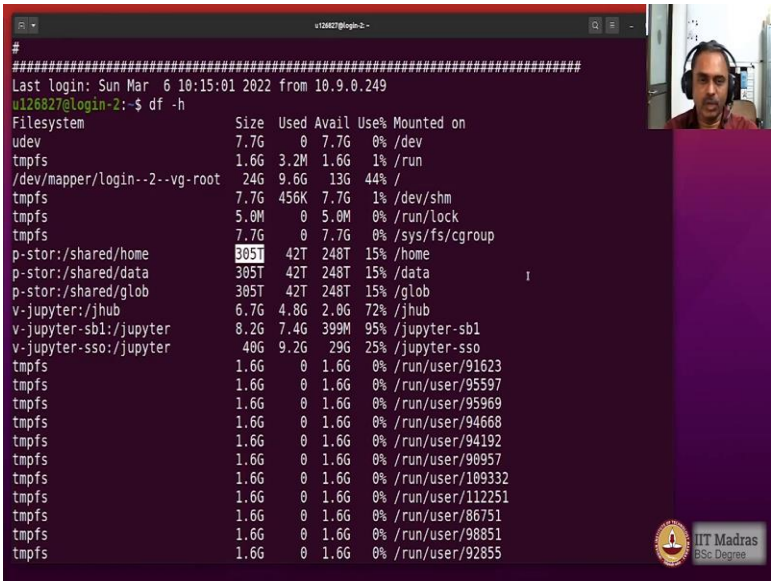

So, let us look at the storages that are available in our machine. So, the desktop where I am recording, I have got storage that is about one terabyte; you can make out the hard disk capacity here. So, we have already looked at that; and I will log on to my desktop machine, where I have got slightly larger storage. And you see that here the storage says it is 22 terabytes.

So, the largest capacity of a hard disk right now is about 12 terabytes; so this definitely means that it cannot be one disk, so it is actually a RAID storage which is coming from multiple disks. And for us, it is mounted as just one volume on a folder called slash ehome; so it is just a path. And on that we have got 22 terabytes available, thanks to the RAID concept. Now, let us look at what kinds of storages are available on the Intel dev cloud just for curiosity.

So, we have a lot of mount points, but here is the p-storage, which is parallel storage system; which shows that they have about 300 terabytes storage three times. So, roughly 1 petabyte storage is available on the Intel dev cloud for free for us when we created our login and use it. So, this is obviously not easy to imagine; so there is no single hard disk that will give you this kind of capacity. This is all collection of multiple hard disks being made available as a single folder on the Linux.

So, you can see that for the convenience of a folder that is mounted, you have got a humongous amount of storage available; thanks to the technologies that are available of combining multiple disks into a logical volume.

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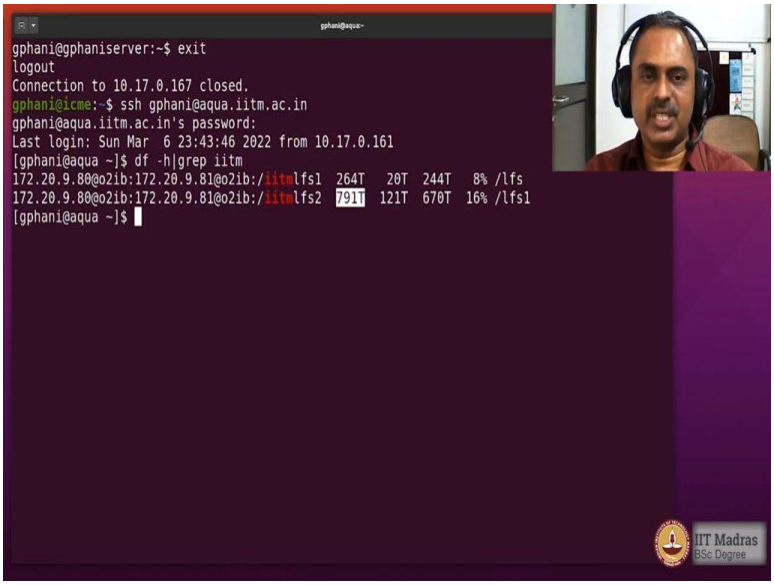

You will also log into the supercomputer in our on campus. So, where we can look at what is the storage; and here you can see that it has two folders, where they are mounting the storage slash lfs and slash lfs1. And these are respectively about 264 terabyte and 791 terabyte; together it is about one petabyte storage. So, in our supercomputer on campus, we have a petabyte storage. Again, it is made possible because there are a lot of drives that are actually combined together as a logical volume for the Linux to make it as an offering for the users; so that they can simply access their folders on these paths.

And work quite smoothly without worrying about which part of their file is stored, on which hard disk in which collection of hard disks et-cetera. So, RAID makes all these things very much

possible with a speed, and LVM technology makes this possible for us to mount as a single mount point in the Linux file system. So, by learning more about these two technologies, we may be able to save some time and effort as well as money.

For example, so for example, when you want to have a large amount of storage for your desktop, instead of buying the capacity that is right now released. You can buy cheaper ones which are at a lower capacity, and combine them as a raid volume. And thereby have a speed up resilience against failure of one of the hard disks; and at the same time mounted as a single path in your file system for the convenience also; so, Linux allows all these things.

So, knowing about these technologies may help you in building your own machine; and also configuring one which is fast, resilient against hardware failures; and convenient for large systems that you may want to work on. So, I hope this was useful for you. So, with that we come to the end of these discussions about Linux operating system, terminal environment and writing scripts. So, have fun.