

4. (15 points) Answer the following questions about VMs:

a. In the system configuration of the VM, explain how changing the number of processors changes the behavior of your VM. Explain a scenario where you want to set this to the minimum, and a scenario where you want to set it to the maximum. Why is setting it to the maximum potentially a bad idea?

We can change the number of processors we want to assign for the VM. Giving different number of processors will affect the computing ability of VM. In general, more processors brings higher performance. However, setting the number of processors to maximum will sometimes decrease the overall performance of both VM and the computer due to the fact that the host operating system won't have enough computing resources to perform background tasks. Therefore, to decide how many processors we should give to VM, we should think about what kind of tasks we expect the VM do. If we just want to use some desktop applications or run some simple programs. We can simply set the number of processors to the minimum. On the other hand, if we expect the VM to video encoding or run a huge data model, we can consider to raise the number of processors to the maximum.

b. In the system configuration of the VM, under the Acceleration Tab, explain the difference between the paravirtualization options: None, Legacy, Minimal, Hyper-V, and KVM. Explain which one would be best to use with Ubuntu Linux, and why.

None: Specifying none explicitly turns off exposing any paravirtualization interface.

Legacy: The legacy option is chosen for VMs which were created with older VirtualBox versions and will pick a paravirtualization interface while starting the VM with VirtualBox 5.0 and newer.

Minimal: Announces the presence of a virtualized environment. Additionally, reports the TSC and APIC frequency to the guest operating system. This provider is mandatory for running any Mac OS X guests.

KVM: Presents a Linux KVM hypervisor interface which is recognized by Linux kernels starting with version 2.6.25. VirtualBox's implementation currently supports paravirtualized clocks and SMP spinlocks. This provider is recommended for Linux guests.

Hyper-V: Presents a Microsoft Hyper-V hypervisor interface which is recognized by Windows 7 and newer operating systems. VirtualBox's implementation currently supports paravirtualized clocks, APIC frequency reporting, guest debugging, guest crash reporting and relaxed timer checks. This provider is recommended for Windows guests.

**We should use KVM for our Ubuntu because it is recognized by Linux kernels and it is recommended for Linux guests.**

c. In storage devices when configuring the VM, there are multiple types of storage controllers:

explain the difference between the IDE, SATA, and NVMe controller. Give an example for each type of storage controller of a scenario where you may want to use this type of controller.

IDE: IDE (ATA) controllers are a backwards-compatible yet very advanced extension of the disk controller in the IBM PC/AT (1984). Initially, this interface worked only with hard disks, but was later extended to also support CD-ROM drives and other types of removable media. In physical PCs, this standard uses flat ribbon parallel cables with 40 or 80 wires. Each such cable can connect two devices to a controller, which have traditionally been called master and slave. Typical PCs had two connectors for such cables. As a result, support for up to four IDE devices was most common.

SATA: Serial ATA (SATA) is a more recent standard than IDE. Compared to IDE, it supports both much higher speeds and more devices per controller. Also, with physical hardware, devices can be added and removed while the system is running. The standard interface for SATA controllers is called Advanced Host Controller Interface (AHCI).

NVMe: Non volatile memory express (NVMe) is a standard for connecting non volatile memory (NVM) directly over PCI Express to lift the bandwidth limitation of the previously used SATA protocol for solid-state devices. Unlike other standards the command set is very simple in order to achieve maximum throughput and is not compatible with ATA or SCSI. OSes need to support NVMe devices to make use of them.

**Based on the document of VirtualBox, it suggests to avoid IDE unless it is the only controller supported by your guest. Moreover, after I did some research, NVMe seems cause some problems when your using it in some OSes. Since that storage controllers are just virtual controllers so it won't actually affect the performance of the guest too much (we don't need to choose NVMe controller if host is running on NVMe SSD). In other words, unlike a physical NVMe, choosing a virtual NVMe controller won't actually brings you much benefit. Therefore, I suggest to use SATA in general cases.**

d. In the network configuration of the VM, there are multiple types of network adapters: explain the difference between NAT, Bridged Adapter, Internal Network, and Host-only Network. Give an example for each type of network of a scenario where you may want to use this type of network.

NAT: Network Address Translation (NAT) is the simplest way of accessing an external network from a virtual machine. Usually, it does not require any configuration on the host network and guest system. For this reason, it is the default networking mode in Oracle VM VirtualBox.

A virtual machine with NAT enabled acts much like a real computer that connects to the Internet through a router. The router, in this case, is the Oracle VM VirtualBox networking engine, which maps traffic from and to the virtual machine transparently. In Oracle VM VirtualBox this router is

placed between each virtual machine and the host. This separation maximizes security since by default virtual machines cannot talk to each other. **Choose this if all you want is to browse the Web, download files, and view email inside the guest.**

**Bridged Adapter:** This is for more advanced networking needs, such as network simulations and running servers in a guest. When enabled, Oracle VM VirtualBox connects to one of your installed network cards and exchanges network packets directly, circumventing your host operating system's network stack. **Choose this if you want your VM be visible to the outside world and host. For example, build a server in VM.**

**Internal Network:** This can be used to create a different kind of software-based network which is visible to selected virtual machines, but not to applications running on the host or to the outside world. Internal Networking is similar to bridged networking in that the VM can directly communicate with the outside world. However, the outside world is limited to other VMs on the same host which connect to the same internal network. **Choose this for security concern. For example, you prefer two or more VMs on the same machine to communicate privately, hiding their data from both the host system and the user,**

**Host-only Network:** This can be used to create a network containing the host and a set of virtual machines, without the need for the host's physical network interface. Instead, a virtual network interface, similar to a loopback interface, is created on the host, providing connectivity among virtual machines and the host. **Host-only networking is particularly useful for preconfigured virtual appliances, where multiple virtual machines are shipped together and designed to cooperate. For example, one virtual machine may contain a web server and a second one a database, and since they are intended to talk to each other, the appliance can instruct Oracle VM VirtualBox to set up a host-only network for the two. A second, bridged, network would then connect the web server to the outside world to serve data to, but the outside world cannot connect to the database.**

e. For the USB configuration of the VM, explain the difference between USB 1.1, 2.0, and 3.0 controllers.

**USB 1.1: OHCI**

**USB 2.0: EHCI + OHCI**

**USB 3.0: This supports all USB speeds.**