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1. Minix Operating System

1.1. Introduction and Motivation

An operating system is the backbone of any computing device, serving as the interface between the hardware and the user. It manages hardware resources, provides essential services, and enables the execution of various applications, making computing accessible and efficient. It is responsible for critical tasks, such as: Resource Management, Process Management, File Management and User Interface. It can be of various types to serve different purposes. For example:

- General-Purpose OS: Like Windows, macOS, and Linux that are designed for personal or professional use.
- Mobile OS: Like Android and iOS are used for mobile devices.
- Embedded OS: Specialized OS for embedded systems found in appliances, cars, and IoT devices.
- Real-Time OS (RTOS): Designed for systems that require immediate processing, such as industrial robots or medical devices.

Here we will focus on Minix. Minix is a small, **UNIX-like** operating system originally developed as a teaching tool by Andrew S. Tanenbaum in 1987. It was created to demonstrate the principles of operating systems and is known for its **microkernel** architecture, which emphasizes modularity and simplicity. Minix served as an inspiration for the development of Linux, and its design is widely regarded for its educational value. The motivation behind Minix was to provide an open, accessible system for students and developers to learn and experiment with operating system concepts.

1.1. Objectives

Minix was created with clear objectives in mind. It was primarily designed as an educational tool to teach operating system concepts and provide practical experience in understanding OS structures. By making the source code accessible, Tanenbaum ensured that students and developers could explore, modify, and learn from the OS's inner workings.

Our main objectives for installing Minix OS in a virtual environment are:

- ✓ Understanding Minix OS Features:
 - Gaining experience with the Minix Operating System
 - Explore its educational uses in teaching operating systems concepts.
- ✓ Experimentation in Virtual Environments:
 - We will use the virtual tool VMware Workstation to safely set up and experiment with Minix OS, without affecting the physical hardware.
 - Learn about resource allocation and compatibility within virtual setups.
- ✓ Filesystem Exploration:
 - Study the Minix Operating System's support for different file systems and understand its default file management system, known as the **MINIX file system**.
- ✓ Skill Development:
 - Enhance technical expertise in installing and configuring operating systems in virtual environments.
 - Troubleshoot issues and document solutions effectively.
- ✓ Practical Application:
 - ✓ It will help us prepare for real-world scenarios where microkernel-based operating systems may be useful (e.g., embedded systems, research).

1.3. Requirements

1.3.1 Hardware

To run Minix OS in a virtual environment, the following hardware requirements are recommended:

- ✓ Processor: A modern x86-64 processor with virtualization support (Intel VT-x or AMD-V).
- ✓ RAM: Minimum 512 MB (1 GB or more is preferable for smoother performance).
- ✓ Storage: At least 1 GB of available disk space.
- ✓ Graphics: Basic VGA-compatible graphics hardware is sufficient.
- ✓ Network: Internet connectivity is optional but useful for updates or additional resources and packages.

1.3.2 Software

- Virtualization Software:
 - ✓ VMware Workstation or VMware Player
- Operating System (ISO):
 - ✓ Minix OS ISO file, which can be downloaded from the official website.
- Host OS:
 - ✓ A supported operating system to run the virtualization software (e.g., Windows, macOS, Linux).
- Filesystem:
 - ✓ Support for the filesystem used by Minix OS (e.g., ext2/ext3, as Minix OS uses its own MINIX file system).

1.4. Installation steps

- Go to the official Minix website (<https://www.minix3.org/>) and download the latest ISO image file
 - Download and Install VMware
 - Launch the application and create a new virtual machine
 - Assign the hardware resources
 - Start the Virtual Machine and load the Minix OS installer
 - Follow Installation Prompts
 - Use the installer to set up Minix OS
 - Partition the virtual disk (follow the Minix setup instructions for filesystem selection)
 - Create a user account with your full name
 - Verify Installation
 - Once the setup is complete, restart the virtual machine
 - Ensure that Minix OS is installed correctly boots correctly then an account can be created through the admin.
- ❖ In the next part we will see screenshots of most of the steps involved:

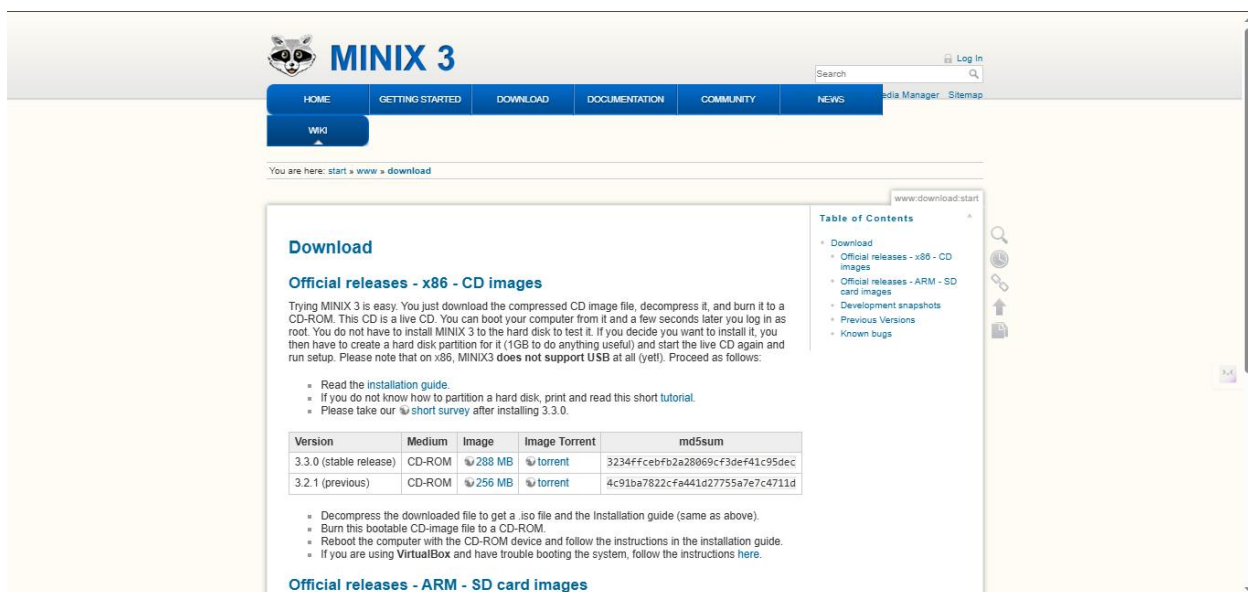
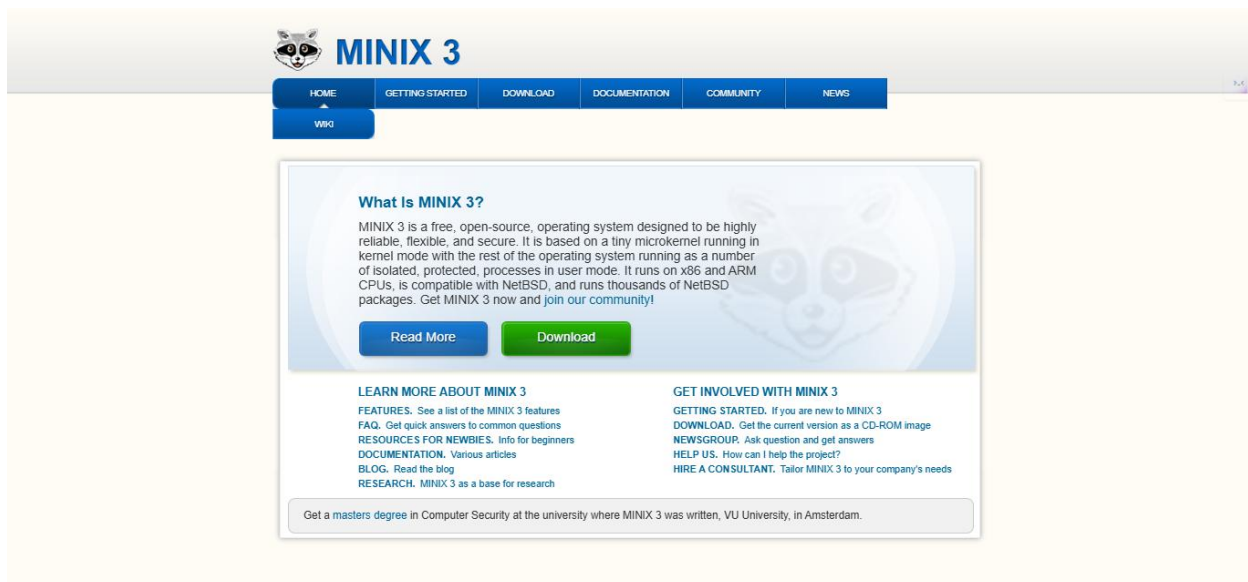


Image-set 1. Downloading Minix's ISO file from their official website

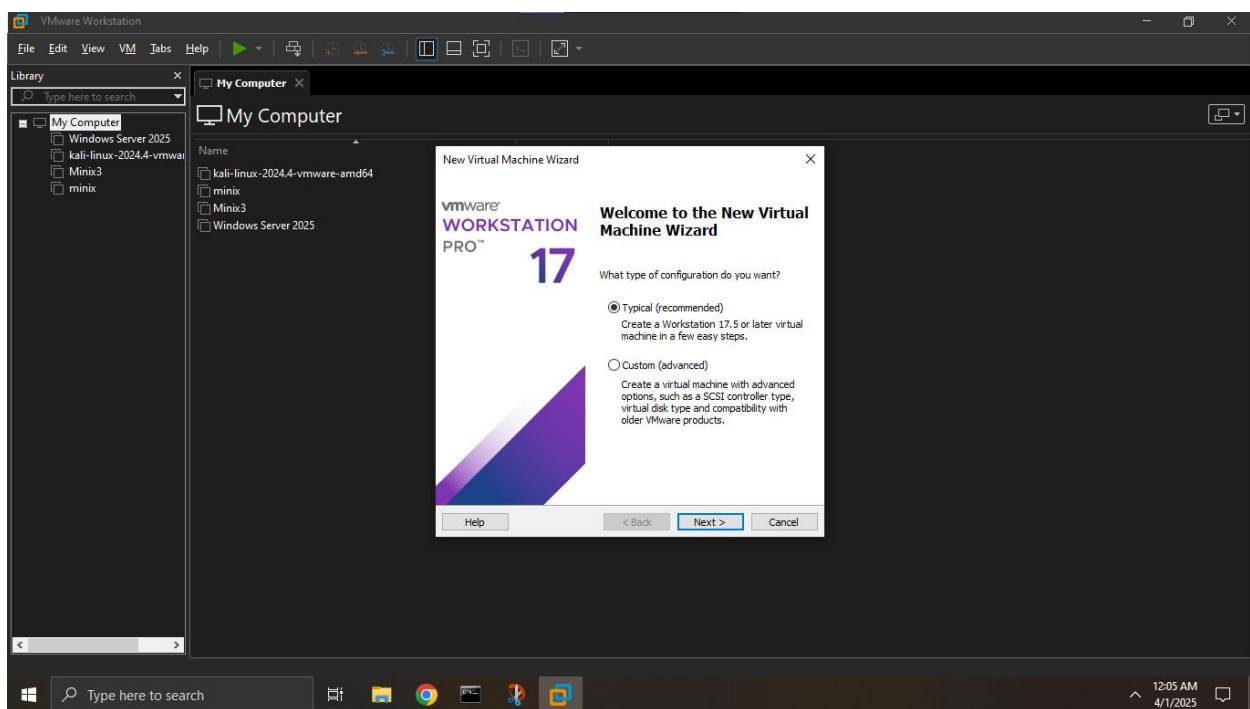
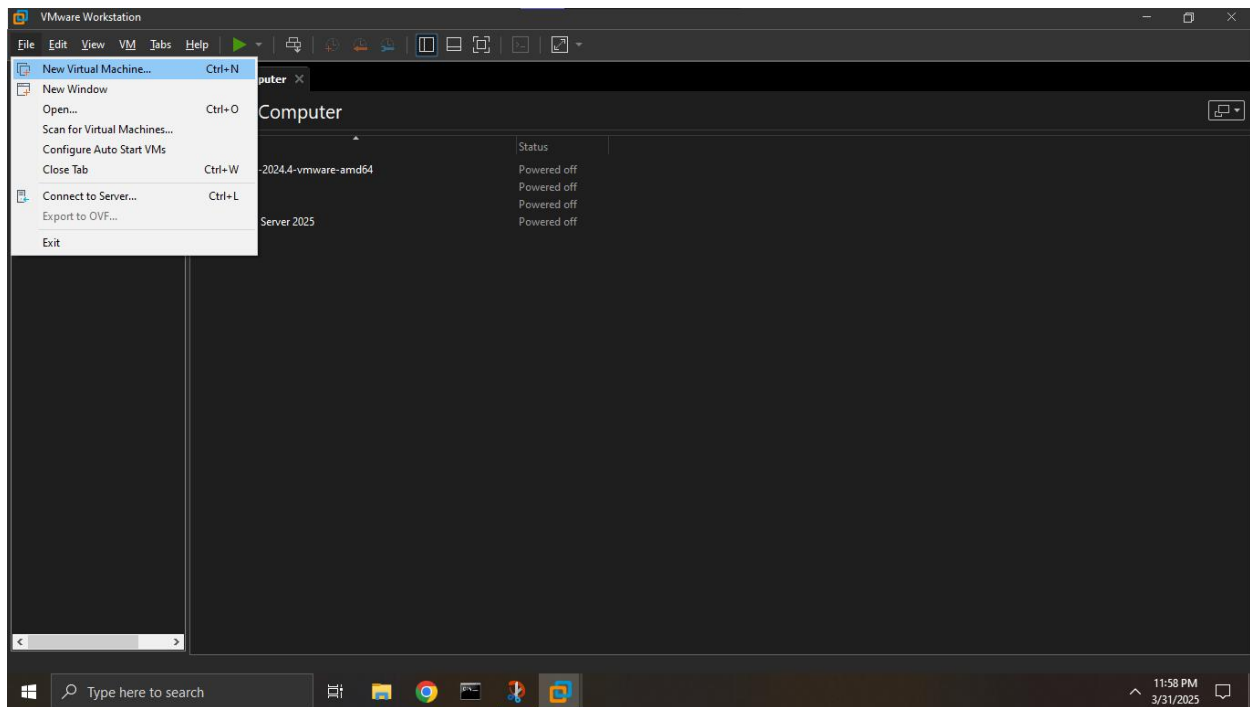


Image-set 2. Setting up the virtual machine

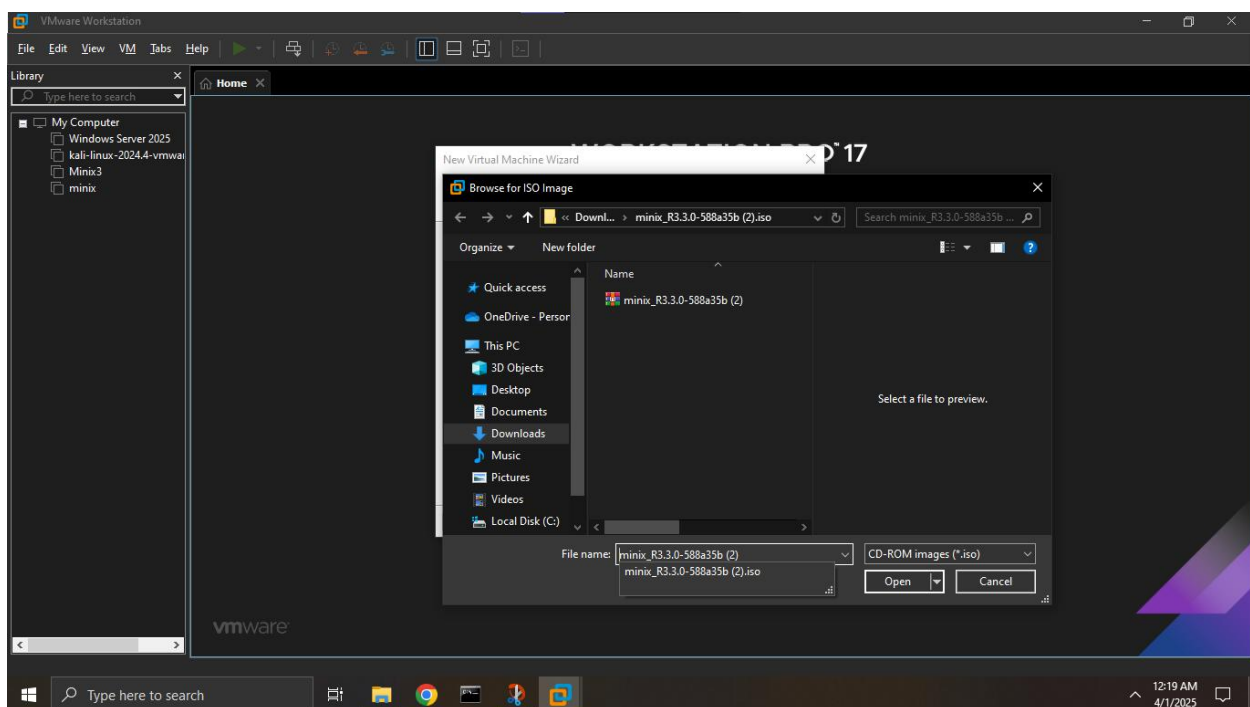
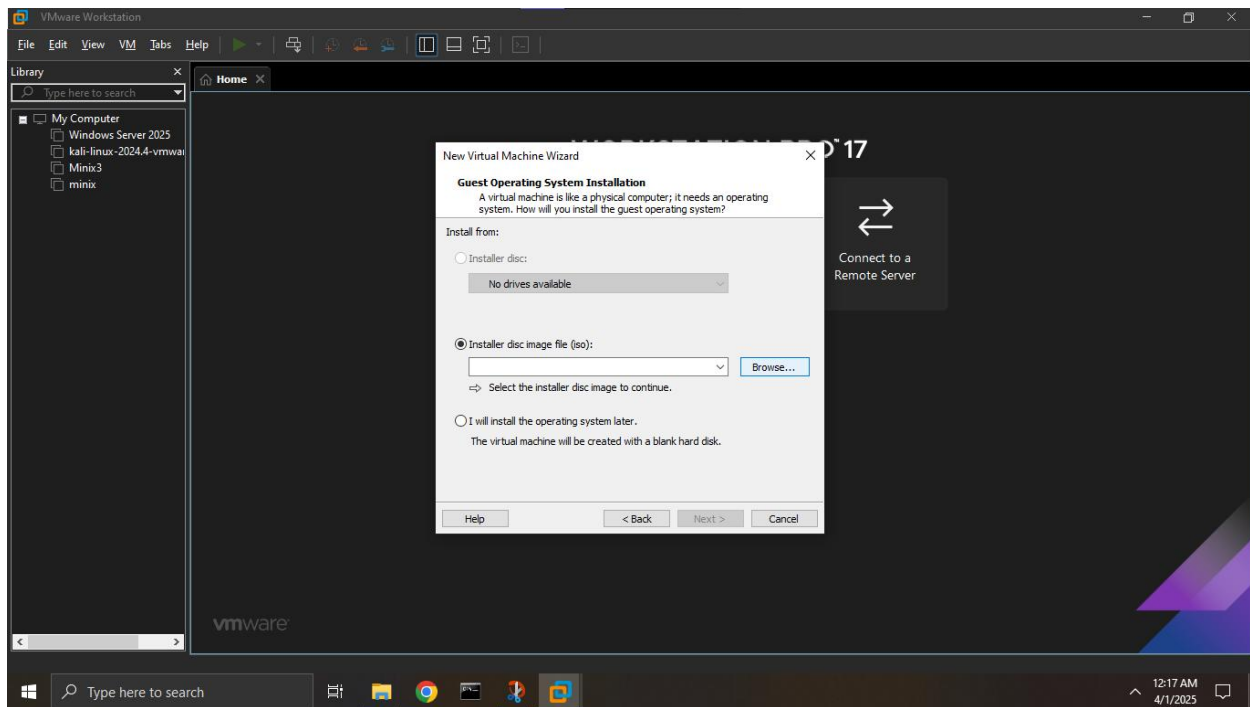


Image-set 3. Loading the Minix ISO file into the new virtual machine

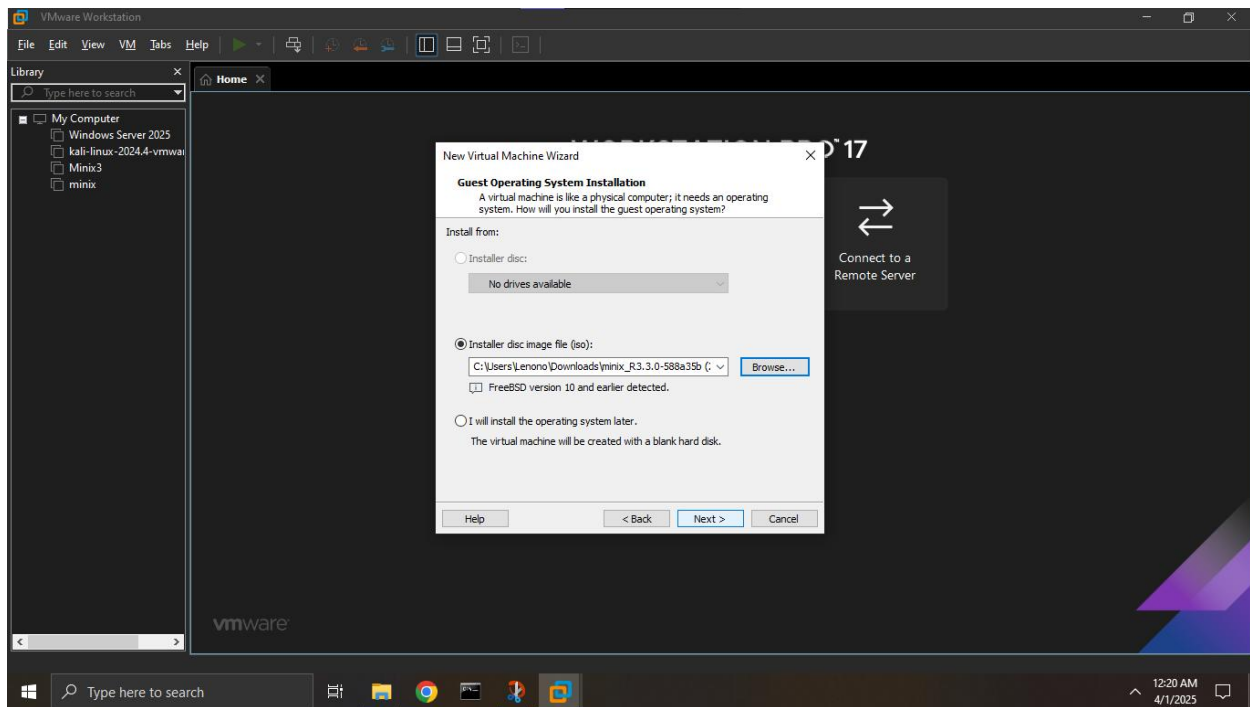


Image-set 4. Assigning hardware

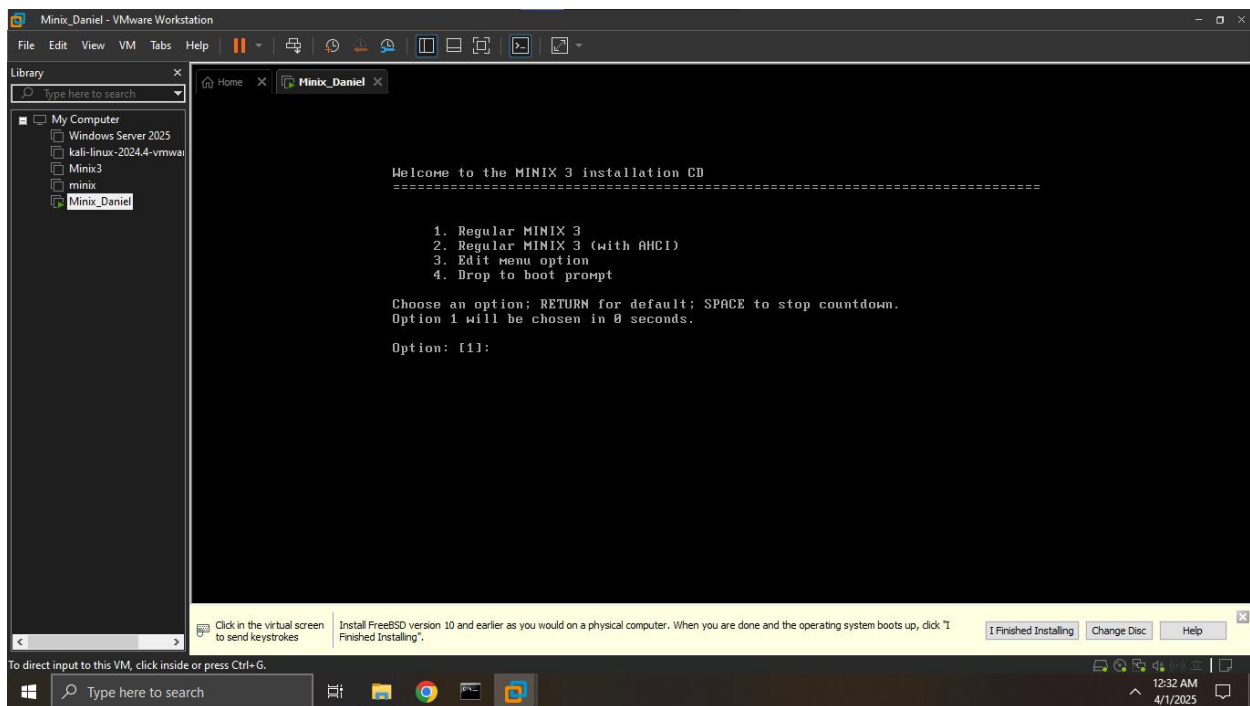
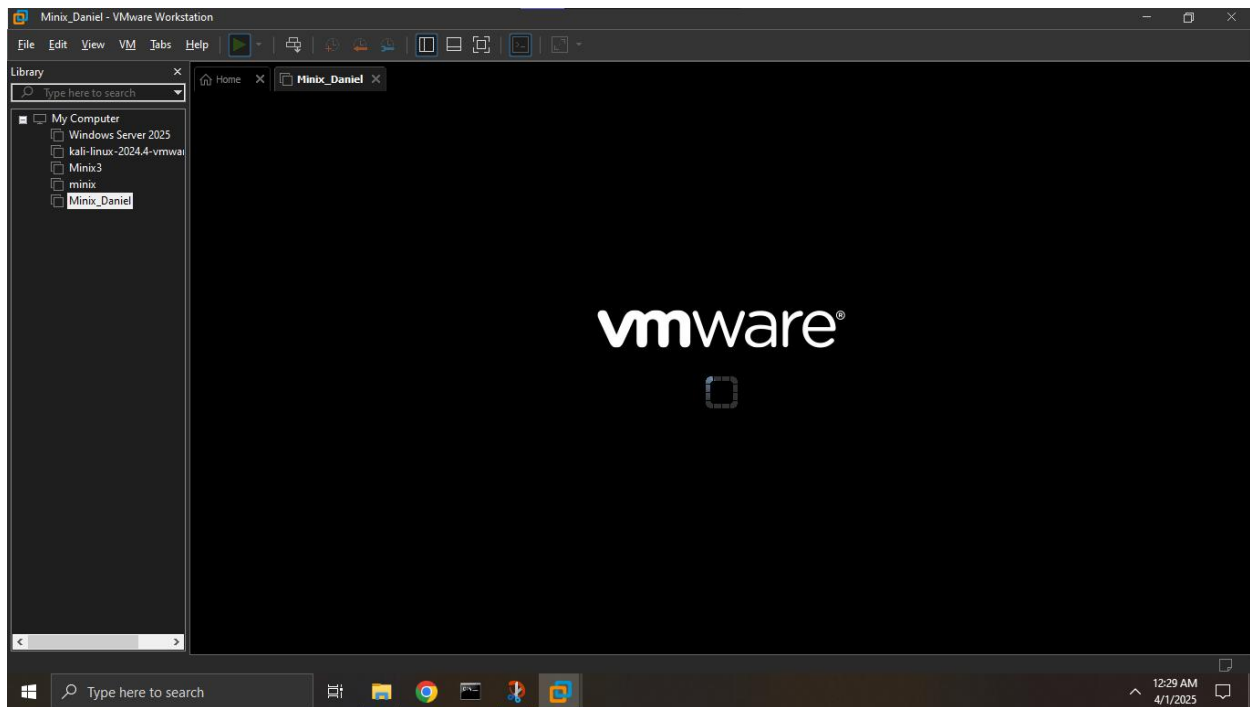


Image-set 5. Turning on the Guest Operating System

To direct input to this virtual machine, press Ctrl+G.

```
13033•6035•55425•i58064•397140•0x9bb7c
WARNING: couldn't open cd9660 (/cd9660/cd9660.kmod)
Loading /mod01_ds
Loading /mod02_rs
Loading /mod03_pm
Loading /mod04_sched
Loading /mod05_ufs
Loading /mod06_memory
Loading /mod07_tty
Loading /mod08_rfs
Loading /mod09_cw
Loading /mod10_pfs
Loading /mod11_init
WARNING: 1 module failed to load

MINIX 3.3.0. (588a35b)
Copyright 2014, Vrije Universiteit, Amsterdam, The Netherlands
MINIX is open source software, see http://www.minix3.org
Started UFS: 9 worker thread(s)

Looking for boot CD. This may take a minute.
Please ignore any error messages.

Trying /dev/c0d2
```

```
Loading ramdisk from /dev/c0d2p1
Root device name is /dev/ram
/dev/ram: clean
/dev/ram is mounted on /
none is mounted on /proc
/usr on cd is /dev/c0d2p2
/dev/c0d2p2 is mounted on /usr
size on /dev/ingrd set to 0kB
Multiuser startup in progress ...
Starting hotplugging infrastructure... done.
devmand error: could not open event file /sys/events bailing out
Starting services: random pty uds ipc log printer.
Starting daemons: update syslogd.

Welcome to MINIX.

The system is now running and many commands work normally. To use MINIX
in a serious way, you need to install it to your hard disk.

Type "root" at the login prompt, and hit enter.
Then type "setup" and hit enter to start the installation process.

Minix/i386 (minix) (console)

login: _
```

Image-set 6. Root login

```
The system is now running and many commands work normally. To use MINIX
in a serious way, you need to install it to your hard disk.

Type "root" at the login prompt, and hit enter.
Then type "setup" and hit enter to start the installation process.

Minix/i386 (minix) (console)

login: root
Copyright (c) 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005,
2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013
The NetBSD Foundation, Inc. All rights reserved.
Copyright (c) 1982, 1986, 1989, 1991, 1993
The Regents of the University of California. All rights reserved.

For post-installation usage tips such as installing binary
packages, please see:
http://wiki.minix3.org/UsersGuide/PostInstallation

For more information on how to use MINIX 3, see the wiki:
http://wiki.minix3.org

We'd like your feedback: http://minix3.org/community/

# _
```

```
The system is now running and many commands work normally. To use MINIX
in a serious way, you need to install it to your hard disk.

Type "root" at the login prompt, and hit enter.
Then type "setup" and hit enter to start the installation process.

Minix/i386 (minix) (console)

login: root
Copyright (c) 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005,
2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013
The NetBSD Foundation, Inc. All rights reserved.
Copyright (c) 1982, 1986, 1989, 1991, 1993
The Regents of the University of California. All rights reserved.

For post-installation usage tips such as installing binary
packages, please see:
http://wiki.minix3.org/UsersGuide/PostInstallation

For more information on how to use MINIX 3, see the wiki:
http://wiki.minix3.org

We'd like your feedback: http://minix3.org/community/

# setup_
```

Image-set 7. Initial setting up of the virtual machine

```

We'd like your feedback: http://minix3.org/community/

# setup

Welcome to the MINIX 3 setup script. This script will guide you in setting up
MINIX on your machine. Please consult the manual for detailed instructions.

Note 1: If the screen blanks, hit CTRL-F3 to select "software scrolling".
Note 2: If things go wrong then hit CTRL-C to abort and start over.
Note 3: Default answers, like [y], can simply be chosen by hitting ENTER.
Note 4: If you see a colon (:) then you should hit ENTER to continue.
:

--- Step 1: Select keyboard type -----
What type of keyboard do you have? You can choose one of:

    abnt2      japanese    russian-cp1251  uk
    dvorak     latin-america russian-cp866   ukrainian-koi8-u
    french     norwegian   russian         us-std
    german     polish      scandinavian   us-swap
    italian    portuguese   spanish

Keyboard type? [us-std] _

```

```

    abnt2      japanese    russian-cp1251  uk
    dvorak     latin-america russian-cp866   ukrainian-koi8-u
    french     norwegian   russian         us-std
    german     polish      scandinavian   us-swap
    italian    portuguese   spanish

Keyboard type? [us-std]

--- Step 2: Selecting full distribution -----

--- Step 3: Create or select a partition for MINIX 3 -----

Now you need to create a MINIX 3 partition on your hard disk.
You can also select one that's already there.

If you have an existing installation, reinstalling will let you
keep your current partitioning and subpartitioning, and overwrite
everything except your s1 subpartition (/home). If you want to
reinstall, select your existing minix partition.

Unless you are an expert, you are advised to use the automated
step-by-step help in setting up.

Press ENTER for automatic mode, or type 'expert':

```

Image-set 8. Choosing keyboard language and setup type

```

--- Step 3: Create or select a partition for MINIX 3 -----
Now you need to create a MINIX 3 partition on your hard disk.
You can also select one that's already there.

If you have an existing installation, reinstalling will let you
keep your current partitioning and subpartitioning, and overwrite
everything except your s1 subpartition (/home). If you want to
reinstall, select your existing minix partition.

Unless you are an expert, you are advised to use the automated
step-by-step help in setting up.

Press ENTER for automatic mode, or type 'expert':

--- Substep 3.1: Select a disk to install MINIX 3 -----
Probing for disks. This may take a short while..... Probing done.
The following disk was found on your system:

Disk [0]: /dev/c0d3,   20 GB
Free space          ( 19 GB)

Enter the disk number to use: [0] 0

```

```

Probing for disks. This may take a short while..... Probing done.
The following disk was found on your system:

Disk [0]: /dev/c0d3,   20 GB
Free space          ( 19 GB)

Enter the disk number to use: [0] 0

--- Substep 3.2: Select a disk region -----
Please select the region that you want to use for the MINIX 3 setup.
If you select an in-use region it will be overwritten by MINIX. The
following region were found on the selected disk:

[0] Free space          ( 19 GB)

Enter the region number to use or type 'delete': [0]

--- Substep 3.3: Confirm your choices -----
This is the point of no return. You have selected to install MINIX 3
into region 0 of disk /dev/c0d3. Please confirm that you want
to use this selection to install MINIX 3.

Are you sure you want to continue? Please enter 'yes' or 'no': yes

```

Image-set 9. Partition and disk region setup

```
Please select the region that you want to use for the MINIX 3 setup.
If you select an in-use region it will be overwritten by MINIX. The
following region were found on the selected disk:
```

```
    [0] Free space          ( 19 GB)
```

```
Enter the region number to use or type 'delete': [0]
```

```
--- Substep 3.3: Confirm your choices -----
```

```
This is the point of no return. You have selected to install MINIX 3
into region 0 of disk /dev/c8d3. Please confirm that you want
to use this selection to install MINIX 3.
```

```
Are you sure you want to continue? Please enter 'yes' or 'no': yes
```

```
--- Step 4: Reinstall choice -----
```

```
No old /home found. Doing full install.
```

```
--- Step 5: Select the size of /home -----
```

```
MINIX will take up 667 MB, without /home.
How big do you want your /home to be in MB (0-19811) ? [3962] 512_
```

```
following region were found on the selected disk:
```

```
    [0] Free space          ( 19 GB)
```

```
Enter the region number to use or type 'delete': [0]
```

```
--- Substep 3.3: Confirm your choices -----
```

```
This is the point of no return. You have selected to install MINIX 3
into region 0 of disk /dev/c8d3. Please confirm that you want
to use this selection to install MINIX 3.
```

```
Are you sure you want to continue? Please enter 'yes' or 'no': yes
```

```
--- Step 4: Reinstall choice -----
```

```
No old /home found. Doing full install.
```

```
--- Step 5: Select the size of /home -----
```

```
MINIX will take up 667 MB, without /home.
How big do you want your /home to be in MB (0-19811) ? [3962] 512
512 MB Ok? [Y] Y_
```

Image-set 10. Home setup

```
This is the point of no return. You have selected to install MINIX 3
into region 0 of disk /dev/c0d3. Please confirm that you want
to use this selection to install MINIX 3.
```

```
Are you sure you want to continue? Please enter 'yes' or 'no': yes
```

```
--- Step 4: Reinstall choice -----
```

```
No old /home found. Doing full install.
```

```
--- Step 5: Select the size of /home -----
```

```
MINIX will take up 667 MB, without /home.
How big do you want your /home to be in MB (0-19811) ? [3962] 512
```

```
512 MB Ok? [Y] Y
```

```
--- Step 6: Select a block size -----
```

```
The default file system block size is 4 kB.
```

```
Block size in kilobytes? [4] 4
```

```
Block size in kilobytes? [4] 4
```

```
You have selected to (re)install MINIX 3 in the partition /dev/c0d3p0.
The following subpartitions are now being created on /dev/c0d3p0:
```

```
Root subpartition: /dev/c0d3p0s0 128 MB
/home subpartition: /dev/c0d3p0s1 512 MB
/usr subpartition: /dev/c0d3p0s2 rest of c0d3p0
```

```
Creating /dev/c0d3p0s0 for / ..
Creating /dev/c0d3p0s1 for /home ..
Creating /dev/c0d3p0s2 for /usr ..
```

```
--- Step 7: Wait for files to be copied -----
```

```
All files will now be copied to your hard disk. This may take a while.
```

```
Remaining: 3526 files. [=====!-----]
/mnt/pkg/lib/engines/libmuron.so
/mnt/pkg/lib/engines/libpadlock.so
/mnt/pkg/lib/engines/libsecure.so
/mnt/pkg/lib/engines/libubsec.so
/mnt/pkg/lib/libcrypto.a
/mnt/pkg/lib/libcrypto.so
```

Image-set 11. Selecting block size and copying files to hard disk


```

Saving random data..
1+0 records in
1+0 records out

--- Step 8: Select your Ethernet chip -----
MINIX 3 currently supports the following Ethernet cards. PCI cards detected
by MINIX are marked with *. Please choose:

0. No Ethernet card (no networking)
1. 3Com 581 or 3Com 589 based card
2. Realtek 8029 based card (also emulated by qemu)
3. NE2000, 3com 503 or WD based card (also emulated by Bochs)
4. lan8710a (on BeagleBone, BeagleBone Black)
5. Attansic/Atheros L2 FastEthernet
6. DEC Tulip 21140A in VirtualPC
7. * Intel PRO/1000 Gigabit
8. Intel PRO/100
9. AMD LANCE (also emulated by VMWare and VirtualBox)
10. Realtek 8139 based card
11. Realtek 8169 based card
12. Virtio network device
13. Different Ethernet card (no networking)

Ethernet card? [7] 7_

```

```

13. Different Ethernet card (no networking)

Ethernet card? [7] 7

Configure network using DHCP or manually?

1. Automatically using DHCP
2. Manually

Configure method? [1] 1
/dev/c8d3p0s2 unmounted from /mnt/usr
Unmounted c8d3p0s2
/dev/c8d3p0s8 unmounted from /mnt
Unmounted c8d3p0s8

Please type 'reboot' to exit MINIX 3 and reboot. To boot into your new
system, you might have to remove installation media.

This ends the MINIX 3 setup script. You may want to take care of post
installation steps, such as local testing and configuration.

Please consult the user manual for more information.

# reboot_

```

Image-set 12. Network configuration and reboot

```
--- Welcome to MINIX 3. This is the boot monitor. ---
Memory: 638/259968 k

1. Start MINIX 3
2. Start latest MINIX 3
3. Start latest MINIX 3 in single user mode
4. Edit menu option
5. Drop to boot prompt
6. Start MINIX 3 (3.3.0)

Choose an option; RETURN for default; SPACE to stop countdown.
Option 2 will be chosen in 0 seconds.

Option: [2]:2
```

```
pty uds ipc log printer.
Starting daemons: update cron syslogd.
Starting networking: dhcpcd nonamed.
Local packages (start): done.

Minix/i386 (192.168.223.130) (console)

login: root
Password:
Copyright (c) 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005,
2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013
The NetBSD Foundation, Inc. All rights reserved.
Copyright (c) 1982, 1986, 1989, 1991, 1993
The Regents of the University of California. All rights reserved.

For post-installation usage tips such as installing binary
packages, please see:
http://wiki.minix3.org/UsersGuide/PostInstallation

For more information on how to use MINIX 3, see the wiki:
http://wiki.minix3.org

We'd like your feedback: http://Minix3.org/COMMUNITY/

#
```

Image-set 13. Minix was successfully installed and correctly booted

```
#
#
#
#
#
#
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#
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#
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#
#
#
#
#
group add Software
#
```

```
#  
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#  
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#  
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#  
#  
#  
#  
#  
#  
#  
#  
#  
#  
#  
# group add Software  
# user add -m -g Software Daniel_Tefera  
#
```

Image-set 14. Creating a group called software and a personal user account

```
#
#
#
#
#
#
#
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#
#
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#
#
#
#
#
#
# chfn Daniel_Tefera
```

```
#Changing user database information for Daniel_Tefera.  
Login: Daniel_Tefera  
Password: *****  
Uid [#]: 1002  
Gid [# or name]: 1001  
Change [month day year]:  
Expire [month day year]:  
Class:  
Home directory: /home/Daniel_Tefera  
Shell: /bin/sh  
Full Name:  
Location:  
Office Phone:  
Home Phone:
```

```
/tmp/pw.00247a: unmodified: line 1
```

Image-set 15. using chfn command to view and edit the user information

1.5. Issues

- The first issue was that VM Ware needs the user to turn on VT-x options when they are available but it was turned off in my computer.

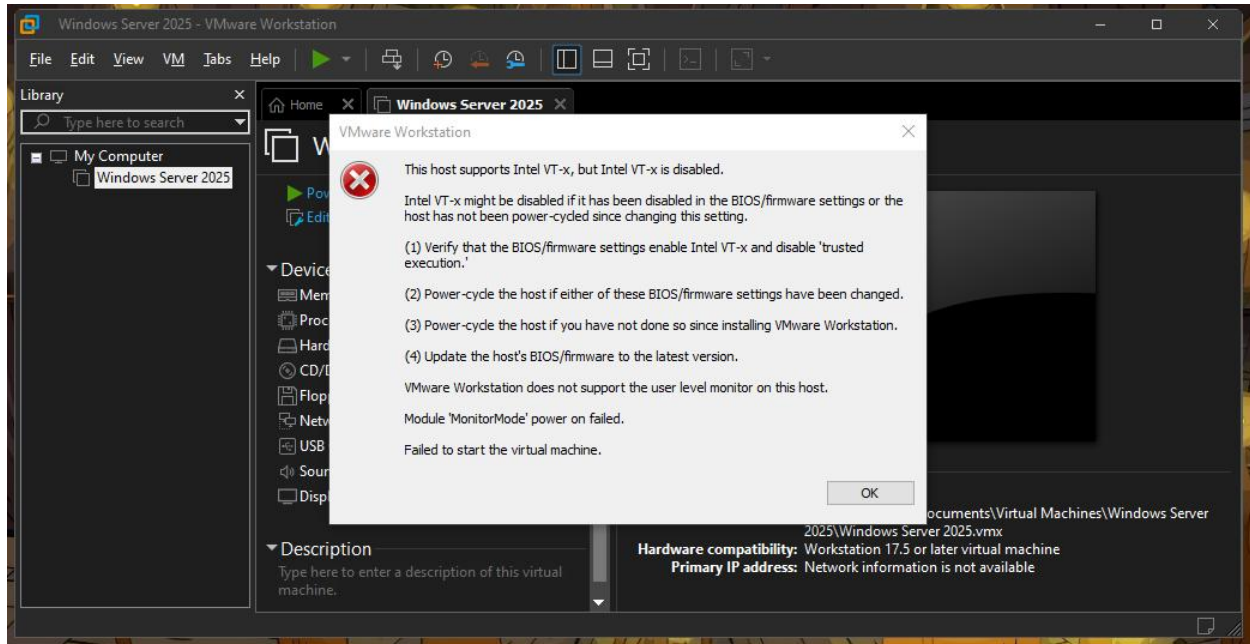


Image 1. VT-x error

- The second problem was that the GUI interface for Minix was unavailable for both updating and installation so I couldn't use the command **Startx** to start the GUI mode.
- The other problem was with installing the necessary packages and the unfamiliar command line interface environment and commands.
- There also was a limit to the characters used for the username, so I couldn't use my full name.

1.6. Solutions

- For the first problem I had to go to the BIOS mode in my computer to enable VT-x.
- For the second problem I researched and it happens that the problem is a bug in the latest available and stable version of Minix, Minix 3.0. There is Minix 4.0 but it isn't available on their official website. So we should wait until it gets fixed but that may not happen as the operating system could be in a "coma" like state. Its last update was on may 2017 G.C. 8 years ago!
- For the third problem I had to update all packages (`pkgin update`) then specifically install what I needed like the editing environment nano(`pkgin install nano`) and the compiler clang(`pkgin install clang`). The gcc compiler isn't available in Minix.
- I had to use Daniel_Tefera instead of Daniel_Tefera_Alamirew.

1.7. Filesystem support

Minix OS is primarily designed to use the Minix filesystem, but it can also support other filesystems.

1.7.1. Supported Filesystems

- ✓ **MINIX Filesystem:** This is the default filesystem for Minix OS, designed for simplicity and efficiency. It is ideal for educational purposes and is lightweight, making it suitable for the OS's microkernel architecture. It has limited maximum file size and partition size compared to more modern filesystems.
- ✓ **Ext2:** This is an older Linux filesystem that can be used with Minix OS for broader compatibility. It is robust and has no journaling, which aligns with the simplicity of Minix. It is fast and straightforward, suitable for lightweight systems.
- ✓ **FAT32:** Its universally supported.
- ✓ **Ext3/Ext4, NTFS and Btrfs/ZFS** are not supported.

1.8. Advantages and disadvantages

1.8.1. Advantages

- ✓ Educational Focus: Minix OS is specifically designed for teaching and research purposes in operating systems. Its simplicity makes it easier to understand the internal workings of OS design.
- ✓ Microkernel Architecture: The OS uses a microkernel structure, which enhances modularity, reliability, and maintainability.
- ✓ Lightweight: Minix OS has minimal hardware requirements, making it ideal for resource constrained environments.
- ✓ Filesystem Simplicity: The Minix filesystem is straightforward and great for beginners learning about file management systems.
- ✓ Portability: It can run on diverse hardware platforms and in virtual environments, making it versatile for experimentation.

1.8.2. Disadvantages

- ✓ Limited Features: Minix OS lacks the advanced features found in modern operating systems, such as sophisticated GUI interfaces and multitasking capabilities.
- ✓ Filesystem Restrictions: The Minix filesystem has size limitations, making it less suitable for handling large files or partitions.
- ✓ Driver Support: Limited support for modern hardware drivers, which can lead to compatibility issues.
- ✓ Not Suitable for Production: While excellent for educational purposes, Minix OS is not designed for commercial or production environments.

- ✓ Older Technology: Being designed with educational goals in mind, it does not stay updated with modern computing needs and trends. And bugs like the GUI installation problem we saw earlier may not get fixed.

1.9. Conclusion

Minix OS provides an excellent foundation for learning the core principles of operating systems due to its microkernel architecture, lightweight design, and educational focus. Setting up Minix OS in a virtual environment allows users to safely experiment with the OS's capabilities, understand its filesystem support, and troubleshoot issues without risking physical hardware. Despite its limitations in modern features and driver support, Minix OS remains a powerful tool for understanding modularity and reliability in system design!

1.10. Future Outlook/Recommendations

- ✓ Enhance Educational Usability: Minix OS could further develop tools and documentation to support students and researchers, making complex OS concepts more accessible. More tutorials and case studies on microkernel usage could be provided.
- ✓ Compatibility Improvements: Future updates could focus on broader hardware and software compatibility, ensuring Minix OS can function seamlessly across diverse virtual environments.
- ✓ Filesystem Development: Expanding filesystem capabilities to support larger files and partitions would make Minix OS more practical for modern use cases.
- ✓ User Interface Enhancements: Adding more interactive GUIs could make Minix OS more user-friendly while maintaining its lightweight nature.
- ✓ Integration with Modern Platforms: Minix OS could explore integration with IoT devices, embedded systems, and other cutting-edge technologies where its modularity would shine.

2. Virtualization

- Virtualization is the process of creating a virtual version of computing resources, including hardware platforms, storage devices, and network resources. This allows multiple virtual instances of operating systems to run on a single physical machine. In modern operating systems, virtualization is a very important technology that enhances resource utilization, security, and flexibility. By integrating hypervisors, supporting containerization, and providing robust management tools, these systems enable efficient operation of multiple isolated environments, making them essential for both enterprise and cloud computing.

- We Use Virtualization for:
 - ✓ Resource Optimization: Virtualization enables better utilization of hardware resources by running multiple OS instances on one physical computer. This reduces the price that we would have to pay for deploying multiple computers for tasks like application software testing.
 - ✓ Isolation: Each virtual machine (VM) operates independently. This increases security and minimizes conflicts between applications.
 - ✓ Development and Testing: Developers can create isolated environments to test applications without affecting the host Operating System.
 - ✓ Scalability: Virtualization allows for quick scaling of resources in response to varying workloads.

- How Virtualization Works:

Virtualization works by using a hypervisor to create and manage virtual machines (VMs) on a physical server. The hypervisor allocates resources like CPU, memory, and storage to each VM, allowing them to run independently as if they were separate physical computers. Users can install different operating systems on these VMs and run applications without impacting each

other. This setup enhances resource efficiency, flexibility, and security, as each VM is isolated from the others.

❖ Main actors and concepts in virtualization

- ✧ **Hypervisor:** A hypervisor is software that creates and manages virtual machines. There are two types: Type 1 (bare-metal) which runs directly on hardware, while Type 2 (hosted) runs on top of an existing operating system like VM Ware. It allocates the resources that the Guest Operating System needs.
- ✧ **Guest Operating System :** Each Virtual Machine runs *its own operating system*, known as the Guest Operating System, which can be different from the host OS.
- ✧ **Containerization:** Is the use of container technologies that provide lightweight, isolated environments for applications, enhancing deployment and scalability while sharing the same OS kernel..

References

<https://www.minix3.org/>

<https://en.wikipedia.org/wiki/Minix>

<https://en.wikipedia.org/wiki/Virtualization>