ns-3 simulator

(Brief Tutorial)

Outline

Introduction

- The goal of this lecture is to experience a simulator
  - There are no annoying coding and debugging assignments (just run the scripts)
- The ns-3 simulator is a discrete-event network simulator
- ns-3 is an open source project
- *ns-3* is not an officially supported software product of any company
- *ns-3* is designed as a set of libraries that can be combined together and also with other external software libraries
- *ns-3* is primarily used on Linux or macOS systems

Resources

- Main web site
  - https://www.nsnam.org
- **Tutorial ★**
  - https://www.nsnam.org/docs/release/3.36/tutorial/html/index.html
- Manual (Release 3.36)
  - https://www.nsnam.org/docs/release/3.36/manual/singlehtml/index.html
- **API documentation ★ ★**
  - https://www.nsnam.org/docs/release/3.36/doxygen/index.html
- Git
  - https://gitlab.com/nsnam/ns-3-dev
- Google groups (You can check Q&A history)
  - https://groups.google.com/g/ns-3-users
- TA email
  - jtzlbsj4a@naver.com

Installation

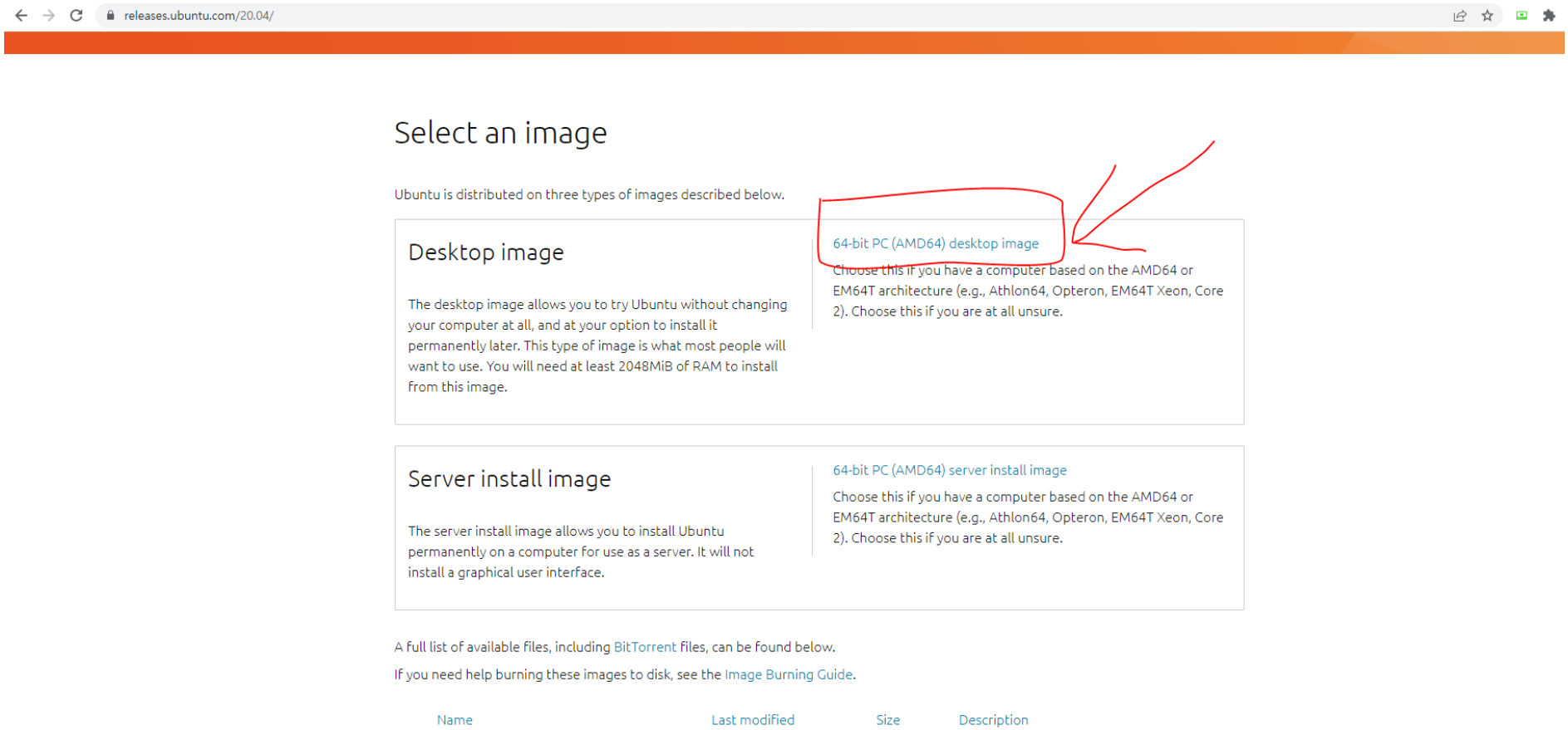
- Ubuntu installation for Windows users
  - Those who are ready for the Ubuntu environment can move on to slide 34

☞ For Mac users, refer https://www.nsnam.org/wiki/Installation#macOS

  - Ubuntu
    - One of the popular Linux distributions
    - https://releases.ubuntu.com/20.04/
  - VirtualBox
    - Powerful tool that can virtualize almost any operating system (OS)
    - https://www.virtualbox.org/wiki/Downloads

Installation

- Ubuntu 20.04 https://releases.ubuntu.com/20.04/
  - Download Ubuntu 20.04 desktop image
  - It takes up 3.1GB of memory and takes a long time (5+ minutes) to download



Installation

- VirtualBox https://www.virtualbox.org/wiki/Downloads/
- Download VirtualBox for Windows hosts

VirtualBox

About
Screenshots
Downloads
Documentation
End-user docs
Technical docs
Contribute
Community

Download VirtualBox

Here you will find links to VirtualBox binaries and its source code.

VirtualBox binaries

By downloading, you agree to the terms and conditions of the respective license.

If you're looking for the latest VirtualBox 6.1 packages, see VirtualBox 6.1 builds. Version 6.1 will remain supported until December 2023.

VirtualBox 7.0.8 platform packages

- Windows hosts
- macOS / Intel hosts
- Developer preview for macOS / Arm64 (M1/M2) hosts
- Linux distributions
- Solaris hosts
- Solaris 11 IPS hosts

The binaries are released under the terms of the GPL version 3.

See the changelog for what has changed.

You might want to compare the checksums to verify the integrity of downloaded packages. *The SHA256 checksums should be favored as the MD5 alg*

- SHA256 checksums, MD5 checksums

Note: After upgrading VirtualBox it is recommended to upgrade the guest additions as well.

Installation

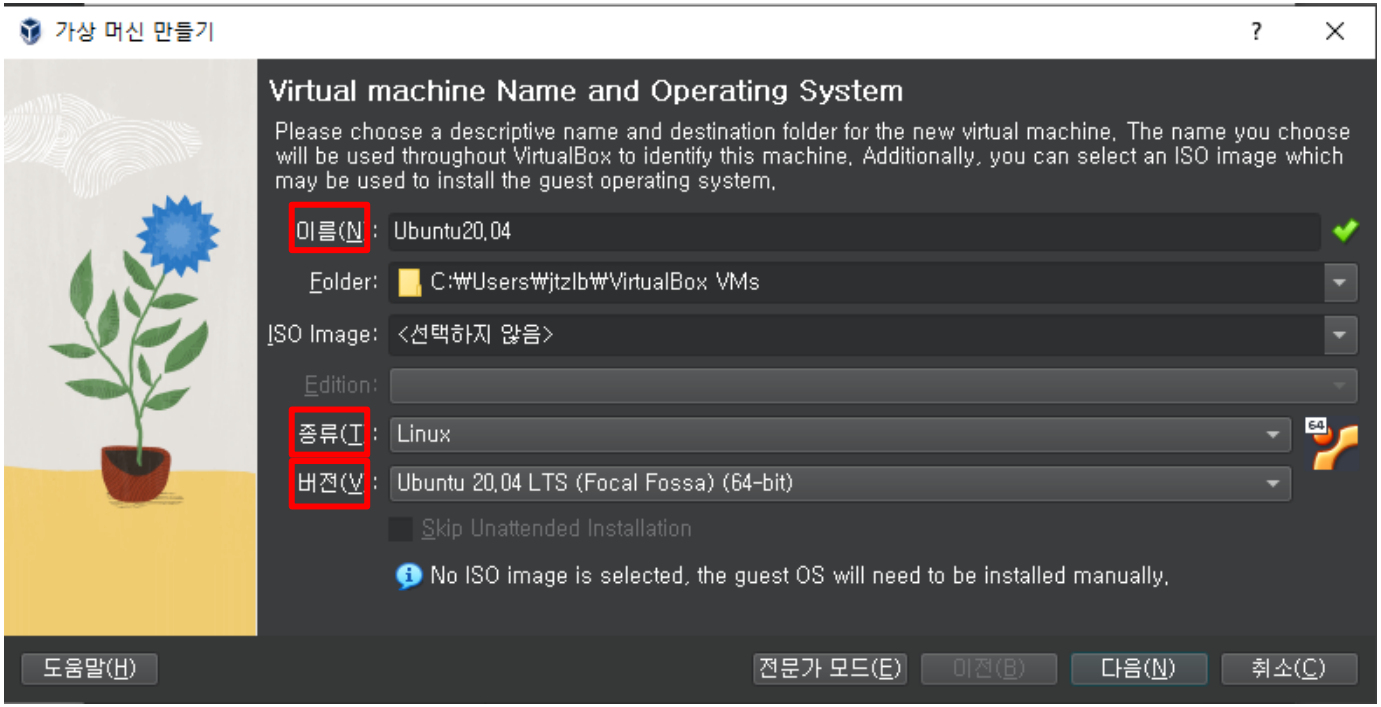
- VirtualBox
  - Executes the VirtualBox setup file
  - ‘Press Next’ is all you need until the successful installation

Installation

- VirtualBox setting
  - Executes the VirtualBox after the installation
  - Then, press the New (새로 만들기) button

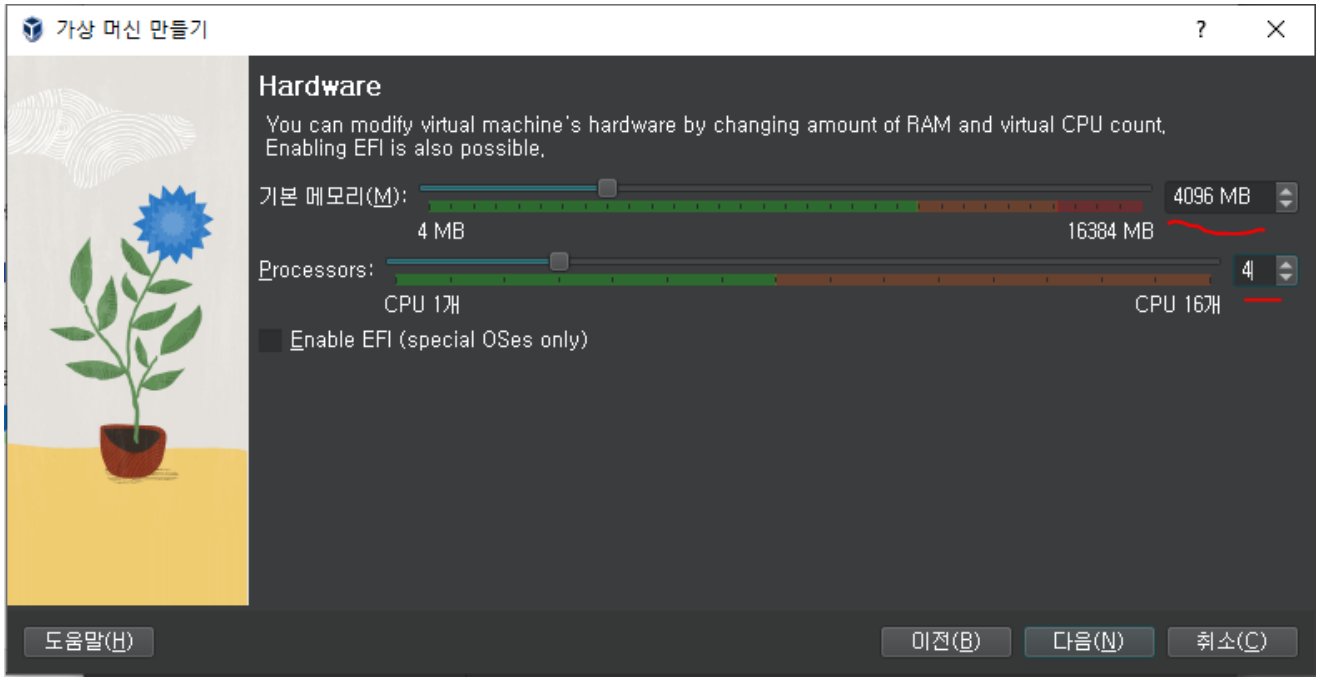
Installation

- VirtualBox setting
  - Type anything you want in the name field
  - Select Linux and version Ubuntu 20.04 LTS
  - Press the Next button



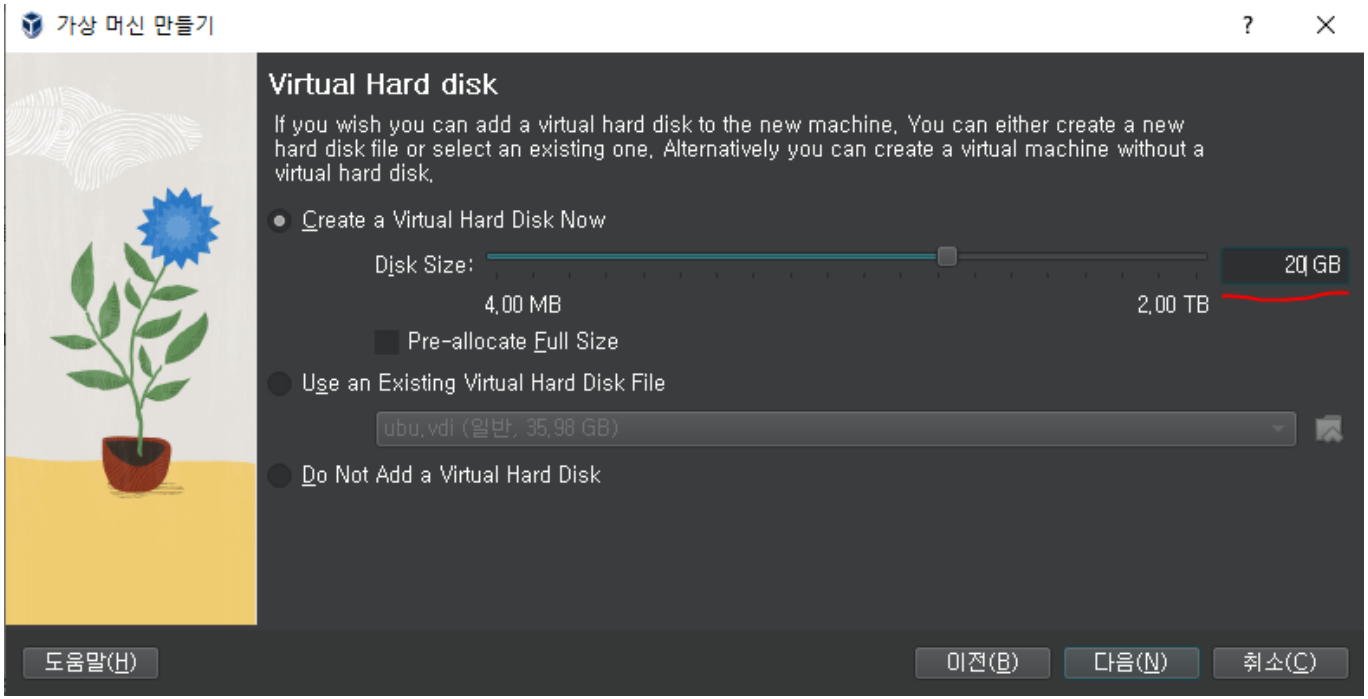
Installation

- VirtualBox setting
  - Allocate sufficient RAM and processors for the virtual machine
    - If you give it less, it will slow down
  - Press the Next button



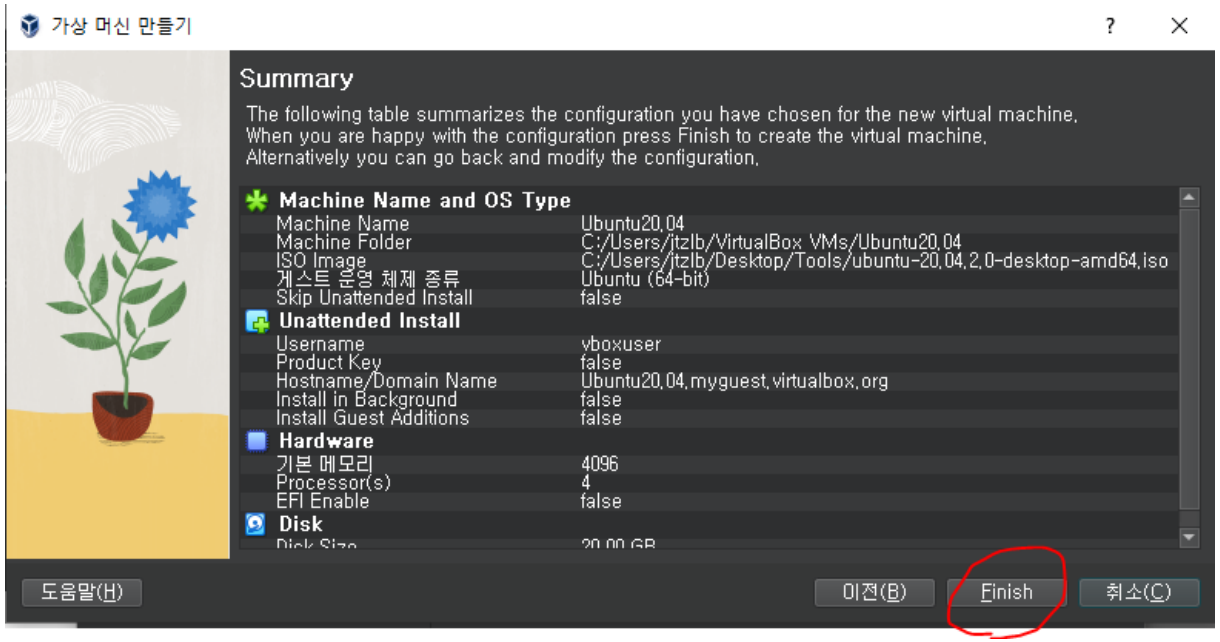
Installation

- VirtualBox setting
  - Allocate sufficient memory for the virtual machine, then press the Next button



Installation

- VirtualBox setting
  - Finish

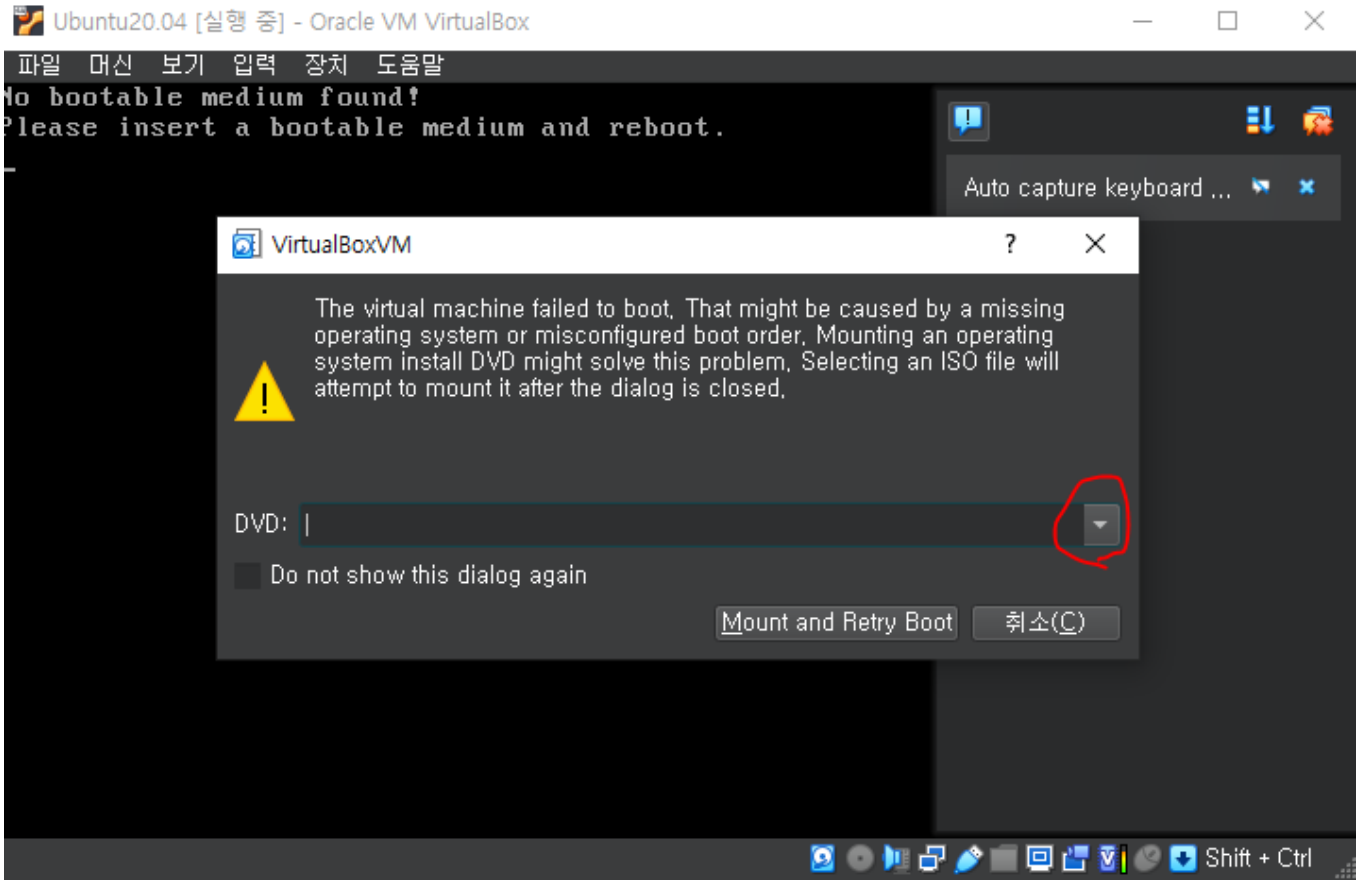


Installation

- VirtualBox setting
  - After the basic settings, select the newly created virtual machine and click the Start button

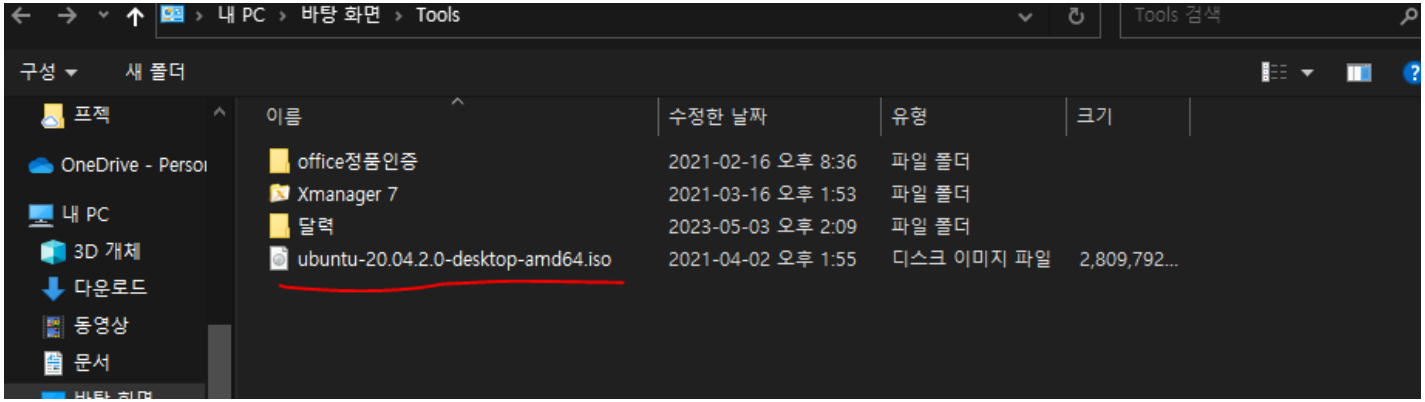
Installation

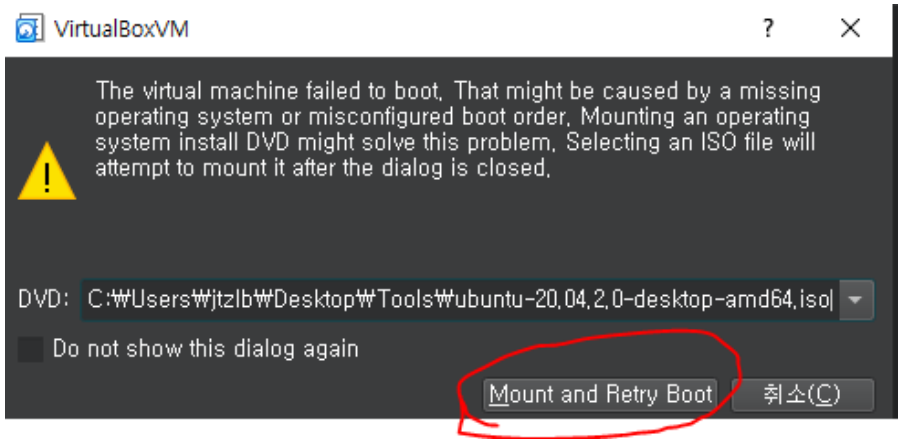
- VirtualBox setting
  - It's time to plug-in the Ubuntu ISO image
  - Press the dropdown button



Installation

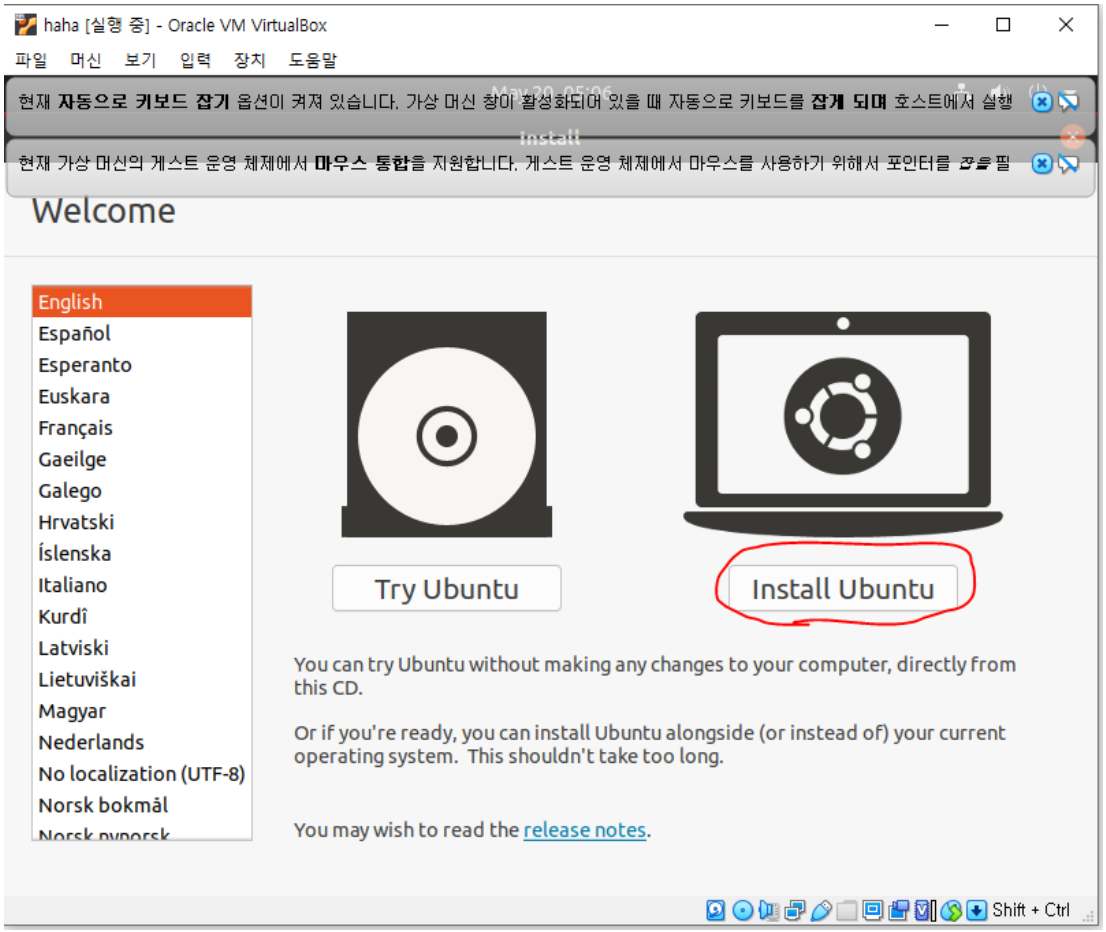
- VirtualBox setting
  - Find & select the iso image
  - Then, press the mount and retry boot button





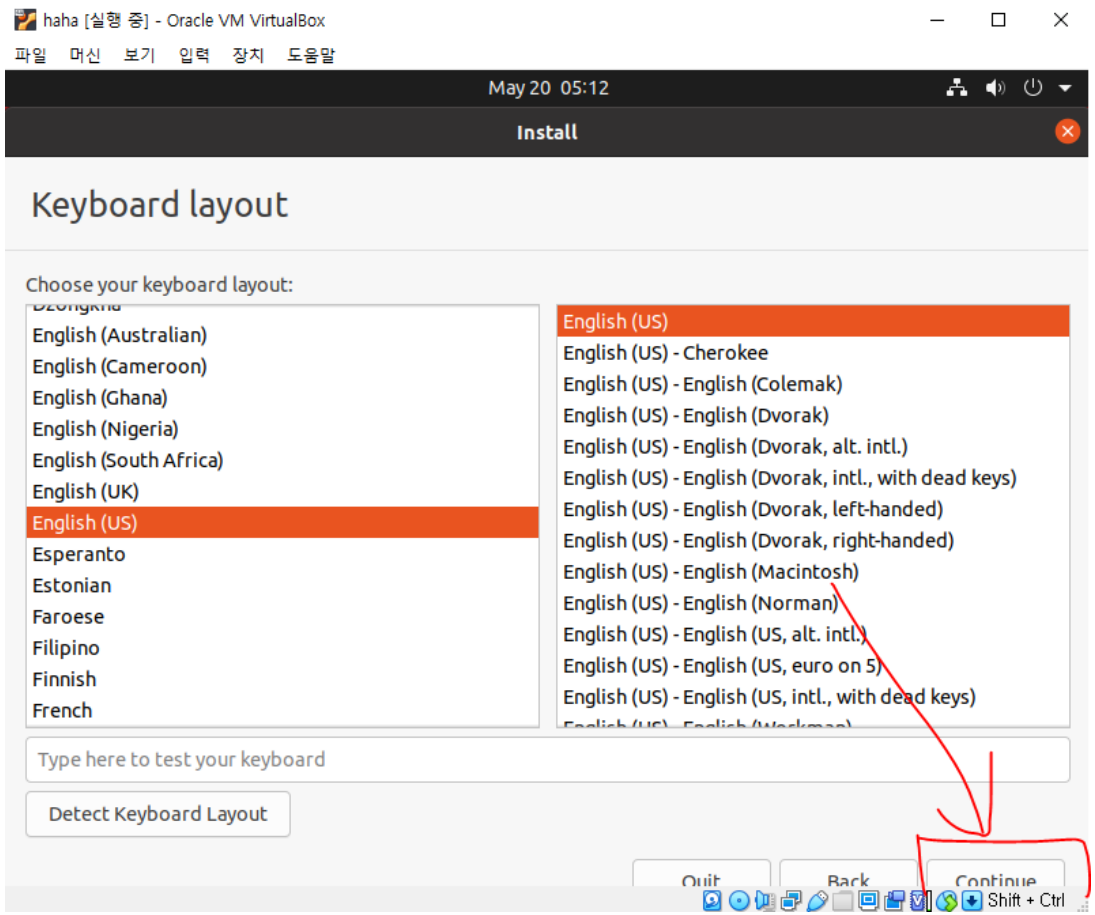
Installation

- Ubuntu setup
  - This screen appears a few moments later
  - Let's press the install Ubuntu



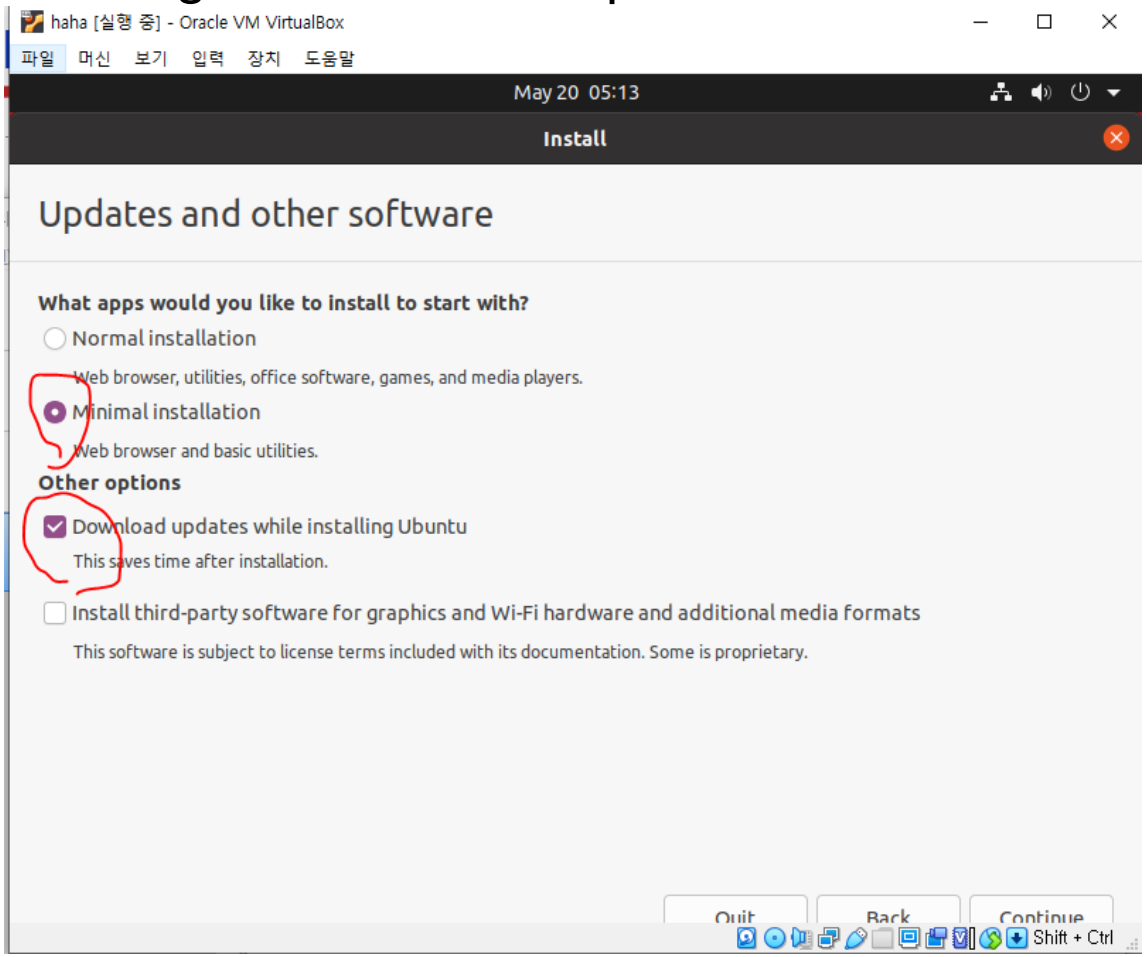
Installation

- Ubuntu setup
  - Press the Continue button



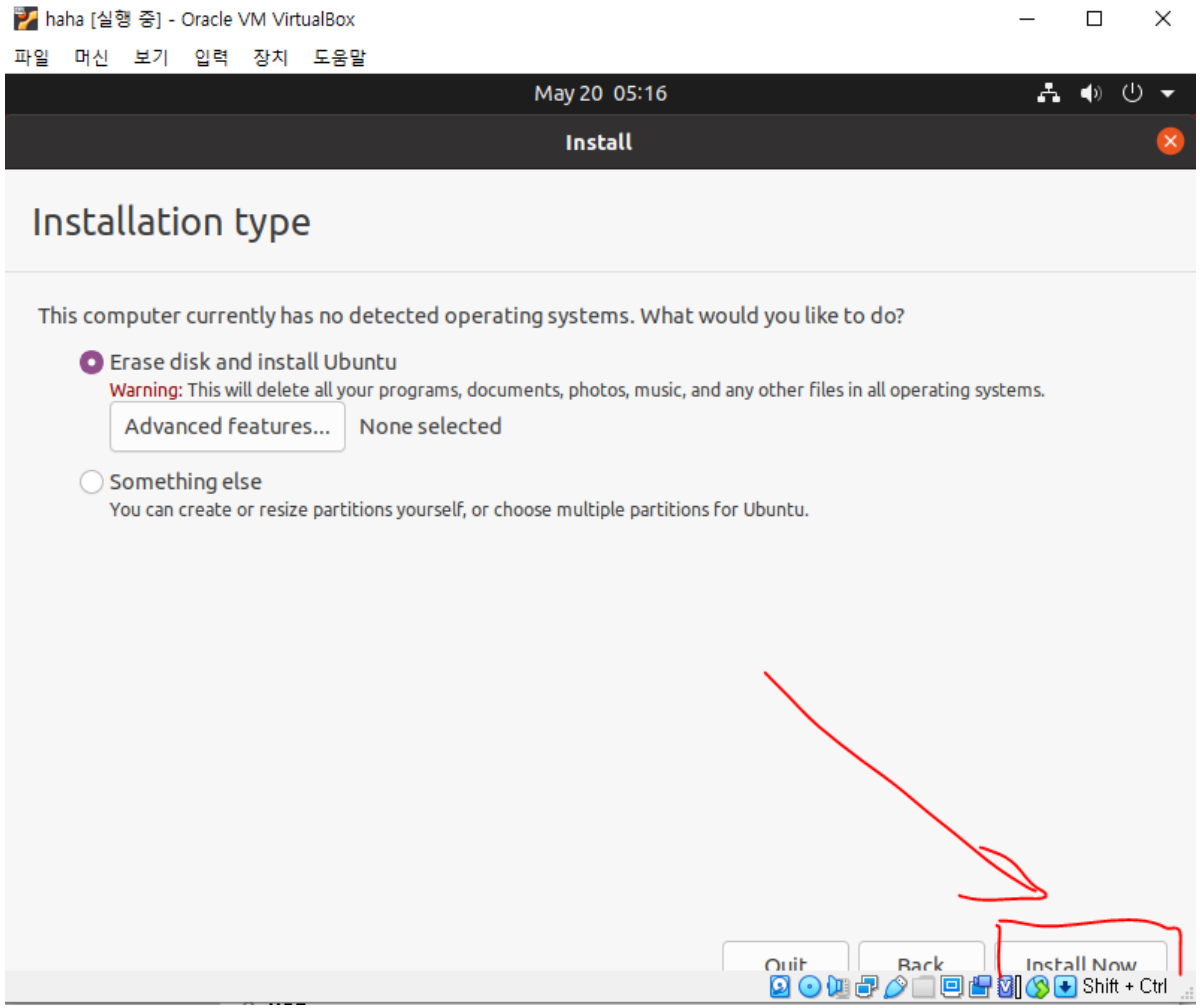
Installation

- Ubuntu setup
  - Select the Minimal installation option, Download update while installing Ubuntu, and then press the Continue button



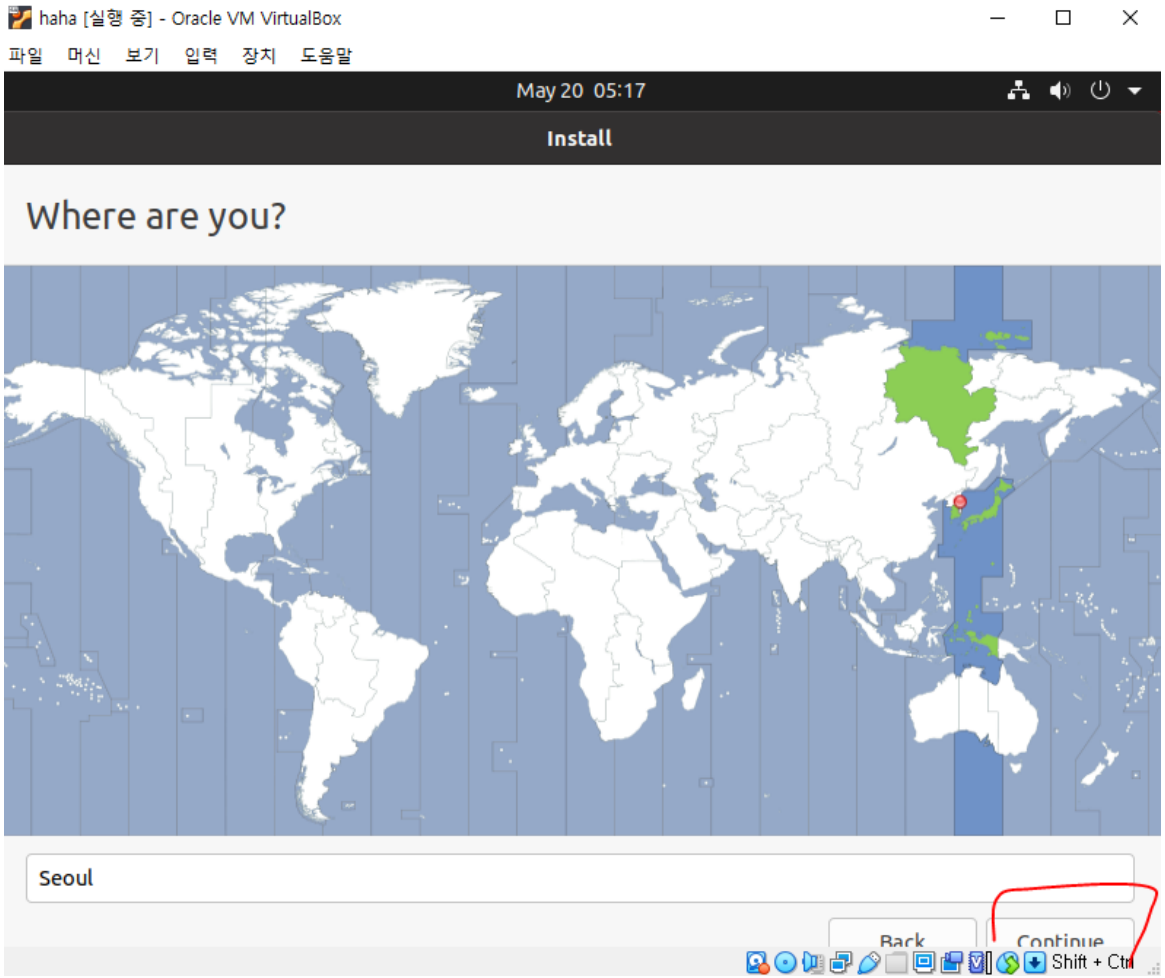
Installation

- Ubuntu setup
  - Press the Install Now



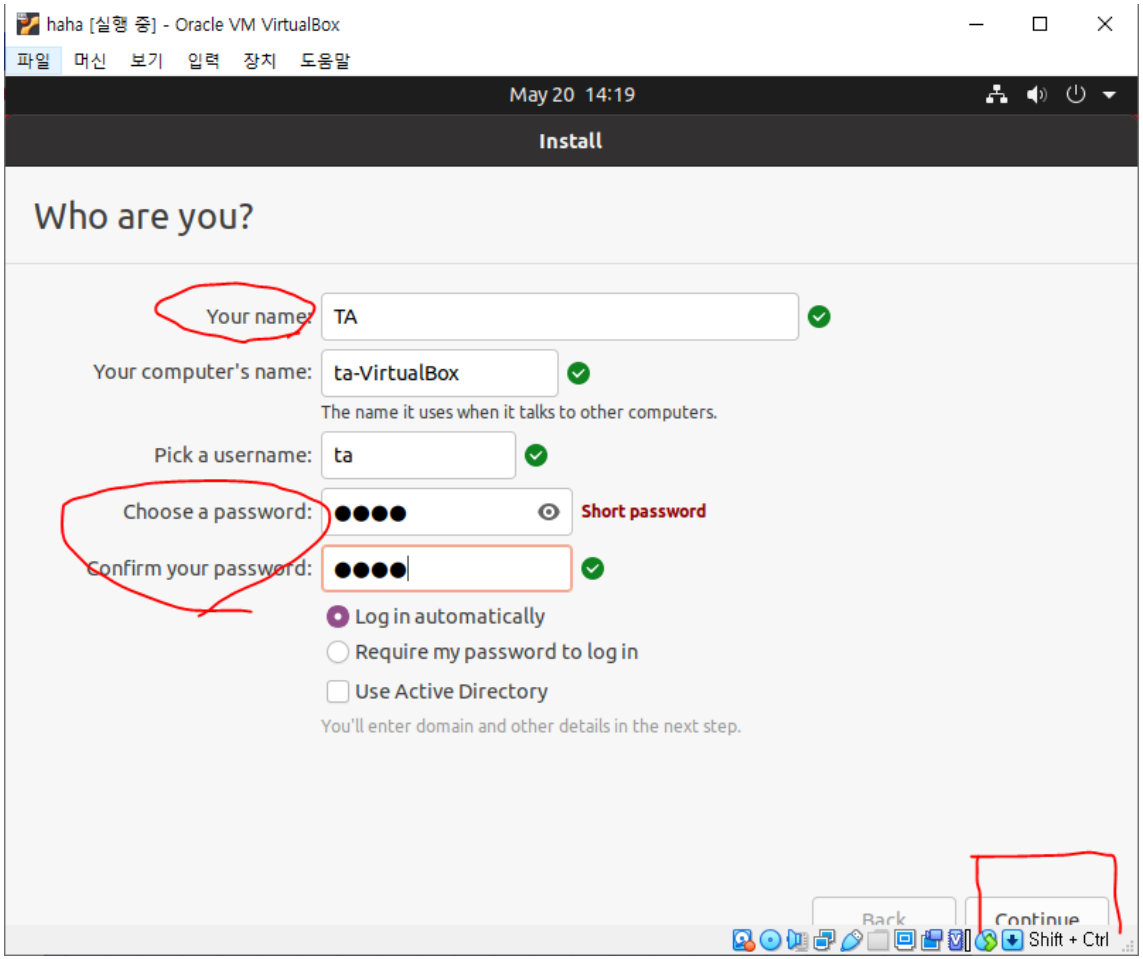
Installation

- Ubuntu setup
  - Press the Continue button



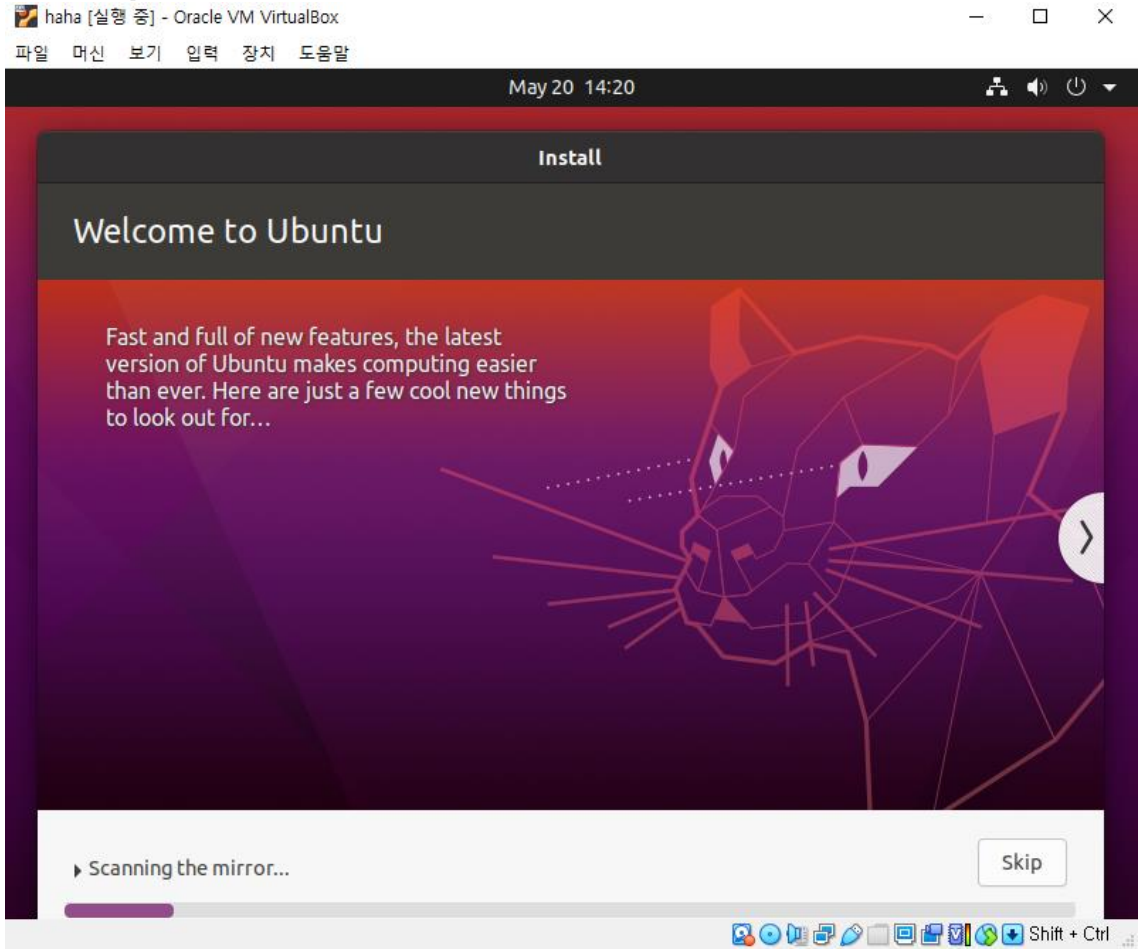
Installation

- Ubuntu setup
  - Who are you?



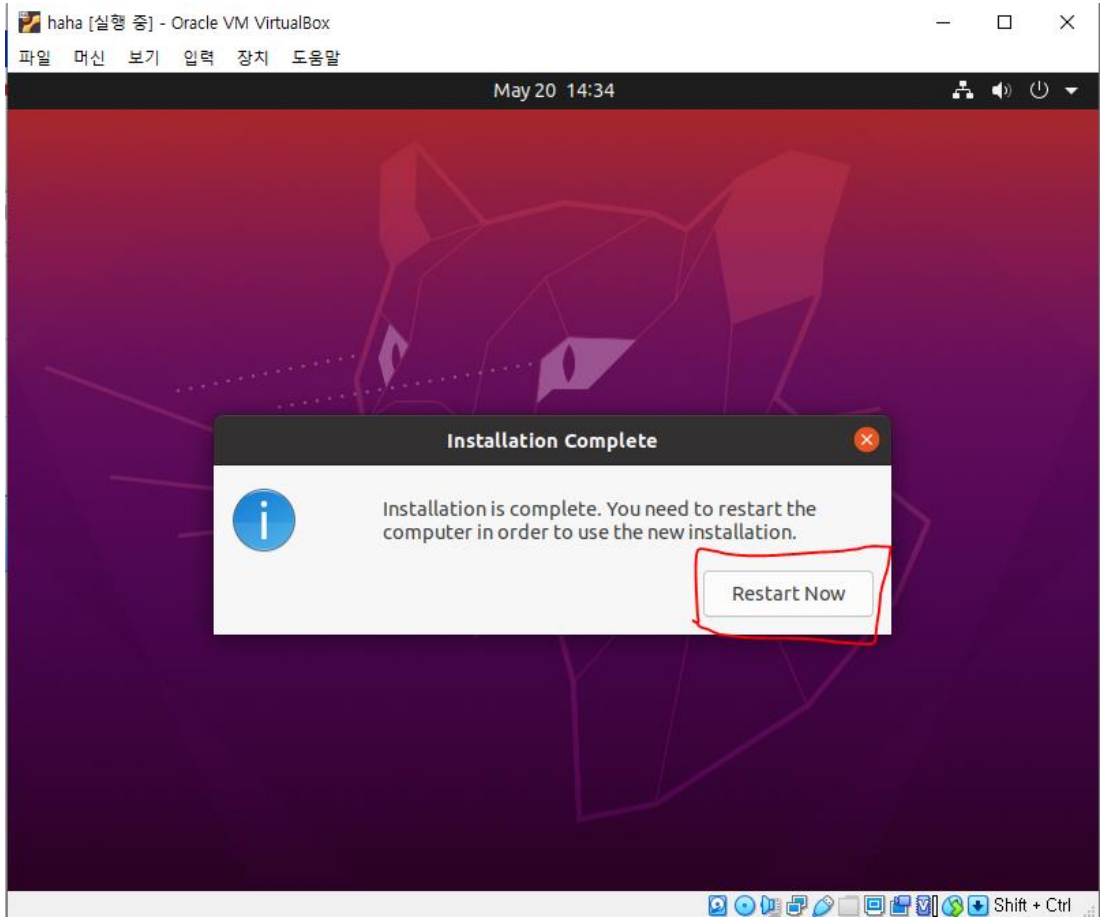
Installation

- Ubuntu setup
  - Welcome to Ubuntu… It takes a long time (10+ minutes) to complete the installation



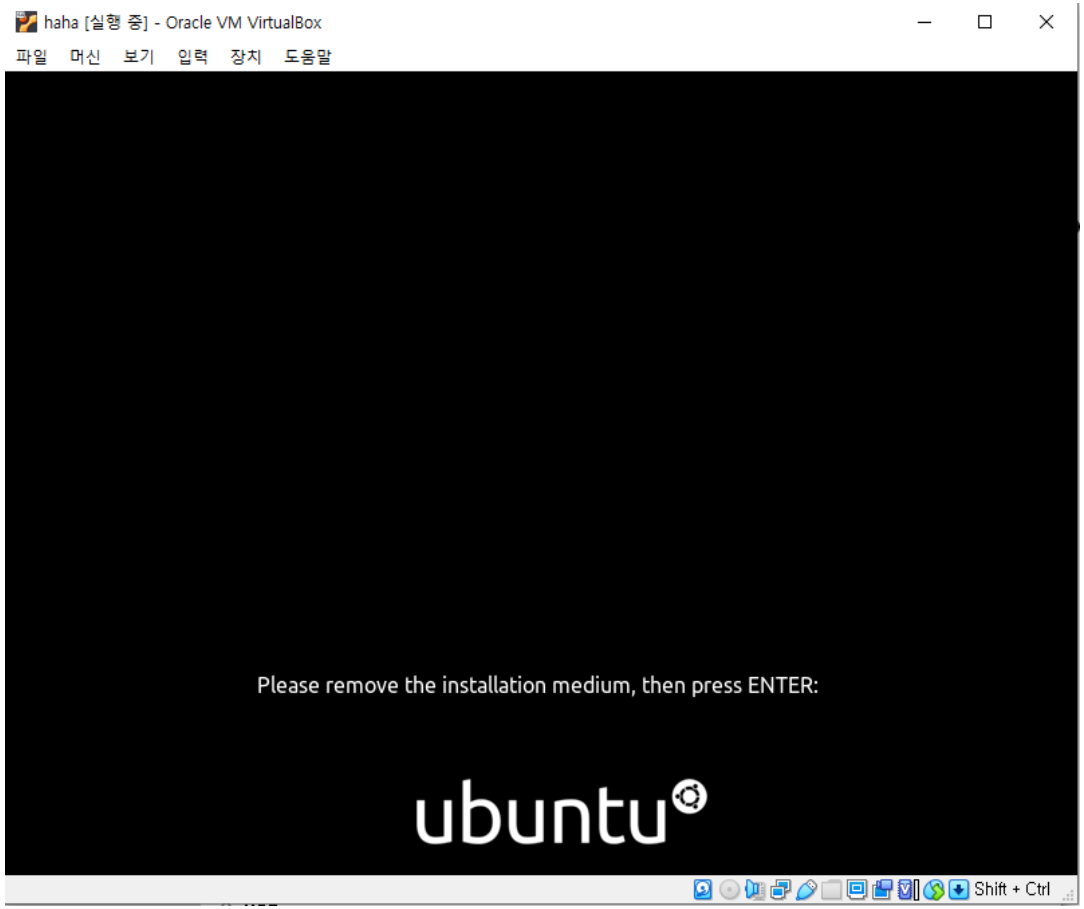
Installation

- Ubuntu setup
  - Congratulations. You have completed the Ubuntu installation.
  - Restart now



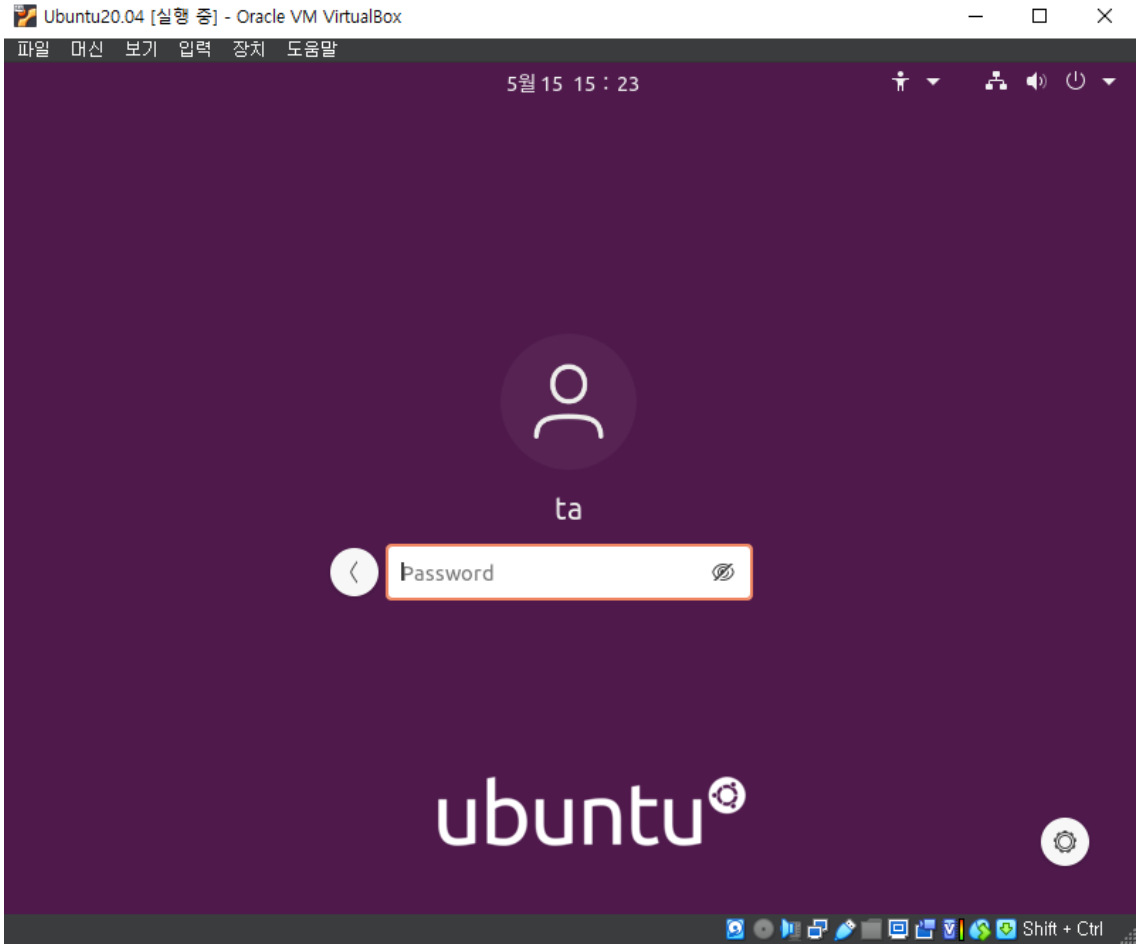
Installation

- Ubuntu setup
  - Just press ENTER after restarting



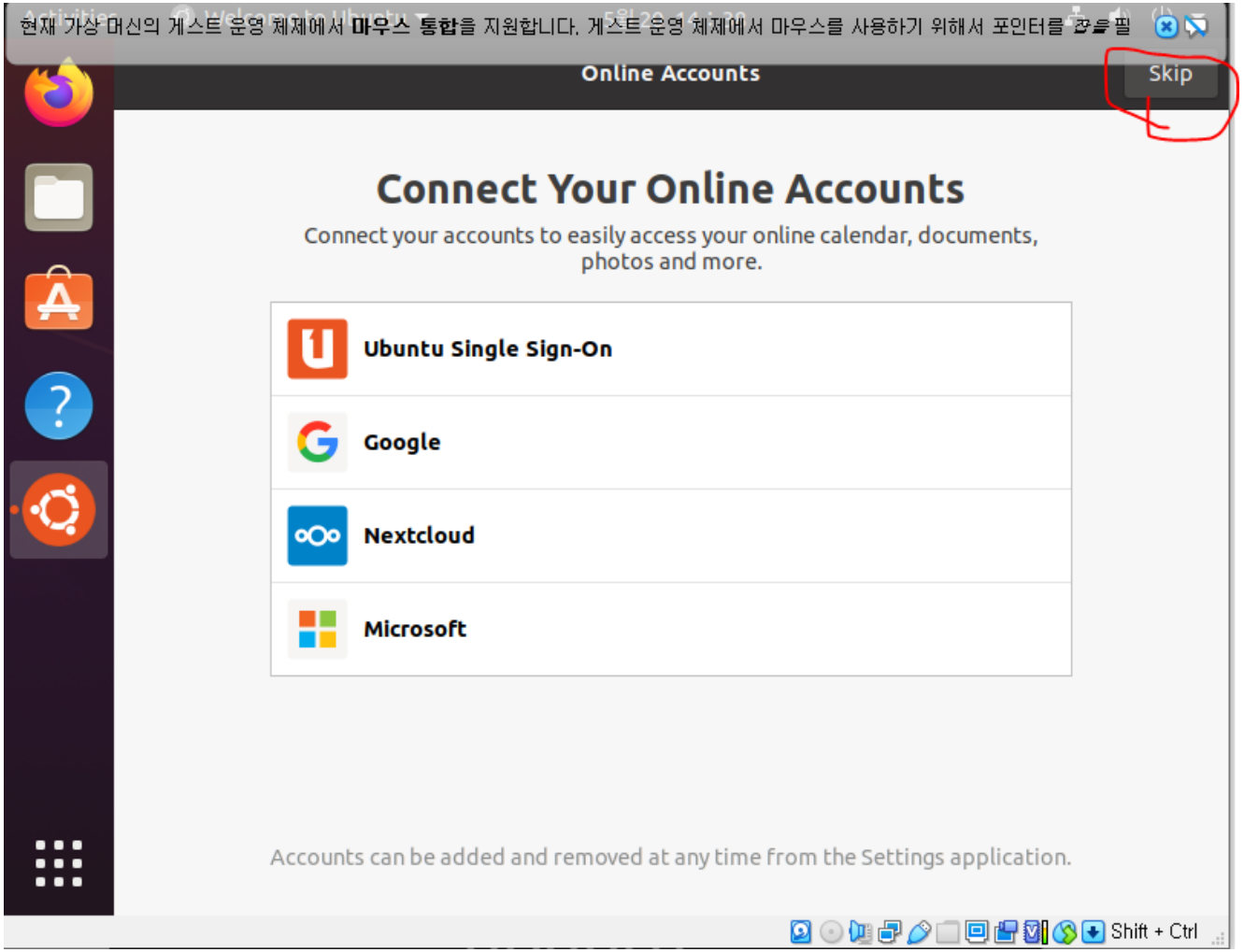
Installation

- Ubuntu setup
  - Log-in



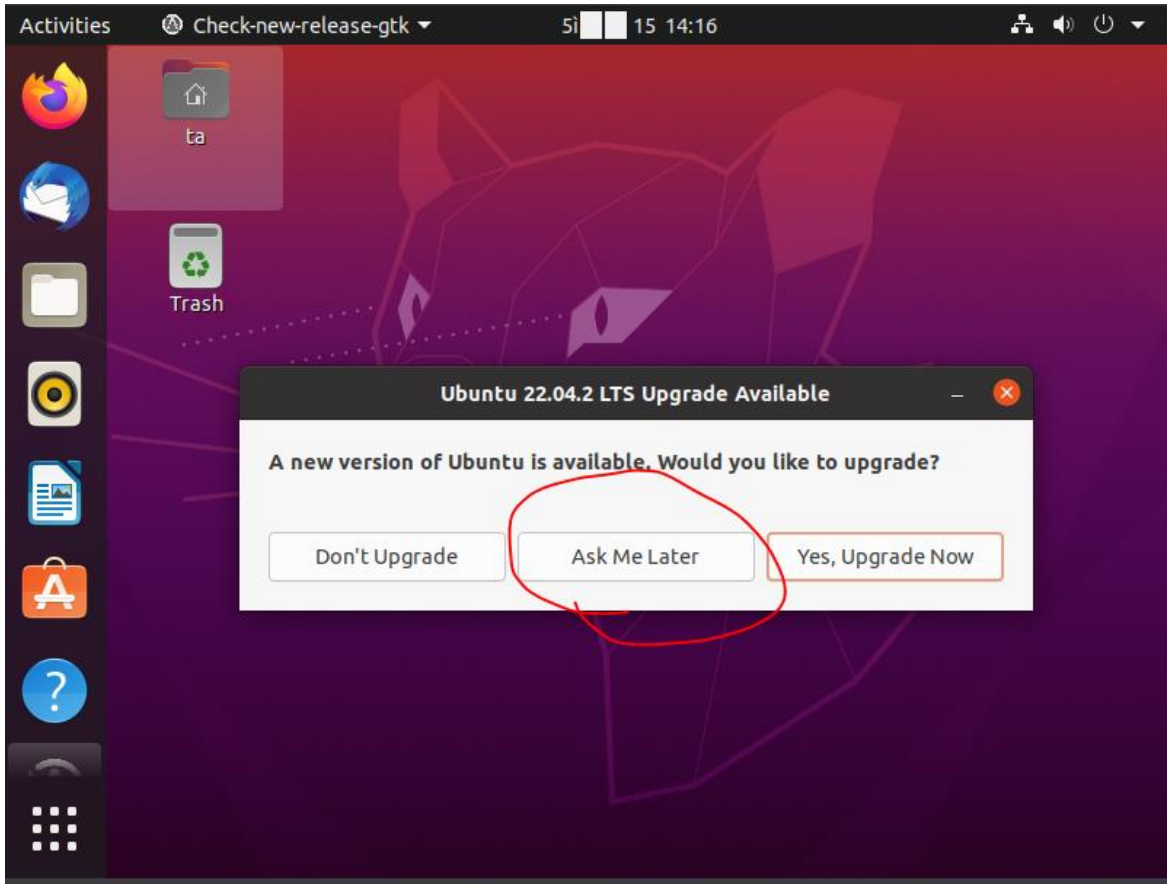
Installation

- Ubuntu setup
  - Skip all the suggestions



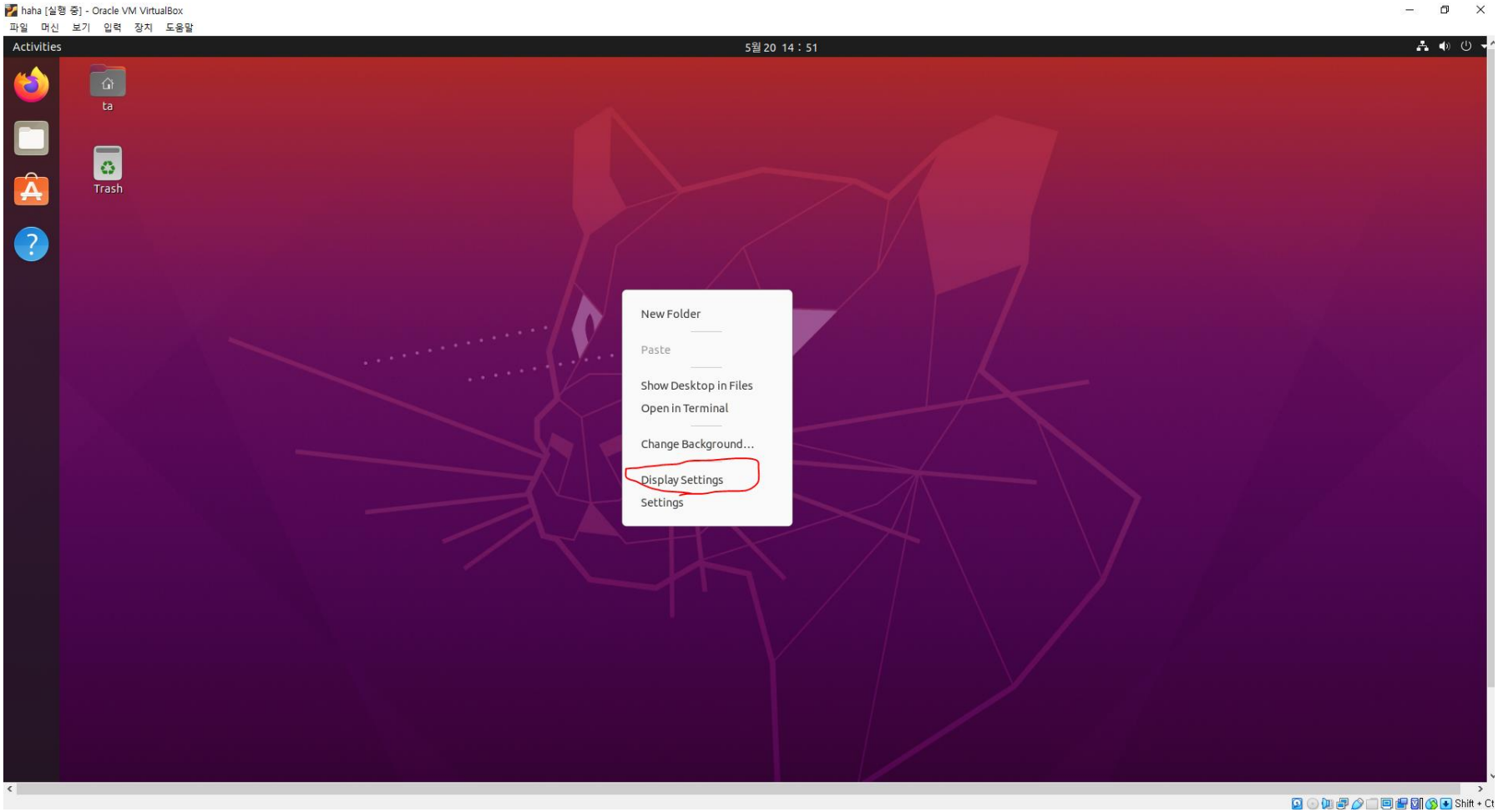
Installation

- Ubuntu setup
  - If you see a pop-up window like this, press the Ask Me Later



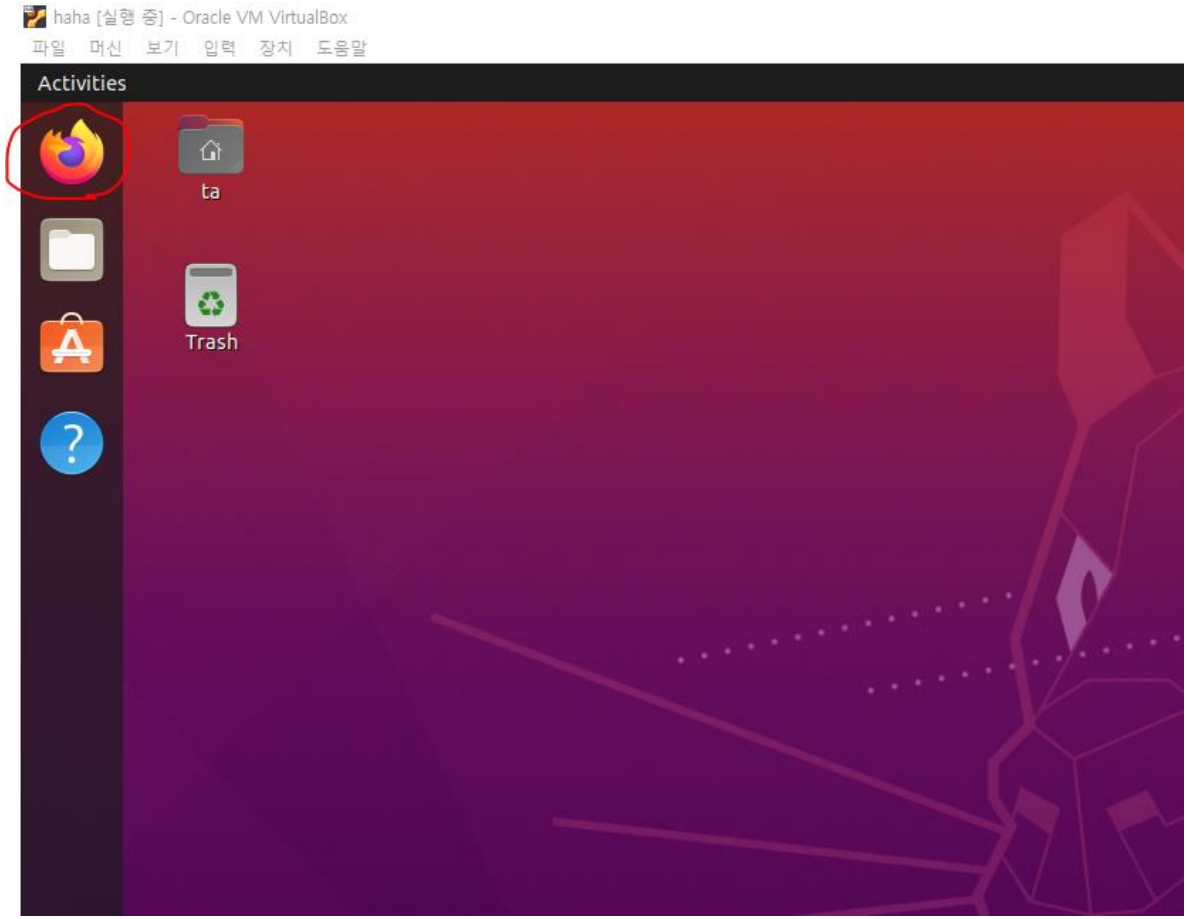
Installation

- Optional
  - You can open display settings by right-clicking the background



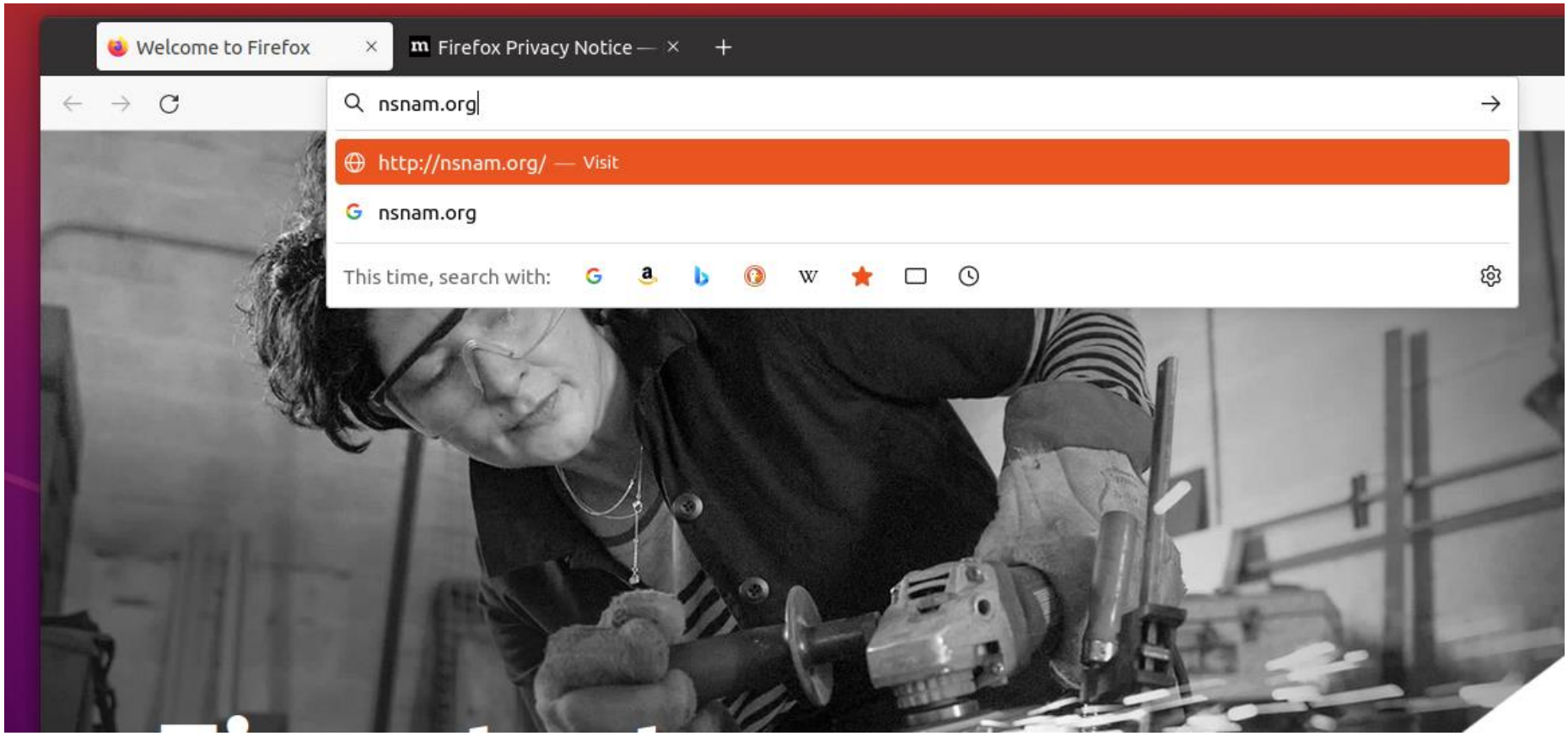
Installation

- ns-3 installation
  - Open Firefox web browser on the left side



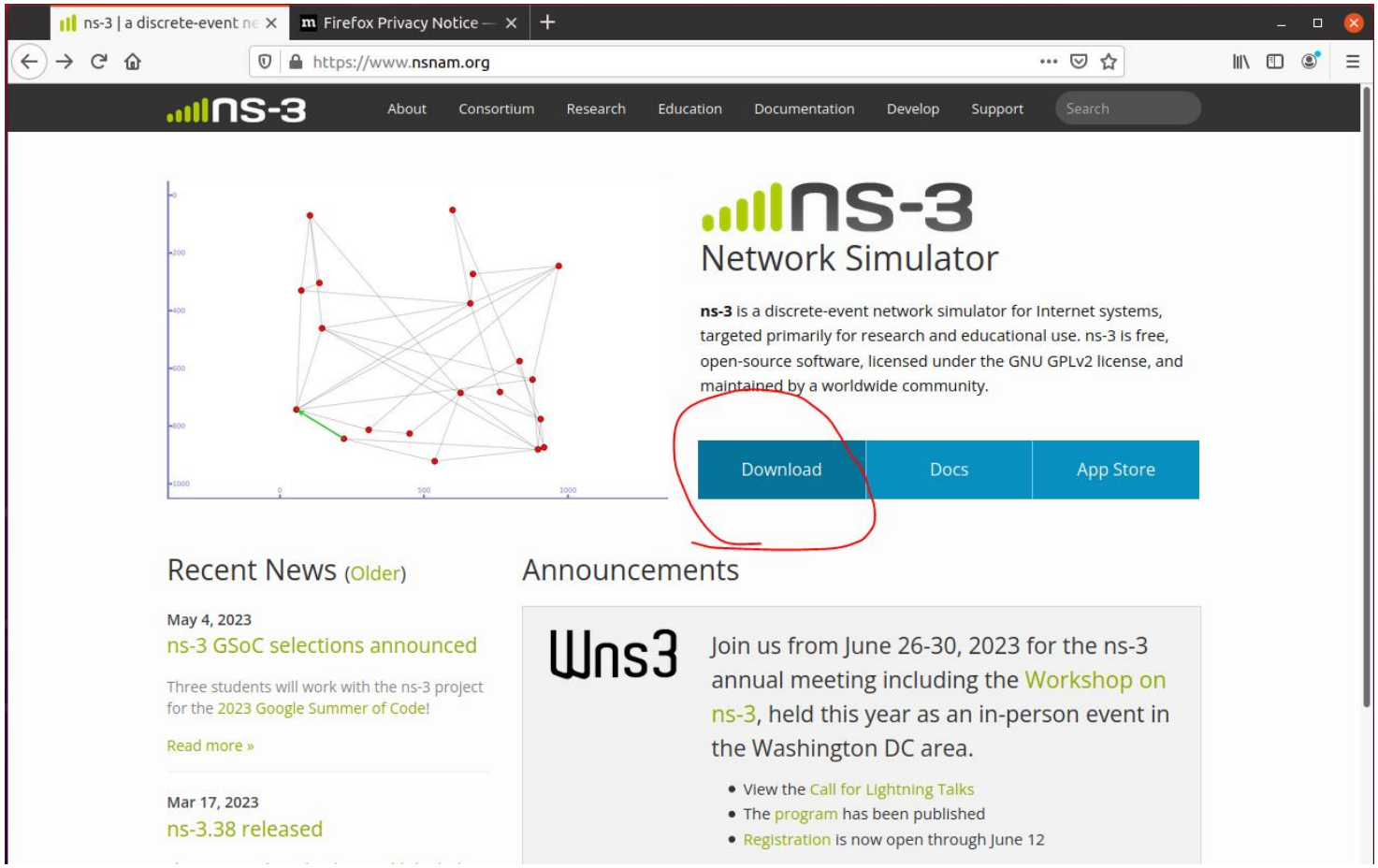
Installation

- ns-3 installation
  - Visit to nsnam.org



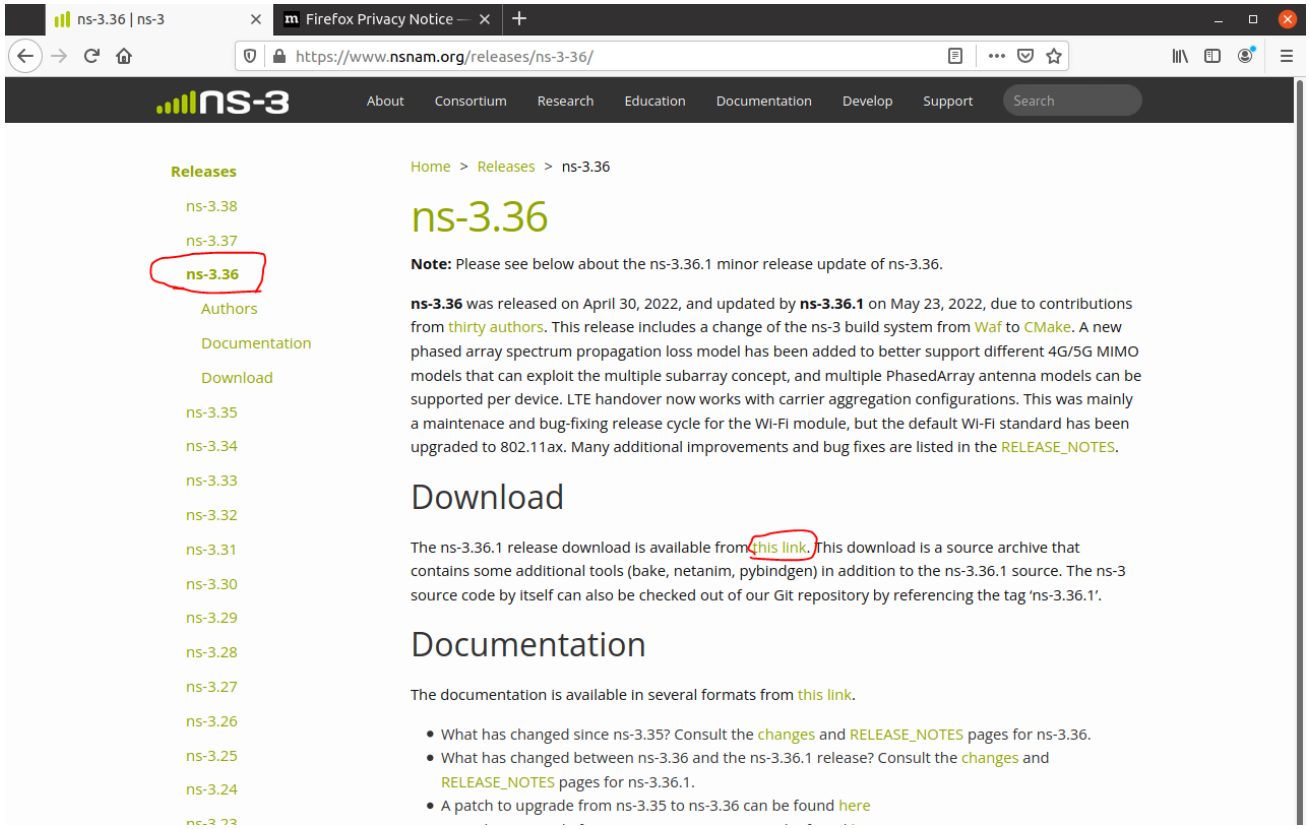
Installation

- ns-3 installation
  - Press the Download button



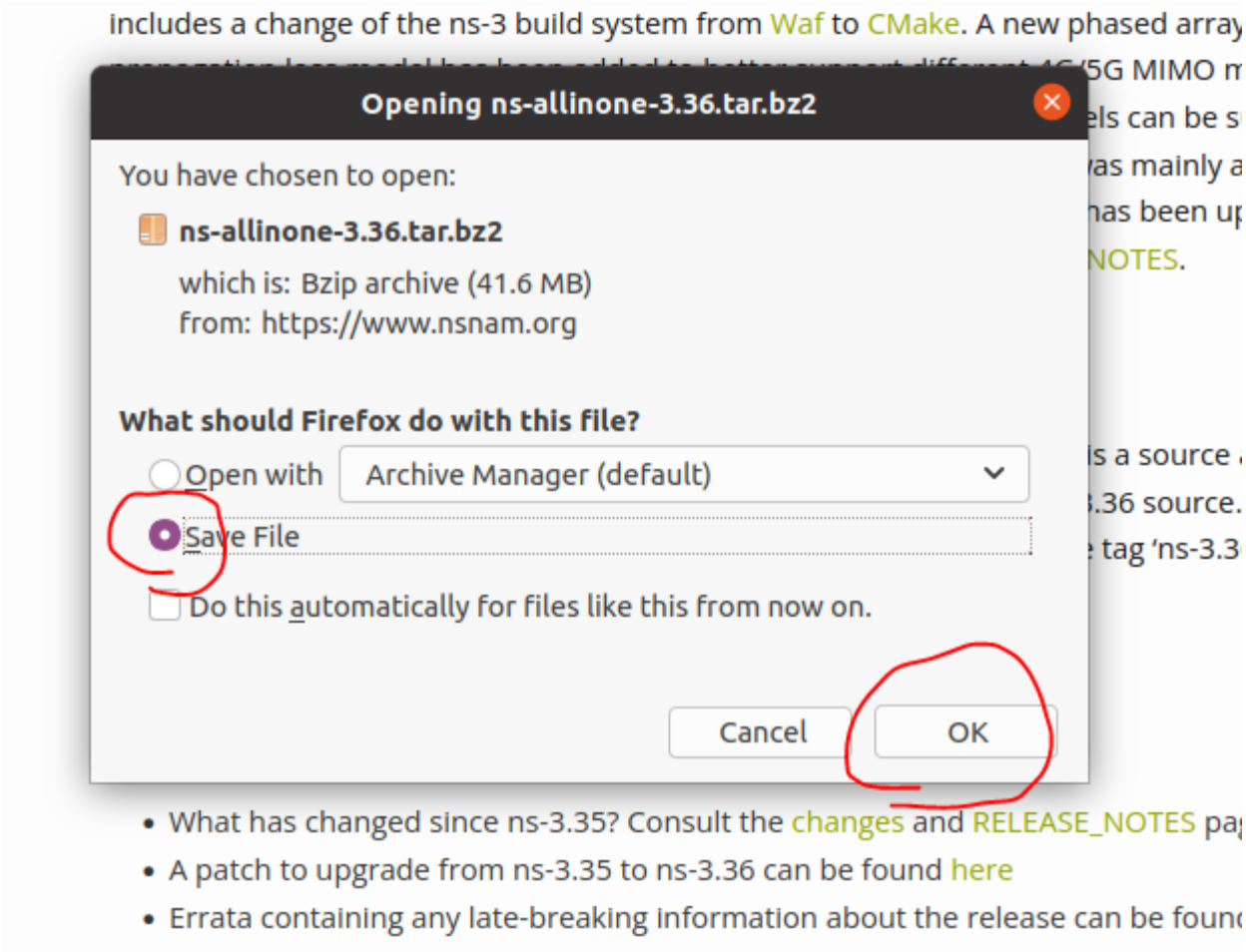
Installation

- ns-3 installation
  - Select the 'ns-3.36', and then, Press the word 'this link' in the Download section



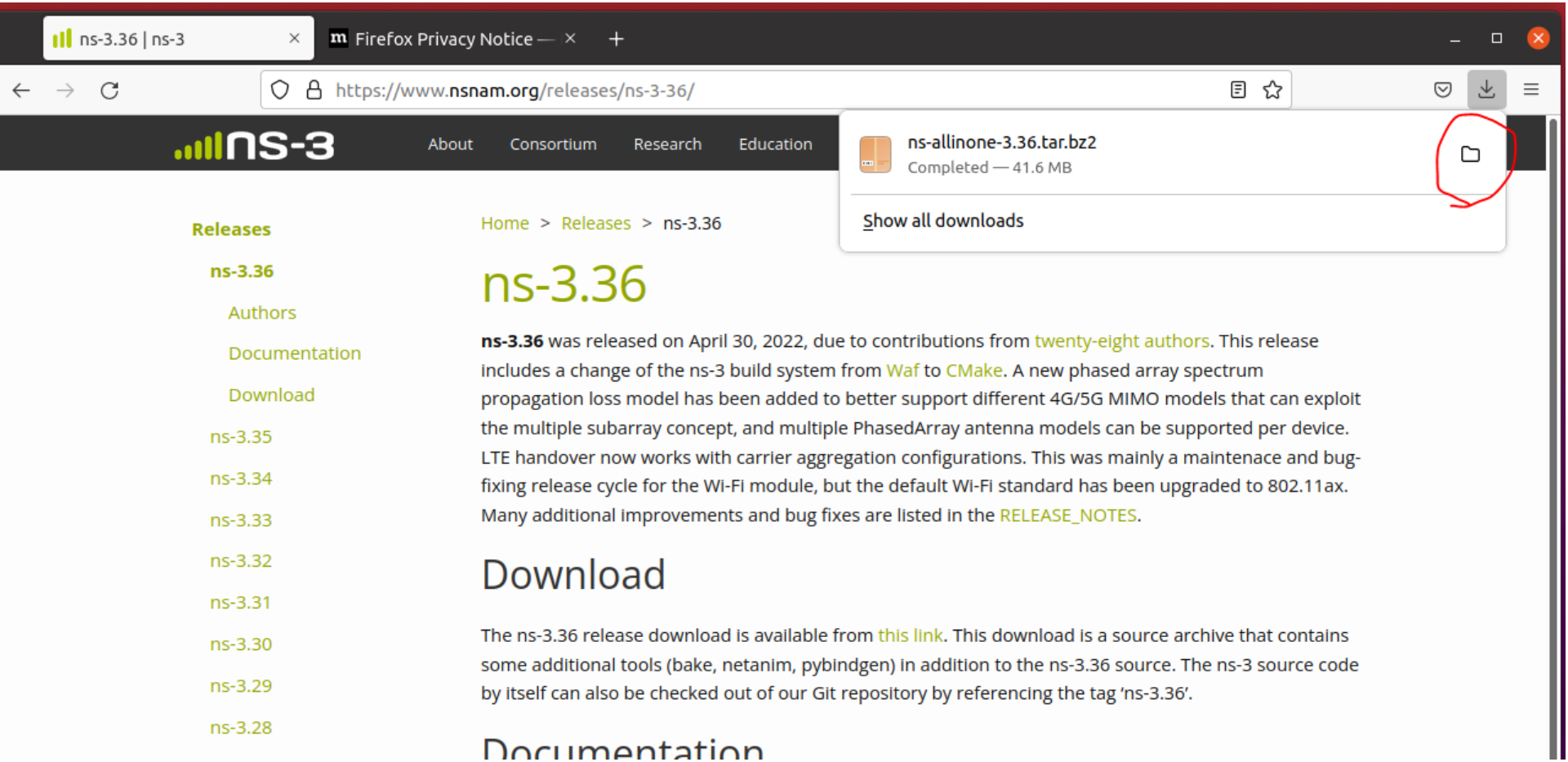
Installation

- ns-3 installation
  - Select the Save file option and press the OK



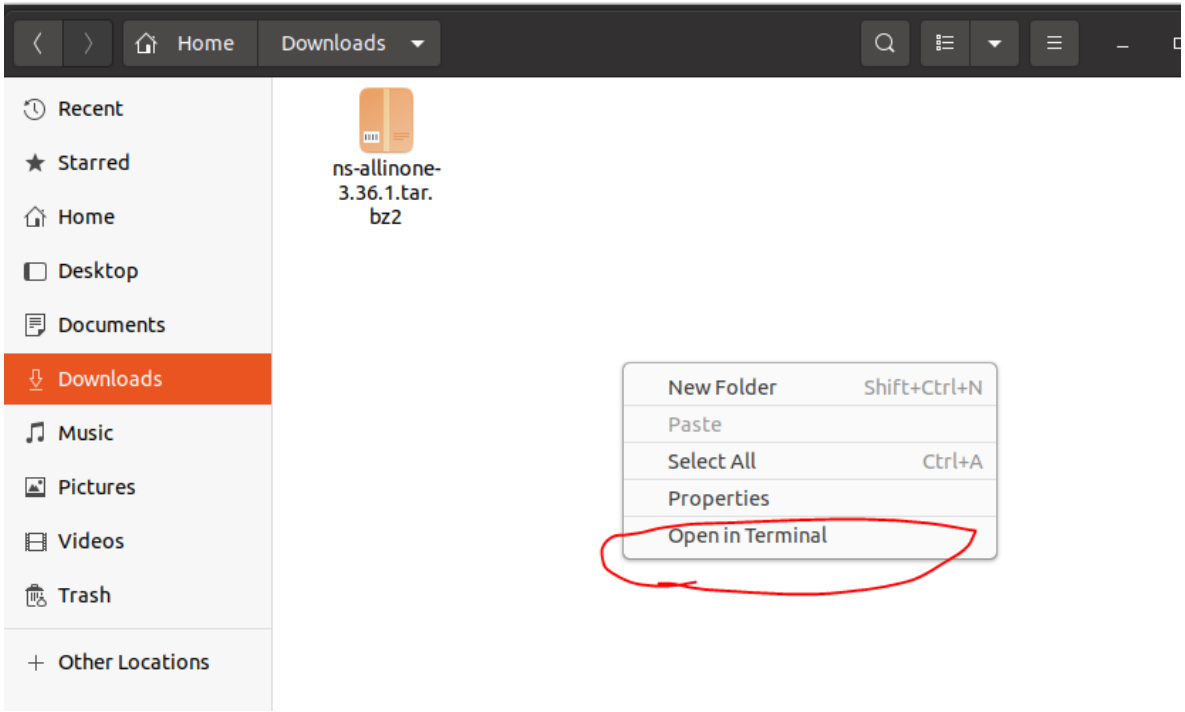
Installation

- ns-3 installation
  - When the download is complete, open the Downloads directory



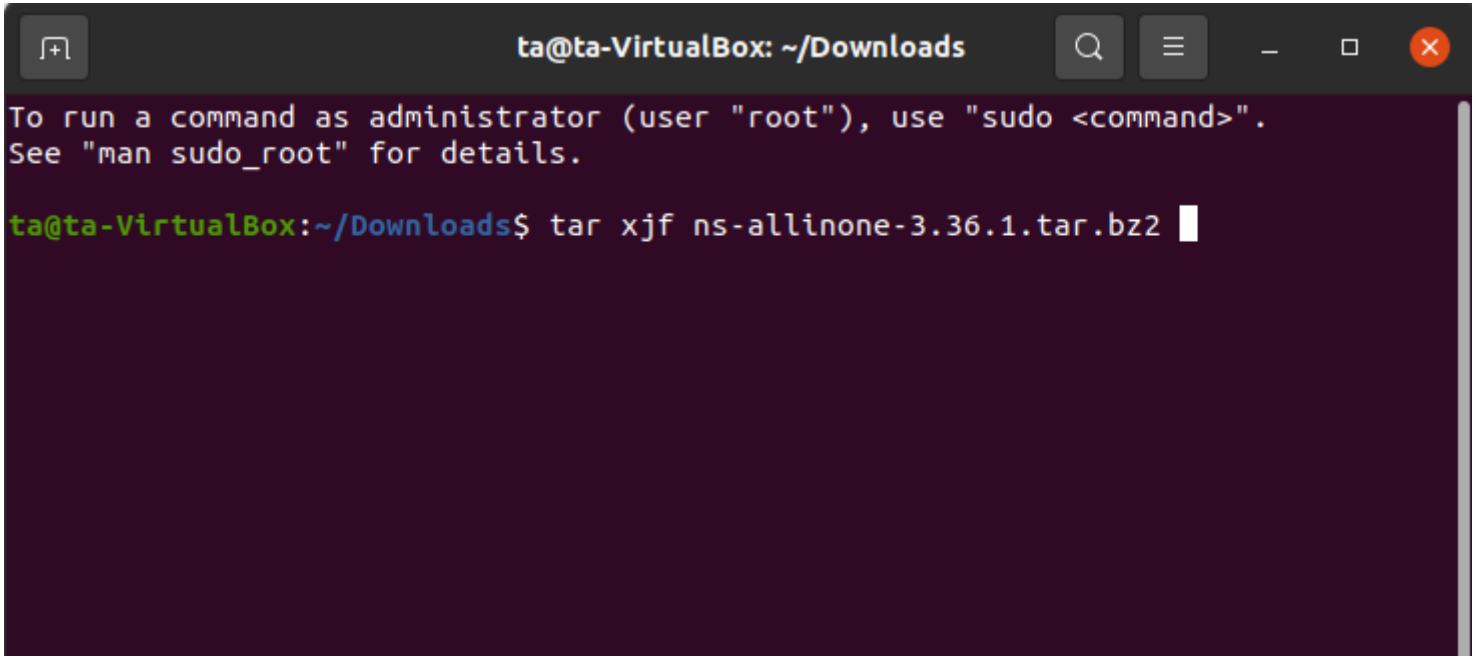
Installation

- ns-3 installation
  - Right-click on the blank space in the Downloads directory and press "Open in Terminal"



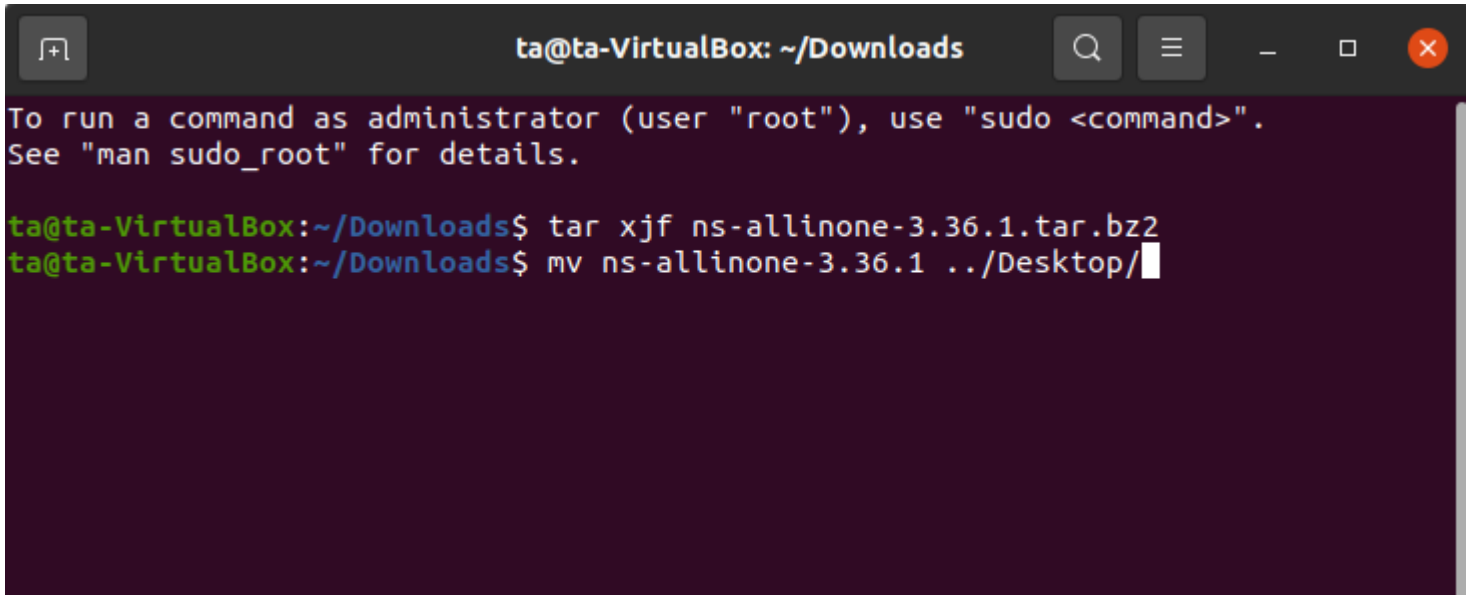
Installation

- ns-3 installation
  - Type `tar xjf ns-allinone-3.36.1.tar.bz2` in the terminal
  - Tip: Type up to `tar xjfs ns` and press Tab key to complete the filename automatically.



Installation

- ns-3 installation
  - Type `mv ns-allinone-3.36.1 ../Desktop/` in the terminal
    - This command will move (mv) ns-3 directory to Desktop directory
    - .. stands for the parent directory
  - Tip: Type up to `mv ns` and press Tab key to complete the filename automatically.



Installation

- ns-3 installation
  - Type cd ../Desktop/ns-allinone-3.36.1/ns-3.36.1/
  - The command cd means change directory, so it will change your working directory to the ns-3.36.1 directory
    - Note that I changed directory to ns-3.36.1, not ns-allinone-3.36.1

```
ta@ta-VirtualBox:~/Downloads$ tar xjf ns-allinone-3.36.1.tar.bz2
ta@ta-VirtualBox:~/Downloads$ mv ns-allinone-3.36.1 ../Desktop/
ta@ta-VirtualBox:~/Downloads$ cd ../Desktop/ns-allinone-3.36.1/ns-3.36.1/
ta@ta-VirtualBox:~/Desktop/ns-allinone-3.36.1/ns-3.36.1$
```

Installation

- ns-3 installation
  - Download minimal requirements to run ns-3
    - Type sudo apt install python3 g++ cmake
      - sudo means run the command with super user authority, and apt install command is used for download the packages
      - g++ is a c++ compiler and cmake is a tool for build, test and package software
    - Then enter your login password

```
ta@ta-VirtualBox:~/Desktop/ns-allinone-3.36/ns-3.36$ sudo apt install python3 g++ cmake
[sudo] password for ta:
```

    - Enter y, if the question below appears

```
After this operation, 103 MB of additional disk space will be used.
Do you want to continue? [Y/n] y
```

Installation

- ns-3 installation
  - Type these two commands

```
ta@ta-VirtualBox:~/Desktop/ns-allinone-3.36.1/ns-3.36.1$ ./ns3  clean
ta@ta-VirtualBox:~/Desktop/ns-allinone-3.36.1/ns-3.36.1$ ./ns3 configure --enable-test --enable-examples
```

    - ./ns3 clean
      - ./ns3 means execute ns3 file in the current working directory (./)
      - clean for clean out the previous build is not usually strictly necessary, but is a good practice
    - ./ns3 configure --enable-test --enable-examples
      - configure is for change the build configuration of ns-3 projects, such as logging options and compiler optimization (details are in the ns-3 manual)
      - Further, You can use the --enable-test and example options to build a project that includes examples and tests
  - Then type ./ns3 build to build the ns-3 project
    - It takes a long long time (30+ minutes)

```
ta@ta-VirtualBox:~/Desktop/ns-allinone-3.36/ns-3.36$ ./ns3 build
```

Installation

- When the build is complete, enter the command below

  ./ns3 run hello-simulator

```
[100%] Linking CXX shared library ../../../build/lib/libns3.36.1-lte-test-default.so
Scanning dependencies of target test-runner
[100%] Building CXX object utils/CMakeFiles/test-runner.dir/test-runner.cc.o
[100%] Linking CXX executable ../../build/utils/ns3.36.1-test-runner-default
Finished executing the following commands:
cd cmake-cache; cmake --build . -j 3 ; cd ..
ta@ta-VirtualBox:~/Desktop/ns-allinone-3.36.1/ns-3.36.1$ ./ns3 run hello-simulator
Hello Simulator
ta@ta-VirtualBox:~/Desktop/ns-allinone-3.36.1/ns-3.36.1$
```

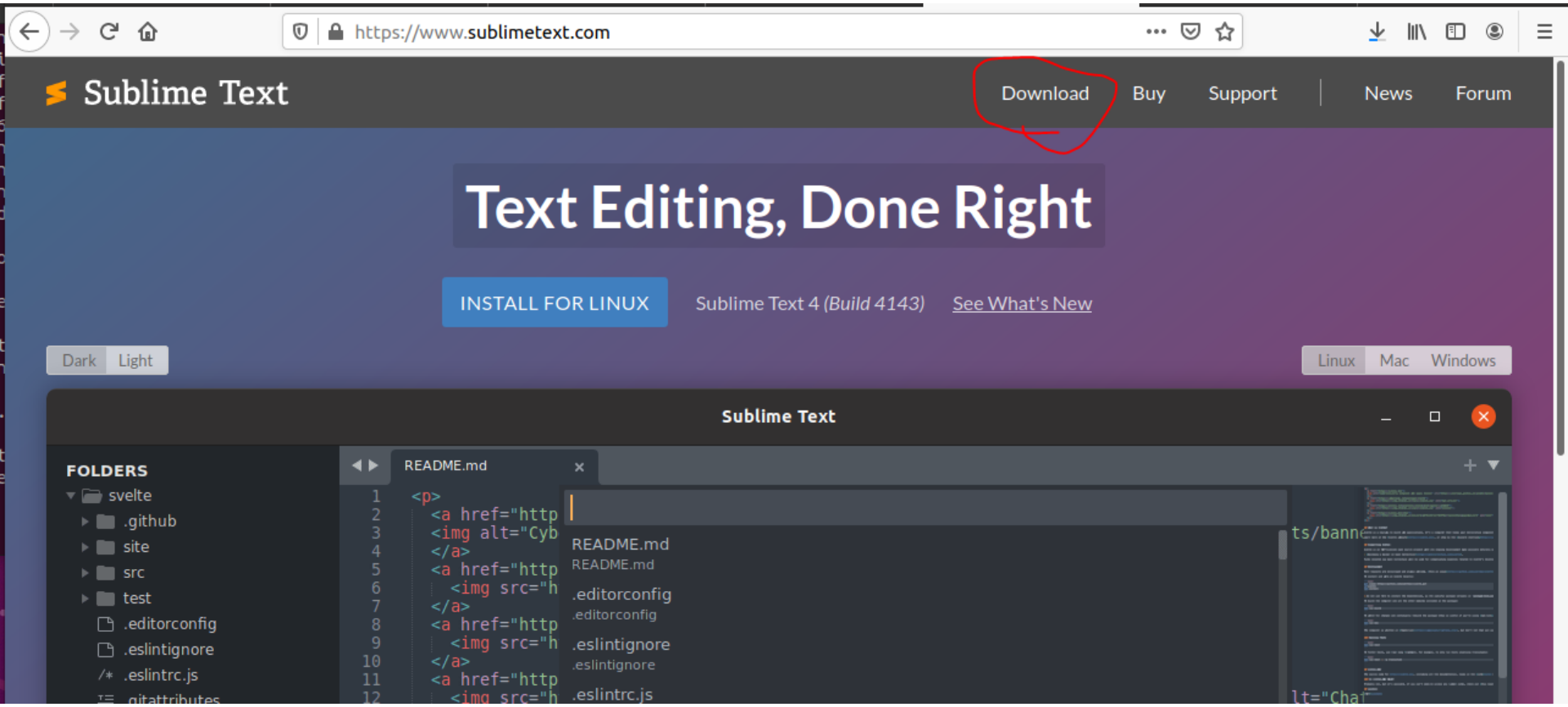
Congratulations! You are now an ns-3 user

Installation

- Optional
  - It is recommended that you use your favorite text editor or IDE
  - Popular text editors
    - Vim https://www.vim.org/
    - Emacs https://www.gnu.org/software/emacs/
    - Sublime text https://www.sublimetext.com/
    - Nano https://www.nano-editor.org/
  - IDE
    - VS code https://code.visualstudio.com/
    - CLion https://www.jetbrains.com/clion/
  - This lecture uses Sublime text

Installation

- Optional
  - Sublime text installation



Installation

- Optional
  - Sublime text installation

Download

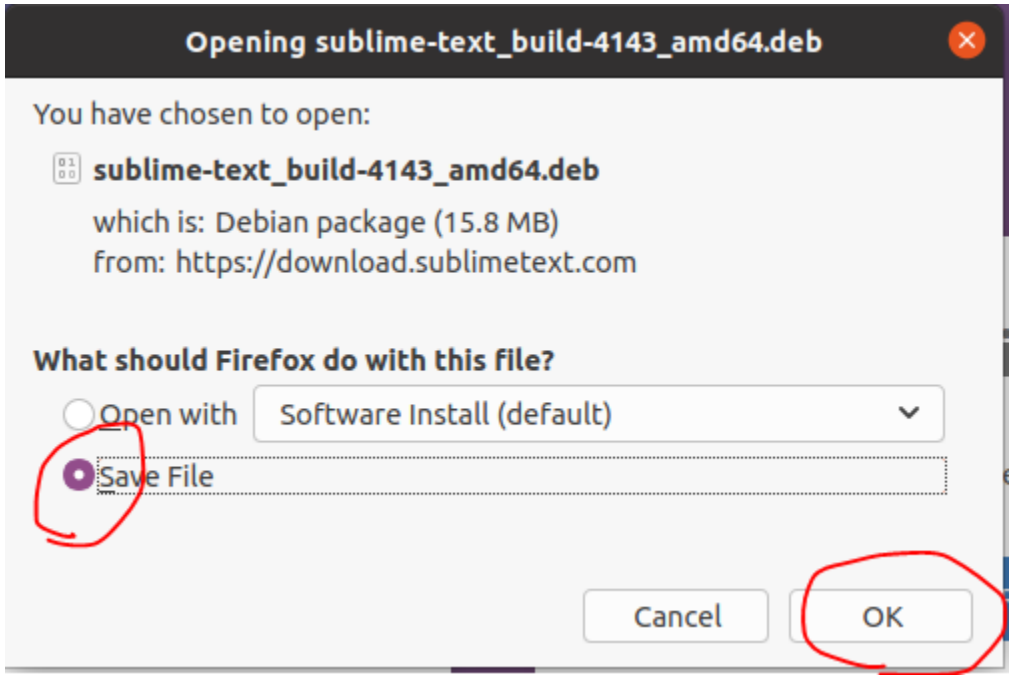
Sublime Text 4 is the current version of Sublime Text. For bleeding-edge releases, see the dev builds.

Version: Build 4143

- macOS
- Windows - also available as a portable version
- Linux repos - **direct downloads** 1
  - 64 bit .deb – *sig*, *key* 2
  - 64 bit .rpm – *signed*, *key*
  - 64 bit .pkg.tar.xz – *sig*, *key*
  - 64 bit .tar.xz – *sig*, *key*
  - ARM64 .deb – *sig*, *key*
  - ARM64 .tar.xz – *sig*, *key*

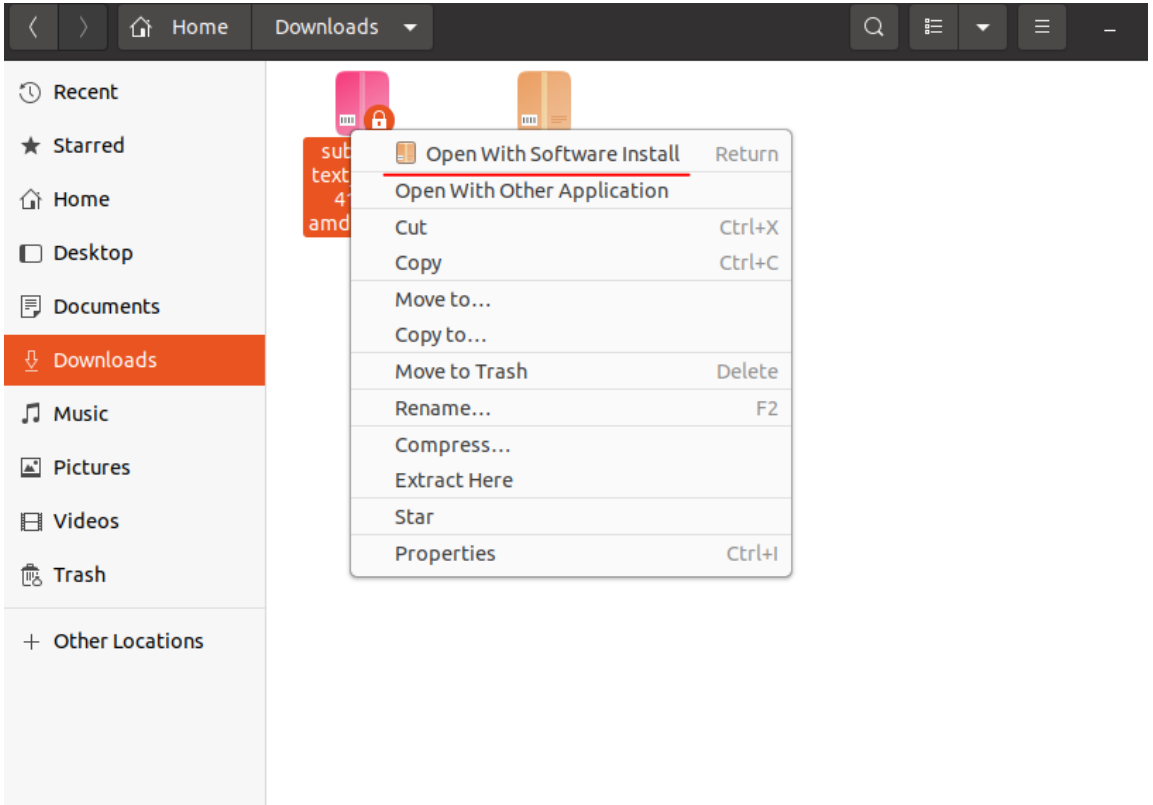
Installation

- Optional
  - Sublime text installation



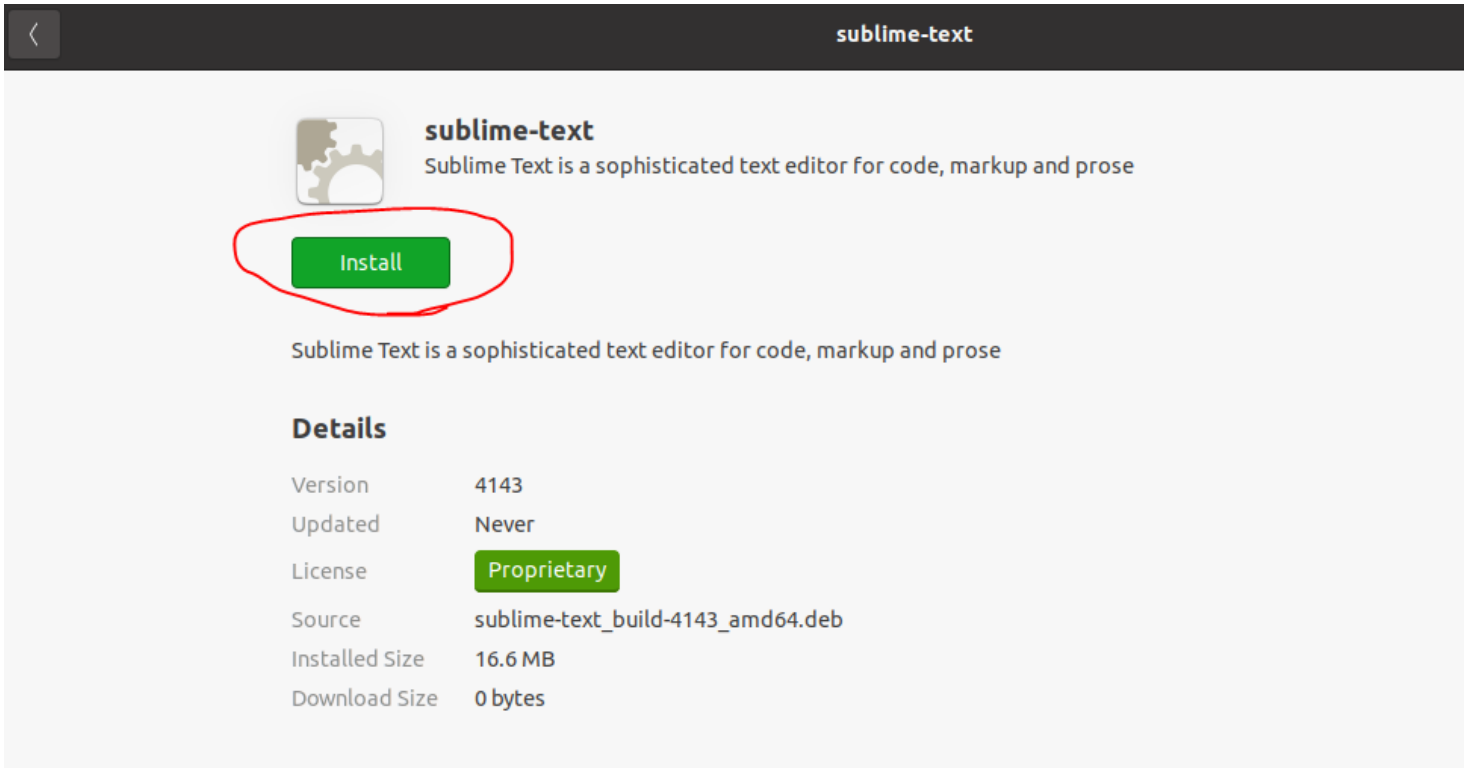
Installation

- Optional
  - Sublime text installation



Installation

- Optional
  - Sublime text installation



Brief tutorial

- ns-3 key abstraction
  - Node
    - A computing device that connects to a network
  - Application
    - ns-3 applications run on ns-3 Nodes to drive simulations in the simulated world
    - Basic abstraction for a user program that generates some activity
  - Channel
    - The media over which data flows in the network
  - NetDevice
    - It can be regarded as a network interface card (NIC)
    - A net device is "installed" in a Node in order to enable the Node to communicate with other Nodes in the simulation via Channels
  - Topology helpers
    - It provides many convenient operations, such as create a NetDevice, add a MAC address, assigning IP address, connect the NetDevice to a Channel, etc.

Brief tutorial

- Tutorial script
  - From now on, ns-allinone-3.36.1/ns-3.36.1 is considered as a base directory
  - You can find tutorial scripts in the examples/tutorial directory

```
ta@ta-VirtualBox: ~/Desktop/ns-allinone-3.36.1/ns-3.36.1/examples/tutorial
ta@ta-VirtualBox:~/Desktop/ns-allinone-3.36.1/ns-3.36.1$ ls
AUTHORS    build-support  CMakeLists.txt   doc        ns3                scratch   testpy.supp  VERSION
bindings   CHANGES.md     contrib          examples   README.md          src       utils
build      cmake-cache    CONTRIBUTING.md  LICENSE    RELEASE_NOTES.md   test.py   utils.py
ta@ta-VirtualBox:~/Desktop/ns-allinone-3.36.1/ns-3.36.1$ cd examples/tutorial
ta@ta-VirtualBox:~/Desktop/ns-allinone-3.36.1/ns-3.36.1/examples/tutorial$ ls
CMakeLists.txt      first.cc    hello-simulator.cc  seventh.cc  third.py
examples-to-run.py  first.py    second.cc           sixth.cc    tutorial-app.cc
fifth.cc            fourth.cc   second.py           third.cc    tutorial-app.h
ta@ta-VirtualBox:~/Desktop/ns-allinone-3.36.1/ns-3.36.1/examples/tutorial$
```

  - In this lecture, we will study one tutorial script
  - Let's open the first.cc with a sublime text (or with your favorite editor)

subl first.cc

```
ta@ta-VirtualBox:~/Desktop/ns-allinone-3.36.1/ns-3.36.1/examples/tutorial$ subl first.cc
```

Note: ls (list segment), allows to list directory

subl (sublime text), open file or directory with the sublime text editor

Brief tutorial

- first.cc
  - Module includes

```
#include "ns3/core-module.h"
#include "ns3/network-module.h"
#include "ns3/internet-module.h"
#include "ns3/point-to-point-module.h"
#include "ns3/applications-module.h"
```

    - ns-3 provides many modules to make it much easier for users to write simulation scripts
    - Each of the *ns-3* include files is placed in a /build/include/ns3 directory
      - You can take a look at the contents of these files

```
ta@ta-VirtualBox:~/Desktop/ns-allinone-3.36.1/ns-3.36.1/build/include/ns3$ ls
a2-a4-rsrq-handover-algorithm.h                    lte-rrc-header.h
a3-rsrp-handover-algorithm.h                       lte-rrc-protocol-ideal.h
aarfcd-wifi-manager.h                              lte-rrc-protocol-real.h
aarf-wifi-manager.h                                lte-rrc-sap.h
abort.h                                            lte-spectrum-phy.h
acoustic-modem-energy-model.h                      lte-spectrum-signal-parameters.h
acoustic-modem-energy-model-helper.h               lte-spectrum-value-helper.h
address.h                                          lte-stats-calculator.h
address-utils.h                                    lte-ue-ccm-rrc-sap.h
adhoc-aloha-noack-ideal-phy-helper.h               lte-ue-cmac-sap.h
adhoc-wifi-mac.h                                   lte-ue-component-carrier-manager.h
aloha-noack-mac-header.h                           lte-ue-cphy-sap.h
aloha-noack-net-device.h                           lte-ue-mac.h
ampdu-subframe-header.h                            lte-ue-net-device.h
ampdu-tag.h                                        lte-ue-phy.h
amrr-wifi-manager.h                                lte-ue-phy-sap.h
amsdu-subframe-header.h                            lte-ue-power-control.h
angles.h                                           lte-ue-rrc.h
```

Brief tutorial

- first.cc
  - Namespace declaration

```
using namespace ns3;
```

    - After this declaration, you will not have to type ns3:: scope resolution operator before all of the ns-3 code in order to use it
      - If you are not familiar with the concept of the namespace in C++, please visit this site: https://www.cplusplus.com/doc/oldtutorial/namespaces/
  - Log component define

```
NS_LOG_COMPONENT_DEFINE ("FirstScriptExample");
```

    - This line declares a logging component called FirstScriptExample that allows you to enable and disable console message logging by reference to the name
      - Details about logging are discussed later
  - Time resolution setting

```
  Time::SetResolution (Time::NS);
```

    - This line sets the time resolution to one nanosecond
    - The resolution is the smallest time value that can be represented

Brief tutorial

- first.cc
  - Enable two logging components

```
LogComponentEnable ("UdpEchoClientApplication", LOG_LEVEL_INFO);
LogComponentEnable ("UdpEchoServerApplication", LOG_LEVEL_INFO);
```

    - These two lines of code enable debug logging at the INFO level for echo clients and servers
      - Details about logging are discussed later
  - Node container

```
NodeContainer nodes;
nodes.Create (2);
```

    - The **Node**Container topology helper provides a convenient way to create, manage and access any **Node** objects
  - PointToPointHelper

```
PointToPointHelper pointToPoint;
pointToPoint.SetDeviceAttribute ("DataRate", StringValue ("5Mbps"));
pointToPoint.SetChannelAttribute ("Delay", StringValue ("2ms"));
```

    - The first line instantiates a PointToPoint **Helper** object to configure and connect PointToPoint**NetDevice** and PointToPoint**Channel** objects
    - The second line tells the PointToPoint**Helper** object to use the value "5Mbps" as the "DataRate" when it creates a PointToPoint**NetDevice** object

Brief tutorial

- first.cc
  - The third line tells the PointToPoint **Helper** to use the value "2ms" as the value of the propagation delay of when it creates PointToPoint**Channel**
- NetDeivceContainer

```
NetDeviceContainer devices;
devices = pointToPoint.Install (nodes);
```

  - The Install method of the PointToPoint **Helper** takes a **Node**Container as a parameter, and creates **NetDevice**Container
  - For each node in the **Node**Container a PointToPoint**NetDevice** is created
  - A PointToPoint**Channel** is created and the two PointToPoint**NetDevices** are attached
  - After executing the PointToPoint.Install (nodes) call, we will have two **nodes**, each with an installed point-to-point **net device** and a single point-to-point **channel** between them
- InternetStackHelper

```
InternetStackHelper stack;
stack.Install (nodes);
```

  - It will install an Internet Stack (TCP, UDP, IP, etc.) on each of the **nodes** in the node container.

Brief tutorial

- first.cc
  - Ipv4AddressHelper

```
Ipv4AddressHelper address;
address.SetBase ("10.1.1.0", "255.255.255.0");
```

    - We need to associate the **devices** on our **nodes** with IP addresses
    - The code above declares an address **helper** object and tell it that it should begin allocating IP addresses from the network 10.1.1.0 using the mask 255.255.255.0

```
Ipv4InterfaceContainer interfaces = address.Assign (devices);
```

    - address.Assign performs the address assignment
    - It makes the association between an IP address and a **device** using an Ipv4Interface object
    - To contain a list of Ipv4Interface objects for future reference, we use Ipv4InterfaceContainer

Brief tutorial

- first.cc
  - UdpEchoServerHelper

```
UdpEchoServerHelper echoServer (9);

ApplicationContainer serverApps = echoServer.Install (nodes.Get (1));
serverApps.Start (Seconds (1.0));
serverApps.Stop (Seconds (10.0));
```

- The first line, declares an UdpEchoServer**Helper** and gets a port number 9 as a parameter
- The Install method takes a **Node**Containter as a parameter just as the other Install methods
- Install will return a container that holds pointers to all of the applications created by the helper
- Applications require a time to "start" and may take an optional time to "stop"
- We set the echo server application to Start (enable itself) at one second into the simulation and to Stop (disable itself) at ten seconds into the simulation.

Brief tutorial

- first.cc
  - UdpEchoClientHelper

```
UdpEchoClientHelper echoClient (interfaces.GetAddress (1), 9);
echoClient.SetAttribute ("MaxPackets", UintegerValue (1));
echoClient.SetAttribute ("Interval", TimeValue (Seconds (1.0)));
echoClient.SetAttribute ("PacketSize", UintegerValue (1024));

ApplicationContainer clientApps = echoClient.Install (nodes.Get (0));
clientApps.Start (Seconds (2.0));
clientApps.Stop (Seconds (10.0));
```

- The first line, declares an UdpEchoClient**Helper** and gets IP address and port number of the server as a parameter
  - Recall that we used an Ipv4InterfaceContainer to keep track of the IP addresses we assigned to our devices
- SetAttribute
  - MaxPackets: maximum number of packets we allow client to send
  - Interval: it tells the client how long to wait between packets
  - PacketSize: it tells how large client's packet payloads should be
- As with the UdpServer case, we set the start and end times for the UdpClient application

Brief tutorial

- first.cc
  - Simulator
    - Running the simulation is done by using the global function Simulator::Run

```
Simulator::Run ();
```

    - Recall that we scheduled events in the 1, 2 and 10 seconds (with UdpEcho Client & Server applications)
    - When Simulator::Run is called, the system will begin looking through the list of scheduled events and
    - The act of sending the packet to the server will trigger a chain of events that will be automatically scheduled executing them
    - When there are no further events to process, Simulator::Run returns

```
Simulator::Destroy ();
```

    - Finally, Simulator::Destroy calls will deal with the hard part of destroying all created objects

Brief tutorial

- Building your first script
  - Let's copy (cp) examples/tutorial/first.cc into the **scratch** directory
    - The command is executed in the base directory

```
ta@ta-VirtualBox:~/Desktop/ns-allinone-3.36/ns-3.36$ cp examples/tutorial/first.cc scratch/myfirst.cc
```

  - Then, build your first example script using ns3:

```
ta@ta-VirtualBox:~/Desktop/ns-allinone-3.36/ns-3.36$ ./ns3
```

  - You can now run the example:

```
ta@ta-VirtualBox:~/Desktop/ns-allinone-3.36/ns-3.36$ ./ns3 run scratch/myfirst
At time +2s client sent 1024 bytes to 10.1.1.2 port 9
At time +2.00369s server received 1024 bytes from 10.1.1.1 port 49153
At time +2.00369s server sent 1024 bytes to 10.1.1.1 port 49153
At time +2.00737s client received 1024 bytes from 10.1.1.2 port 9
```

    - You can see the logging component on the echo client indicate that it has sent a 1024 bytes packet to the Echo Server on 10.1.1.2
    - You can also see the logging component on the echo server say that it has received the 1024 bytes from 10.1.1.1
    - The echo server silently echoes the packet and you can see the echo client log that it has received its packet back from the server

Brief tutorial

- Logging
  - ns-3 supports some kind of message logging facility
  - ns-3 provide a selectable, multi-level (7) approach to message logging
    - LOG_ERROR: log error messages
    - LOG_WARN: log warning messages
    - LOG_DEBUG: log debugging messages
    - LOG_INFO: Log informational messages about program progress
    - LOG_FUNCTION: Log a message describing each function called
    - LOG_LOGIC: Log messages describing logical flow within a function
    - LOG_ALL: Log everything mentioned above
  - ns-3 also provides an unconditional logging macro that is always displayed
    - NS_LOG_UNCOND
  - Recall that myfirst.cc script contains the code below:

```
LogComponentEnable ("UdpEchoClientApplication", LOG_LEVEL_INFO);
LogComponentEnable ("UdpEchoServerApplication", LOG_LEVEL_INFO);
```

  - We can increase the logging level and get more information without changing the script and recompiling by setting the NS_LOG environment variable like this:

```
~/Desktop/ns-allinone-3.36/ns-3.36$ export NS_LOG=UdpEchoClientApplication=level_all
```

    - export NS_LOG=UdpEchoClientApplication=level_all

Brief tutorial

- Logging
  - Now, let's run myfirst.cc script again:

```
ta@ta-VirtualBox:~/Desktop/ns-allinone-3.36/ns-3.36$ ./ns3 run scratch/myfirst
UdpEchoClientApplication:UdpEchoClient(0x55e290805ed0)
UdpEchoClientApplication:SetDataSize(0x55e290805ed0, 1024)
UdpEchoClientApplication:StartApplication(0x55e290805ed0)
UdpEchoClientApplication:ScheduleTransmit(0x55e290805ed0, +0ns)
UdpEchoClientApplication:Send(0x55e290805ed0)
At time +2s client sent 1024 bytes to 10.1.1.2 port 9
At time +2.00369s server received 1024 bytes from 10.1.1.1 port 49153
At time +2.00369s server sent 1024 bytes to 10.1.1.1 port 49153
UdpEchoClientApplication:HandleRead(0x55e290805ed0, 0x55e290817f50)
At time +2.00737s client received 1024 bytes from 10.1.1.2 port 9
UdpEchoClientApplication:StopApplication(0x55e290805ed0)
UdpEchoClientApplication:DoDispose(0x55e290805ed0)
UdpEchoClientApplication:~UdpEchoClient(0x55e290805ed0)
```

    - You can see that additional debug information provided by the application
  - Let's find out what log information UdpEchoClientApplication provides

```
~/Desktop/ns-allinone-3.36/ns-3.36$ find . -name '*.cc' | xargs grep UdpEchoClientApplication
```

    - find . –name '*.cc' command finds every .cc ('*.cc') file from current directory (.)
    - The following command after pipeline (|) gets result of the find command as an input and check if there is a word UdpEchoClientApplication in the input file and display the word if it exists

Brief tutorial

- Logging

```
./src/lte/examples/lena-ipv6-ue-rh.cc:  LogComponentEnable ("UdpEchoClientApplication", LOG_LEVEL_ALL);
./src/applications/model/udp-echo-client.cc:NS_LOG_COMPONENT_DEFINE ("UdpEchoClientApplication");
./src/nix-vector-routing/examples/nix-simple.cc:  LogComponentEnable ("UdpEchoClientApplication", LOG_LEVEL_INFO);
```

- The result shows that UdpEchoClientApplication log component is defined in ./src/applications/model/udp-echo-client.cc. Lets take a look at the file:

```
~/Desktop/ns-allinone-3.36/ns-3.36$ subl ./src/applications/model/udp-echo-client.cc
```

- If you search NS_LOG in the script using ctrl+F command, you can find many logging code in it

```
UdpEchoClient::SetRemote (Address ip, uint16_t port)
{
  NS_LOG_FUNCTION (this << ip << port);
```

```
        NS_LOG_INFO ("At time " << Simulator::Now ().As (Time::S) << " client received "
                     Inet6SocketAddress::ConvertFrom (from).GetIpv6 () << " port " <<
                     Inet6SocketAddress::ConvertFrom (from).GetPort ());
      }
    socket->GetSockName (localAddress);
    m_rxTrace (packet);
```

NS_LOG

Brief tutorial

- Logging
  - From now, let's add logging code to myfirst script
  - Open myfirst.cc script and then, add Info level logging code in line 43 (and save)

```
42    LogComponentEnable ("UdpEchoServerApplication", LOG_LEVEL_INFO);
43    NS_LOG_INFO("Creating topology");
44    NodeContainer nodes;
45    nodes.Create (2);
```

  - build myfirst script again and reset the NS_LOG variable again

```
ta@ta-VirtualBox:~/Desktop/ns-allinone-3.36/ns-3.36$ ./ns3
Scanning dependencies of target scratch_myfirst
[  0%] Building CXX object scratch/CMakeFiles/scratch_myfirst.dir/myfirst.cc.o
[  0%] Linking CXX executable ../../build/scratch/ns3.36-myfirst-default
Finished executing the following commands:
cd cmake-cache; cmake --build . -j 1 ; cd ..
ta@ta-VirtualBox:~/Desktop/ns-allinone-3.36/ns-3.36$ NS_LOG=
```

  - Recall that myfirst.cc log component is defined as FirstScriptExample
  - Enable the FirstScriptExample logging level into LOG_INFO and run the script:

```
ta@ta-VirtualBox:~/Desktop/ns-allinone-3.36/ns-3.36$ NS_LOG=FirstScriptExample=level_info
ta@ta-VirtualBox:~/Desktop/ns-allinone-3.36/ns-3.36$ ./ns3 run scratch/myfirst.cc
Creating topology
At time +2s client sent 1024 bytes to 10.1.1.2 port 9
At time +2.00369s server received 1024 bytes from 10.1.1.1 port 49153
At time +2.00369s server sent 1024 bytes to 10.1.1.1 port 49153
At time +2.00737s client received 1024 bytes from 10.1.1.2 port 9
```

    - You can see the log you just made!