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Installation Manual for

NS-3 on Ubuntu 20.04 LTS

Prof. Fan Li (Instructor)
Prof. Kashif Sharif (Instructor)
Karim Md Monjurul (TA)

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Prerequisites

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- Virtualized Instances of Ubuntu or Any Linux-based Distros
  - VMware Player or Workstation (16.0 or higher)
  - VirtualBox (6.1 or higher) and Extension Pack
  - Docker Desktop for Windows
  - WSL or WSL-2 (Overview)
  - Minimum Requirements
    - 20GB of Memory Allocation
    - 2-4 GB RAM allocation (less means slower)
    - Specific Windows Build 2004 or higher (for WSL-2)
- Basic Linux Commands (i.e., sudo, apt, ls, cat, nano, cp, mv)
- Visual Studio Code (Writing Codes)
- Terminal App (Compiling the Codes and Simulator Execution)
- Wireshark (Packet Sniffer and Analyzer)
- Gnuplot or Matplotlib (Plotting Graphs)

A Short Overview on WSL

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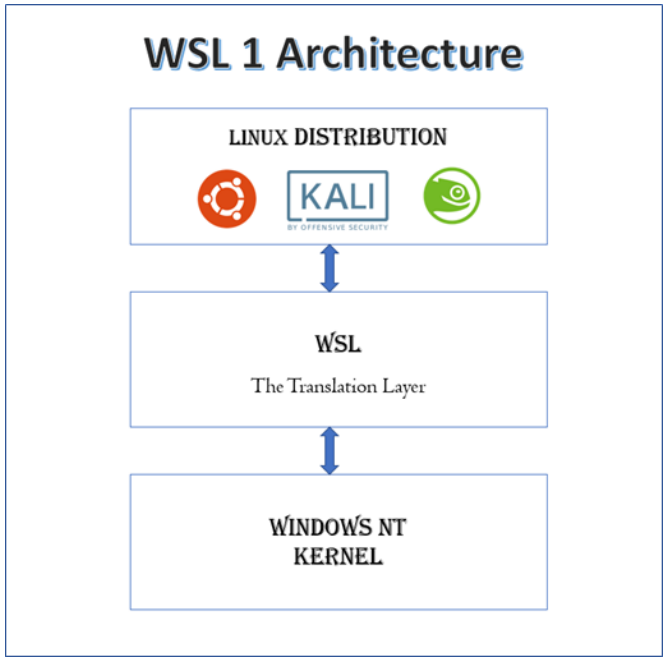
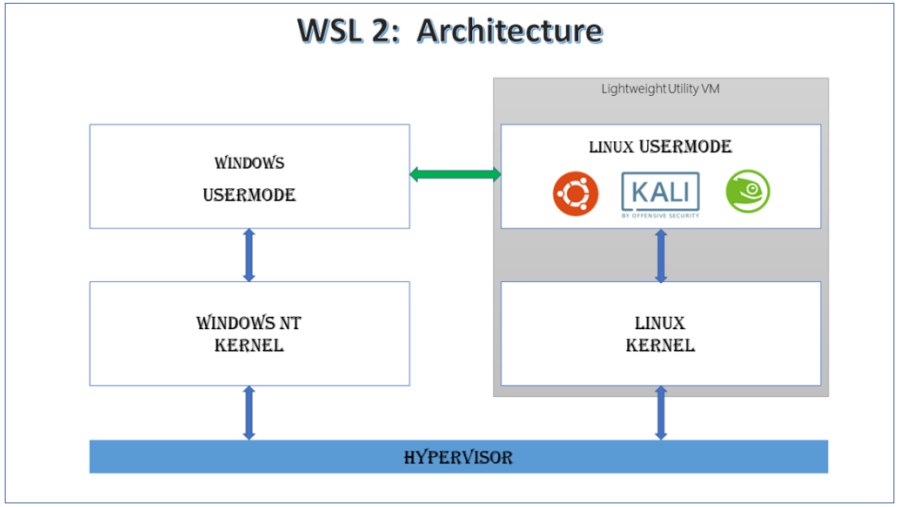
Windows Subsystem for Linux

- Allows to install a Linux distribution as an app from the Windows store.
- Execute from a command prompt or PowerShell terminal
- Run Bash shell scripts and GNU/Linux command-line applications:
  - Languages: C, **C++**, Python, Java, GO, NodeJS, etc.
  - Services: Apache, MySQL, MongoDB, etc.



What WSL-2 brings compared to WSL-1

- WSL2 runs on top of the Windows Hypervisor, which is a bare metal **hypervisor**
- Supports memory reclaim (uses only the right amount of **RAM** required for running the **Linux kernel**)
- Better integration with Windows OS



Prerequisites and Installation Steps to WSL 2

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Windows 10 build 18917 or higher.

- To find your Windows version, open Settings>System>About and look for the "OS build" field. os_build.
- **Step-1:** Enable the "Virtual Machine Platform" and "Windows Subsystem for Linux" feature; Alternatively: Open PowerShell as Administrator and Run:

```
dism.exe /online /enable-feature /featurename:Microsoft-Windows-Subsystem-Linux /all /norestart
```

- **Step-2:** Enable Virtual Machine feature before Ubuntu installation.
  - Require **virtualization** capabilities to use this feature
  - In some cases, you have to enable from **BIOS**.

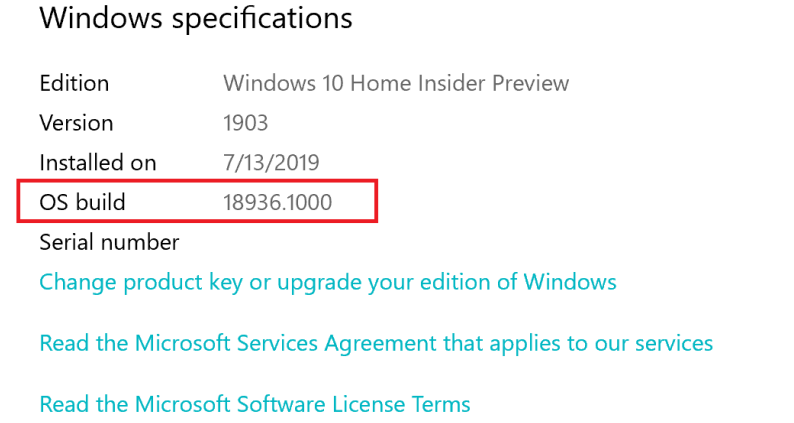
```
dism.exe /online /enable-feature /featurename:VirtualMachinePlatform /all /norestart
```

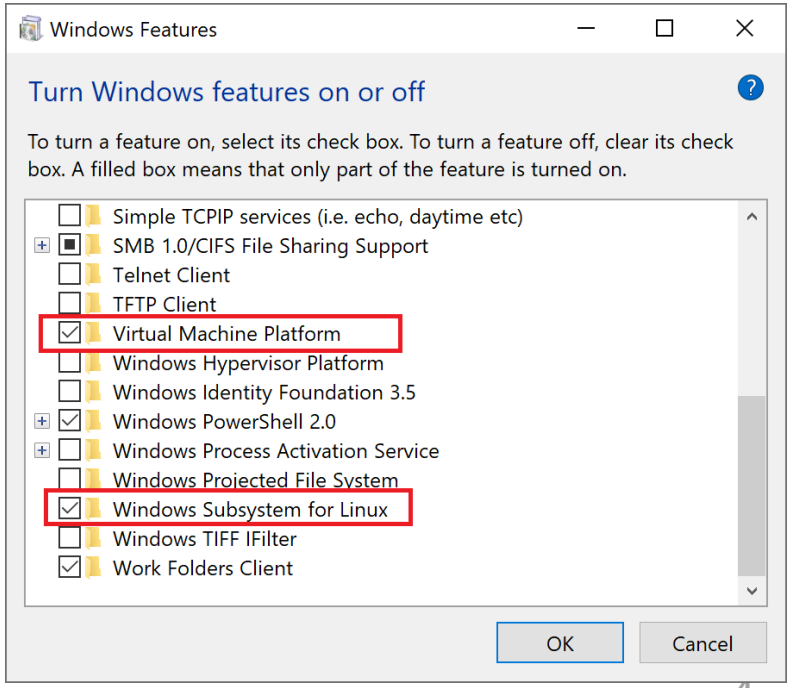
- **Step-3:** Download the Linux kernel update package (Link)
- **Step-4:** Set WSL 2 as your default version

```
wsl --set-default-version 2
```

- **Step-5:** Install your Linux distribution of choice (Microsoft Store)
- **Step-6:** Create a user account and password for your new Linux distribution
- **Step-7:** Check the Distro and WSL version

```
wsl -l -v
```





Prerequisites and Installation Steps to NS-3 on Ubuntu 20.04

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Explain Each Steps and Commands

- **Step-1:** Change the Software Repository (Tsinghua, Aliyun, USTC)

```
sudo sed -i 's#archive.ubuntu.com#mirrors.tuna.tsinghua.edu.cn#g'
/etc/apt/sources.list
```

- **Step-2:** Update the Repo and Upgrade the System

```
sudo apt update && sudo apt -y upgrade
```

- **Step-3:** Install Desktop Environment (KDE, XFCE,LXDE, GNOME 3)

```
sudo apt install xfce4 xfce4-goodies
```

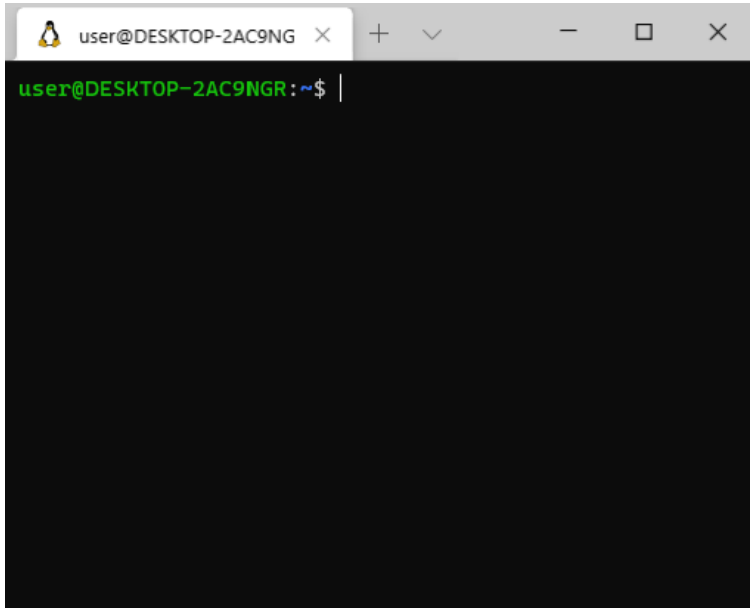
- **Step-4:** Install Core Dependencies

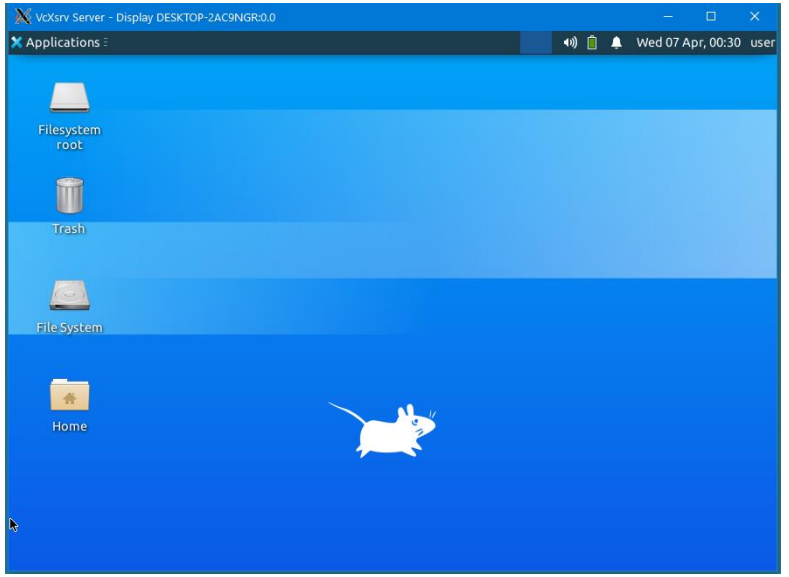
```
sudo apt install build-essential libsqlite3-dev libboost-all-dev
libssl-dev git python3-setuptools castxml
```

- **Step-5:** Dependencies for NS-3 Python bindings

```
sudo apt install gir1.2-goocanvas-2.0 gir1.2-gtk-3.0
libgirepository1.0-dev python3-dev python3-gi python3-gi-cairo
python3-pip python3-pygraphviz python3-pygccxml
```

```
sudo pip3 install kiwi
```





NS-3 Prerequisites and Installation (Cont.)

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Explanation to Each Steps to Installation Process

- **Step-6: ns**-3 Specific Dependencies Libraries

```
sudo apt install g++ pkg-config sqlite3 qt5-default mercurial
ipython3 openmpi-bin openmpi-common openmpi-doc libopenmpi-dev
autoconf cvs bzr unrar gdb valgrind uncrustify doxygen graphviz
imagemagick python3-sphinx dia tcpdump libxml2 libxml2-dev cmake
libc6-dev libc6-dev-i386 libclang-6.0-dev llvm-6.0-dev automake
```

- **Step-6: Download and Extract ns-3 Install Pack**

```
cd
wget -c https://www.nsnam.org/releases/ns-allinone-3.33.tar.bz2
tar -xvjf ns-allinone-3.33.tar.bz2
```

- **Step-7: Install ns-3 Simulator with waf command**

```
cd ns-allinone-3.33/ns-3.33/
./waf configure --enable-examples
./waf
cd
```

- **Step-7.1: Alternatively we can use build.py to compile and build ns-3**

```
cd ns-allinone-3.33/
./build.py --enable-examples --enable-tests
```

ns-3 Package Overview

What NS-3 Pack Includes:

- Directories
  - bake
  - netanim-3.108
  - ns-3.33
  - pybindgen-0.21.0…
- Files
  - build.py, constants.py, util.py

Confirm the Procedure (Terminal):

- Most modules should be built except
  - brite
  - click
  - openflow
- Others should be built including
  - visualizer

Validate NS-3 Installation and Build NetAnim

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Validate Ns-3 Installation

- **Step-8: Check ns-3 installation**

```
cd ns-allinone-3.33/ns-3.33/
./waf --run hello-simulator
```

The terminal should output

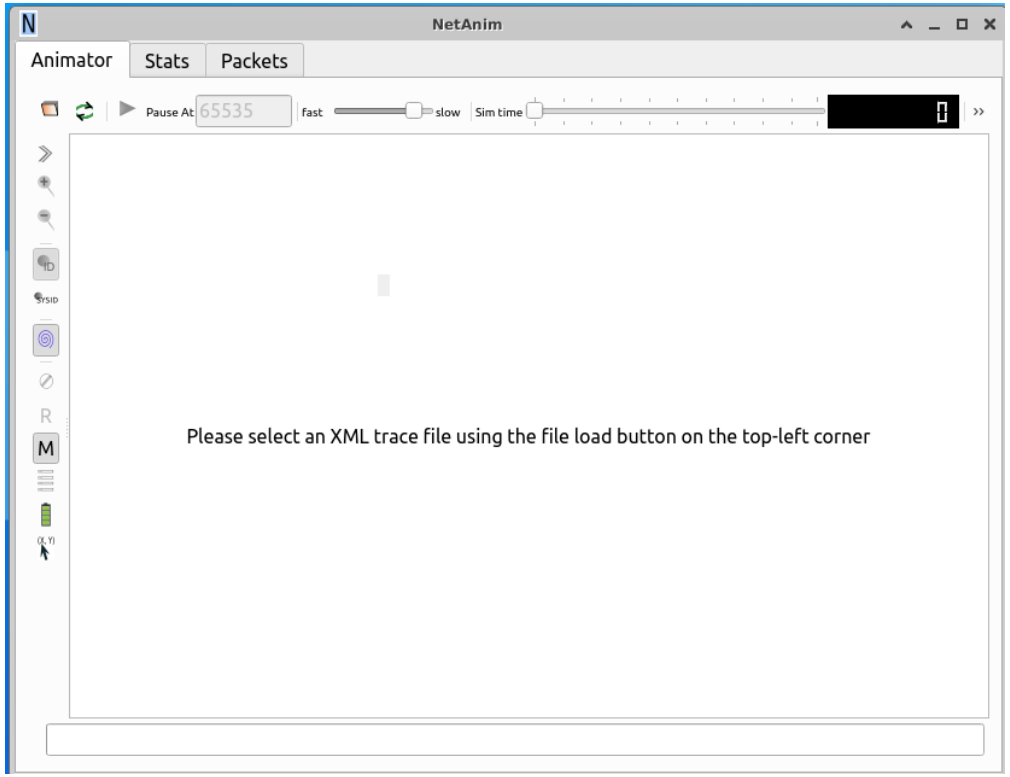
```
Hello Simulator
```

```
Modules built:
antenna                  aodv                     applications
bridge                   buildings                config-store
core                     csma                     csma-layout
dsdv                     dsr                      energy
fd-net-device            flow-monitor             internet
internet-apps            lr-wpan                  lte
mesh                     mobility                 netanim
network                  nix-vector-routing       olsr
point-to-point           point-to-point-layout    propagation
sixlowpan                spectrum                 stats
tap-bridge               test (no Python)         topology-read
traffic-control          uan                      virtual-net-device
visualizer               wave                     wifi
wimax

Modules not built (see ns-3 tutorial for explanation):
brite                    click                    dpdk-net-device
mpi                      openflow

user@DESKTOP-2AC9NGR:~/ns-allinone-3.33/ns-3.33$ ./waf --run hello-simulator
Waf: Entering directory `/home/user/ns-allinone-3.33/ns-3.33/build'
Waf: Leaving directory `/home/user/ns-allinone-3.33/ns-3.33/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (1.160s)
Hello Simulator
```

Validate NetAnim Installation

- **Step-9: Build and Compile netanim-3**

```
cd ns-allinone-3.33/netanim-3.108/
make clean
qmake NetAnim.pro
make
./NetAnim
cd
```



Using NS-3 Simulator to Build, Run Simulation Scenarios

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Compiling examples and custom-written scenarios

- **Test Scenario**

```
./waf --run first
```

```
Waf: Entering directory `/home/user/ns-allinone-3.33/ns-3.33/build'
Waf: Leaving directory `/home/user/ns-allinone-3.33/ns-3.33/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (2.088s)
ExampleFunction received event at 10s
RandomFunction received event at 18.1653s
Member method received event at 20s started at 10s
```

```
tree examples/tutorial/
```

```
├── examples-to-run.py
├── fifth.cc
├── first.cc
├── first.py
├── fourth.cc
├── hello-simulator.cc
├── second.cc
├── second.py
├── seventh.cc
├── sixth.cc
├── third.cc
├── third.py
└── wscript
```

```
ls -l examples/tutorial/
```

```
rw-r--r-- 1 user user   859 Jan 10 02:19 examples-to-run.py
rw-r--r-- 1 user user  6487 Jan 10 02:19 fifth.cc
rw-r--r-- 1 user user  2464 Jan 10 02:19 first.cc
rw-r--r-- 1 user user  2238 Jan 10 02:19 first.py
rw-r--r-- 1 user user  1791 Jan 10 02:19 fourth.cc
rw-r--r-- 1 user user   894 Jan 10 02:19 hello-simulator.cc
rw-r--r-- 1 user user  3592 Jan 10 02:19 second.cc
rw-r--r-- 1 user user  3431 Jan 10 02:19 second.py
rw-r--r-- 1 user user 10001 Jan 10 02:19 seventh.cc
rw-r--r-- 1 user user  7252 Apr  7 03:25 sixth.cc
rw-r--r-- 1 user user  6048 Jan 10 02:19 third.cc
rw-r--r-- 1 user user  5649 Jan 10 02:19 third.py
rw-r--r-- 1 user user  1417 Jan 10 02:19 wscript
```

Custom Scenario

```
nano scratch/1.cc
./waf
./waf --run scratch/1
```

```
 GNU nano 4.8
/*
TCPTestRouteMod v0.1
Two nodes communicating over PPP with TCP protocol
There is a rouing node in the middle.
*/

#include "ns3/netanim-module.h"
#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"

using namespace ns3;
Ptr<OutputStreamWrapper> cWndStream;

NS_LOG_COMPONENT_DEFINE ("TCPTest");

class TestApp : public Application{
public:
  TestApp() : m_socket (0),
    m_peer (),
    m_packetSize (0),
    m_nPackets (0),
    m_dataRate (0),
    m_sendEvent (),
    m_running (false),
    m_packetsSent (0) {
  }
  ~TestApp() {
    m_socket = 0;
  }
```

Visualize Simulation Scenario using PyViz

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PyViz Intro and Configuration in Custom Scenario

- **Run Example Code**

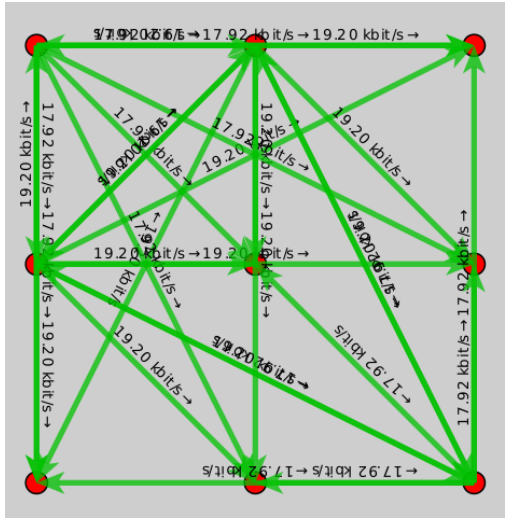
```
./waf --pyrun src/flow-monitor/examples/wifi-olsr-flowmon.py --vis
```

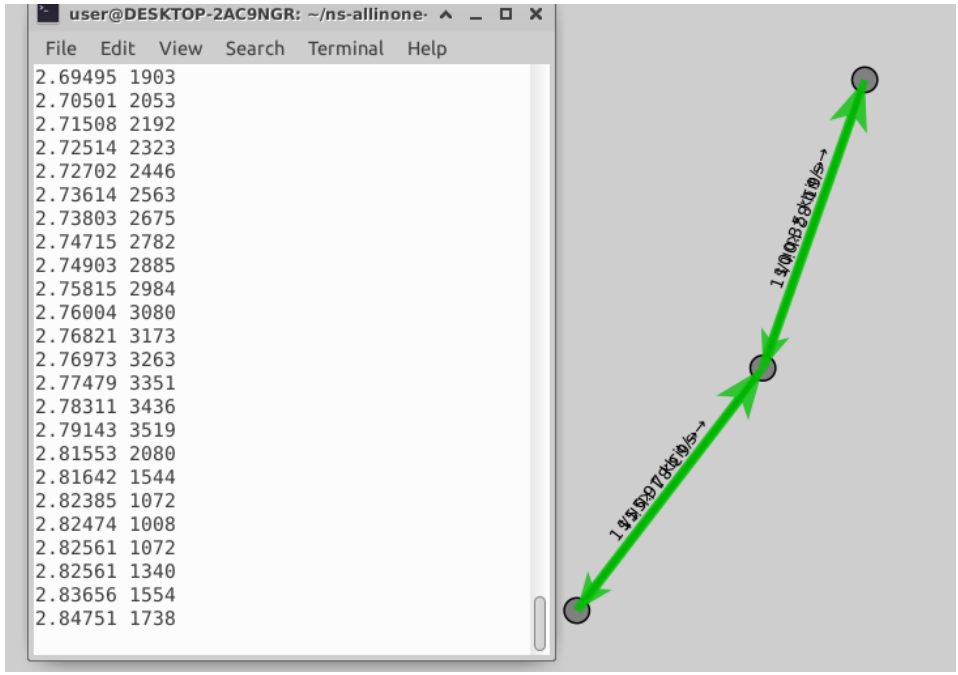
- **Make Changes on the Scenario**

```
//int main ()
int main(int argc, char* argv[])
{
    Time::SetResolution(Time::NS);
    LogComponentEnable("TCPTest", LOG_LEVEL_INFO);
```

```
// Read optional command-line parameters (e.g., en
CommandLine cmd;
cmd.Parse(argc, argv);

//Creating 3 nodes. 2 will be source dest pair, th
NS_LOG_INFO("Creating Nodes");
NodeContainer nodes;
nodes.Create(3);
```





Visualize Simulation Scenario using NetAnim

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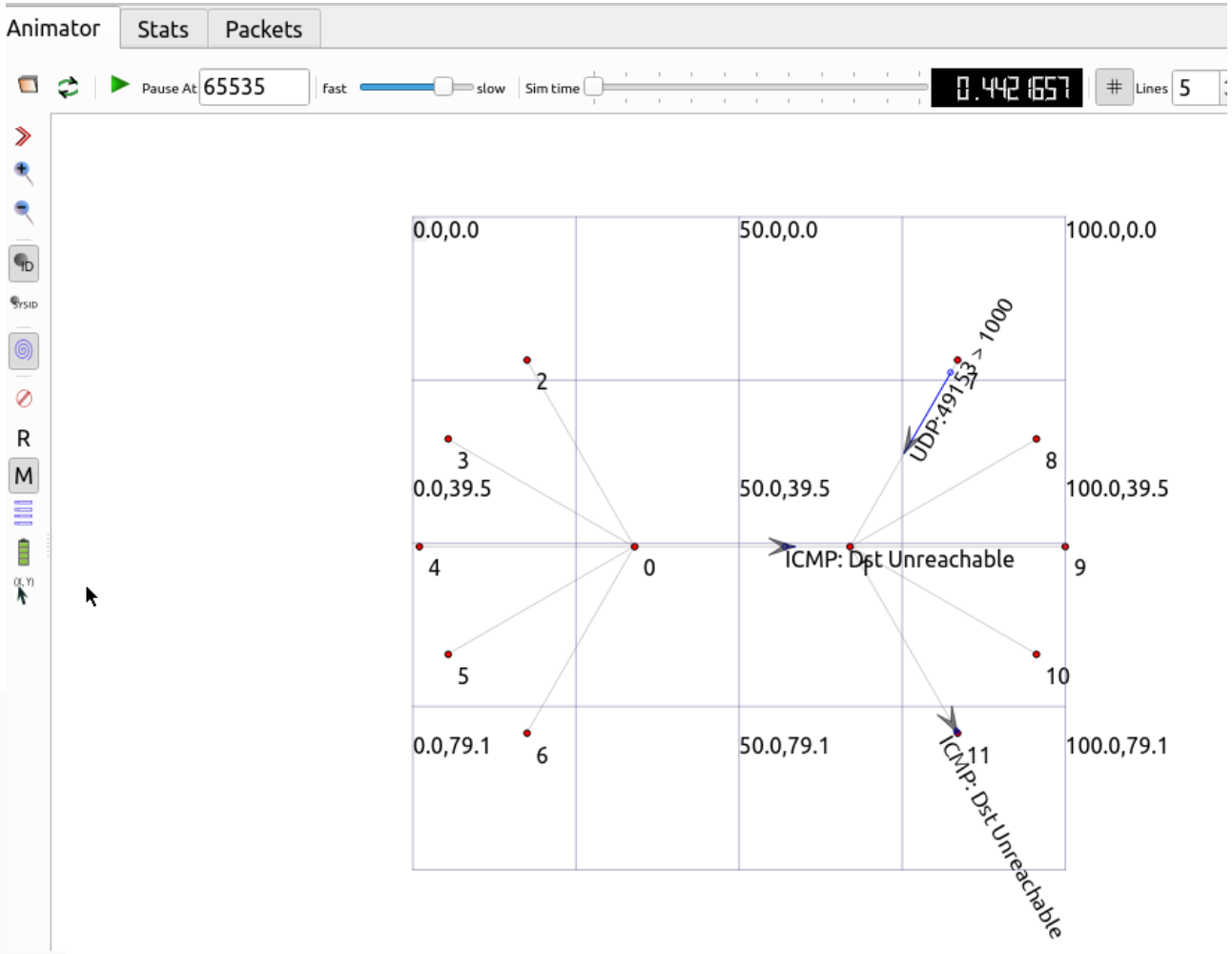
Enabling NetAnim xml in Simulation

- Add the header file
- Add the .xml output file
- .xml file needs to be open in NetAnim

```
17 #include "ns3/netanim-module.h"
18 #include "ns3/core-module.h"
19 #include "ns3/network-module.h"
20 #include "ns3/internet-module.h"
21 #include "ns3/point-to-point-module.h"
22 #include "ns3/applications-module.h"
23
24 NS_LOG_COMPONENT_DEFINE ("FirstScriptExample");
25
26 using namespace ns3;
27 Ptr<OutputStreamWrapper> cWndStream;
28 Ptr<OutputStreamWrapper> ssThreshStream;
```

```
154     sourceApp->SetStartTime(Seconds(1.0));
155     sourceApp->SetStopTime(Seconds(20.0));
156
157     AnimationInterface anim("scratch/first.xml");
158     anim.SetConstantPosition(nodes.Get(0), 0.0, 0.0);
159     anim.SetConstantPosition(nodes.Get(1), 20.0, 20.0);
160
161     p2p.EnablePcapAll("scratch/TCPTest");
162
163     //Initializing the cWndStream
```



Analyzing Packets in Wireshark

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Enable Pcap Tracing into the Scenario

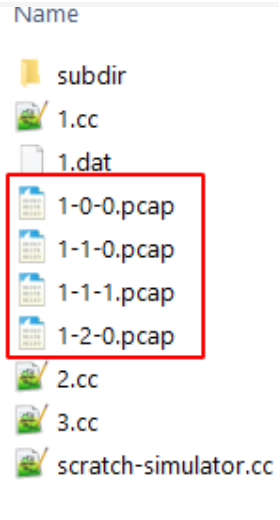
- Add EnablePcapAll function
- Run the simulation
- *.pcap files will be generated
- Two choices to view the pcap files in WSL
  - Install Wireshark on Host Windows
  - Add Wireshark Program Folder to Environment variables -> Path

```
explorer.exe .
wireshark.exe scratch/1-0-0.pcap
```

```
//Enabling Pcap Tracing
p2p.EnablePcapAll("scratch/1");

//Initializing the cWndStream
AsciiTraceHelper asciiTraceHelper;
cWndStream = asciiTraceHelper.CreateFileStr

Simulator::Stop(Seconds(20.0));
NS_LOG_INFO("Starting Simulator");
Simulator::Run ();
NS_LOG_INFO("Destroying Simulator");
Simulator::Destroy ();
```



No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	10.1.1.1	10.1.2.2	TCP	58	49153 → 8080 [SYN] Seq=0 Win=
2	0.008371	10.1.2.2	10.1.1.1	TCP	58	8080 → 49153 [SYN, ACK] Seq=0
3	0.008371	10.1.1.1	10.1.2.2	TCP	54	49153 → 8080 [ACK] Seq=1 Ack=
4	0.008457	10.1.1.1	10.1.2.2	TCP	590	49153 → 8080 [ACK] Seq=1 Ack=
5	0.009401	10.1.1.1	10.1.2.2	TCP	590	49153 → 8080 [ACK] Seq=537 Ac
6	0.010345	10.1.1.1	10.1.2.2	TCP	590	49153 → 8080 [ACK] Seq=1073 A
7	0.011289	10.1.1.1	10.1.2.2	TCP	526	49153 → 8080 [ACK] Seq=1609 A
8	0.016640	10.1.1.1	10.1.2.2	TCP	590	49153 → 8080 [ACK] Seq=2081 A
9	0.017584	10.1.1.1	10.1.2.2	TCP	558	49153 → 8080 [ACK] Seq=2617 A
10	0.018518	10.1.2.2	10.1.1.1	TCP	54	8080 → 49153 [ACK] Seq=1 Ack=
11	0.020406	10.1.2.2	10.1.1.1	TCP	54	8080 → 49153 [ACK] Seq=1 Ack=
12	0.024960	10.1.1.1	10.1.2.2	TCP	590	49153 → 8080 [ACK] Seq=3121 A
13	0.025904	10.1.1.1	10.1.2.2	TCP	558	49153 → 8080 [ACK] Seq=3657 A

```
Header Checksum: 0x0000 [validation disabled]
[Header checksum status: Unverified]
Source Address: 10.1.1.1
Destination Address: 10.1.2.2
Transmission Control Protocol, Src Port: 49153, Dst Port: 8080, Seq: 0, Len: 0
Source Port: 49153
Destination Port: 8080
[Stream index: 0]
[TCP Segment Len: 0]
Sequence Number: 0    (relative sequence number)
Sequence Number (raw): 0
[Next Sequence Number: 1    (relative sequence number)]
Acknowledgment Number: 0
Acknowledgment number (raw): 0
1001 .... = Header Length: 36 bytes (9)
Flags: 0x002 (SYN)
Window: 65535
[Calculated window size: 65535]
Checksum: 0x0000 [unverified]
[Checksum Status: Unverified]
```

```
0000  00 21 45 00 00 38 00 00  00 00 40 06 00 00 0a 01   ·!E··8·· ··@·····
0010  01 01 0a 01 02 02 c0 01  1f 90 00 00 00 00 00 00   ···· ···· ····
```

Generating Data and Plotting the Data into Graph

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Working with Gnuplot

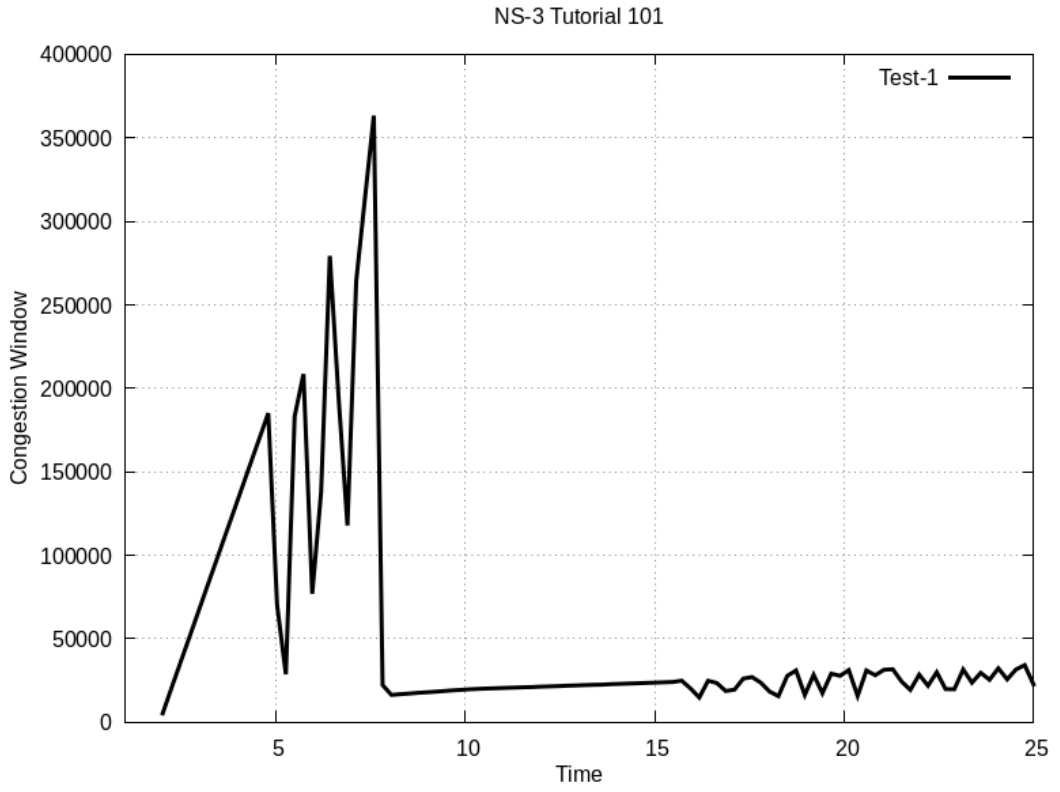
- Generate result.dat file

```
./waf --run scratch/2 >& result.dat
```

- Simple script to Generate Plot

```
gnuplot plot.gnu
```

```
1   reset
2   set terminal wxt size 800,600 font 'Liberation Sans,12'
3   set autoscale
4   set key width -2
5   set grid
6   set key opaque right top horizontal
7
8   set xrange [1:25]
9   set title "NS-3 Tutorial 101"
10  set xlabel "Time" offset 0,0.5
11  set ylabel "Congestion Window" offset 1,0
12
13  plot "result.dat" using 1:2 title "Test-1" lc rgb '#4B96D1'  lw 3 smooth cspline
14
15  pause -1
```



Code Editor

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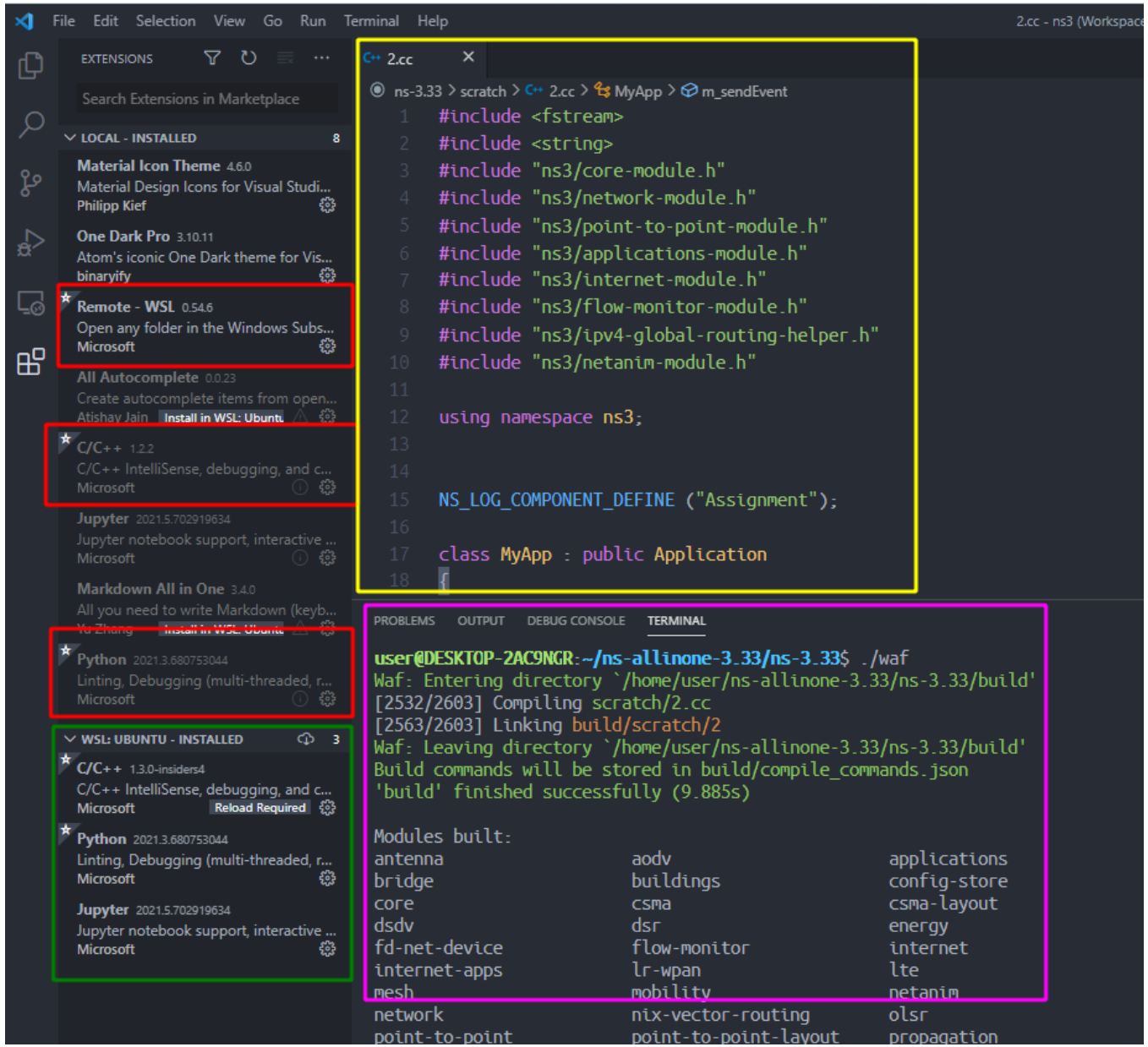
Use Code Editor based on Your Choice

- There is no specific Code Editor for NS-3.
  - Visual Studio code
  - PyCharm
  - Atom
  - Eclipse
- VSCode has better integration with WSL.



Additional Links and References

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1. WSL2 GUI X-Server Using VcXsrv https://www.shogan.co.uk/how-tos/wsl2-gui-x-server-using-vcxsrv/
2. Windows Subsystem for Linux Installation Guide for Windows 10 https://docs.microsoft.com/en-us/windows/wsl/install-win10
3. WSL-1 and WSL-2 Tutorial https://github.com/QMonkey/wsl-tutorial
4. ns3 Shared Resource by Adil Alsuhaim https://github.com/addola/NS3-HelperScripts/
5. Dev on Windows with WSL https://dowww.spencerwoo.com/
6. WSL 2 Networking https://davidbombal.com/wsl-2-networking/
7. NS3在WSL上的安装 https://zhuanlan.zhihu.com/p/265510752
8. NS3 installation https://shihchun.github.io/ns3_installation/
9. NS3 User Groups https://groups.google.com/g/ns-3-users/
10. Comparing TCP algorithms https://haltaro.github.io/comparing-tcp-algorithms/
11. ns-3 Network Simulator https://www.youtube.com/watch?v=2W5mdzQrwXI

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Thank you for listening!

Contact: mkarim@bit.edu.cn

Feel free to direct your questions
about installation of ns-3 to me