

Лабораторная работа №1

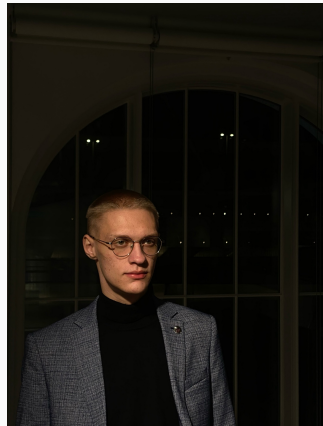
Моделирование сетей передачи данных

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- Развернуть в системе виртуализации (например, в VirtualBox) mininet, познакомиться с основными командами для работы с Mininet через командную строку и через графический интерфейс.

Выполнение лабораторной работы

Настройка образа VirtualBox

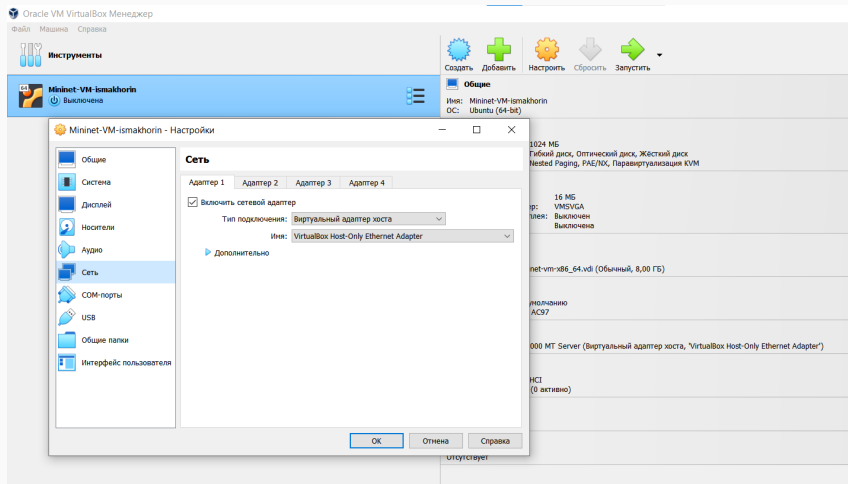
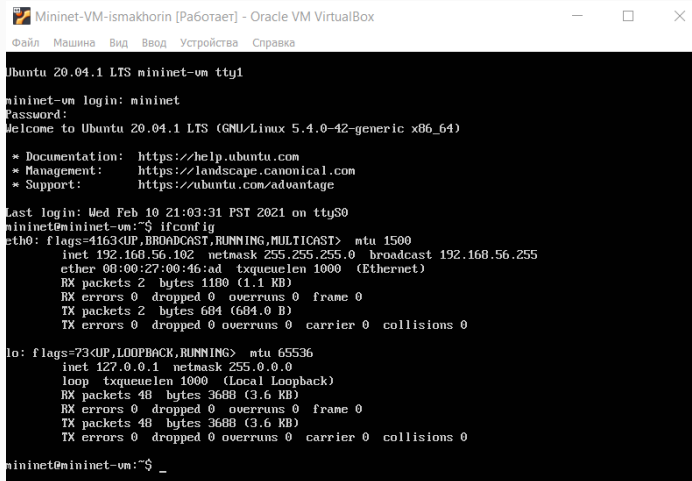


Рис. 1: Установка и настройка виртуальной машины

Подключение к виртуальной машине



```
Mininet-VM-ismakhorin [Работает] - Oracle VM VirtualBox
Файл  Машина  Вид  Ввод  Устройства  Справка

Ubuntu 20.04.1 LTS mininet-vm tty1

mininet-vm login: mininet
Password:
Welcome to Ubuntu 20.04.1 LTS (GNU/Linux 5.4.0-42-generic x86_64)

 * Documentation:  https://help.ubuntu.com
 * Management:    https://landscape.canonical.com
 * Support:       https://ubuntu.com/advantage

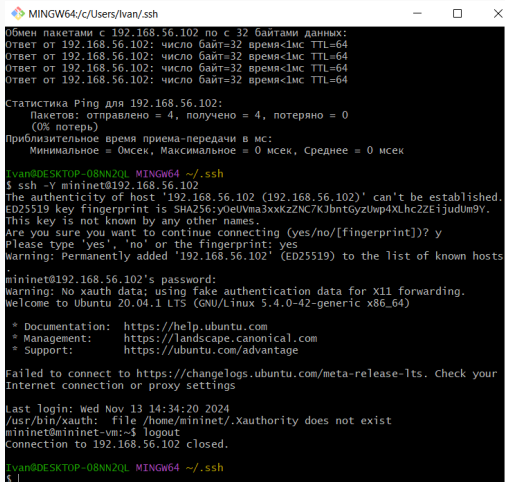
Last login: Wed Feb 10 21:03:31 PST 2021 on ttyS0
mininet@mininet-vm:~$ ifconfig
eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
        inet 192.168.56.102  netmask 255.255.255.0  broadcast 192.168.56.255
        ether 08:00:27:00:46:ad  txqueuelen 1000  (Ethernet)
        RX packets 2  bytes 1180 (1.1 KB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 2  bytes 684 (684.0 B)
        TX errors 0  dropped 0  overruns 0  carrier 0  collisions 0

lo: flags=73<UP,LOOPBACK,RUNNING>  mtu 65536
        inet 127.0.0.1  netmask 255.0.0.0
        loop txqueuelen 1000  (Local Loopback)
        RX packets 48  bytes 3688 (3.6 KB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 48  bytes 3688 (3.6 KB)
        TX errors 0  dropped 0  overruns 0  carrier 0  collisions 0

mininet@mininet-vm:~$ _
```

Рис. 2: Вход и просмотр адреса виртуальной машины

Подключение к виртуальной машине



```
MINGW64:/c/Users/Ivan/.ssh
Обмен пакетами с 192.168.56.102 по с 32 байтами данных:
Ответ от 192.168.56.102: число байт=32 время<1мс TTL=64
Ответ от 192.168.56.102: число байт=32 время<1мс TTL=64
Ответ от 192.168.56.102: число байт=32 время<1мс TTL=64
Ответ от 192.168.56.102: число байт=32 время<1мс TTL=64

Статистика Ping для 192.168.56.102:
  Пакетов: отправлено = 4, получено = 4, потеряно = 0
  (0% потерь)
Приблизительное время приема-передачи в мс:
  Минимальное = 0мсек, Максимальное = 0 мсек, Среднее = 0 мсек

Ivan@DESKTOP-08NN2QL MINGW64 ~/.ssh
$ ssh -Y mininet@192.168.56.102
The authenticity of host '192.168.56.102 (192.168.56.102)' can't be established.
ED25519 key fingerprint is SHA256:yOeUVma3xxKzZNC7KJbntGyzUwp4XLhc2ZEijudUm9Y.
This key is not known by any other names.
Are you sure you want to continue connecting (yes/no/[fingerprint])? y
Please type 'yes', 'no' or the fingerprint; yes
Warning: Permanently added '192.168.56.102' (ED25519) to the list of known hosts
mininet@192.168.56.102's password:
Warning: No xauth data; using fake authentication data for X11 forwarding.
Welcome to Ubuntu 20.04.1 LTS (GNU/Linux 5.4.0-42-generic x86_64)

 * Documentation:  https://help.ubuntu.com
 * Management:    https://landscape.canonical.com
 * Support:       https://ubuntu.com/advantage

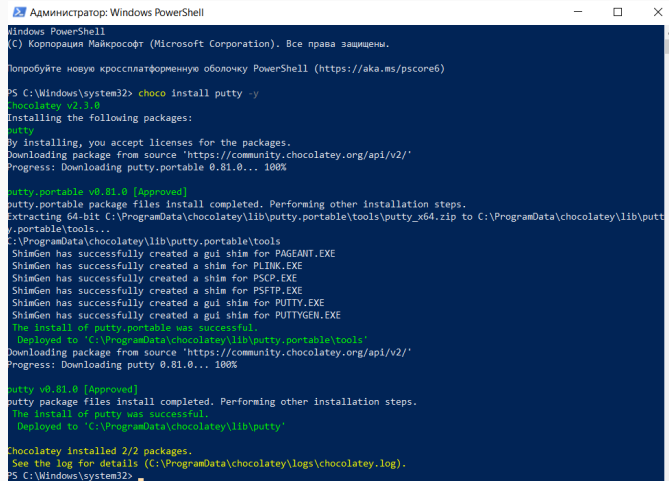
Failed to connect to https://changelogs.ubuntu.com/meta-release-lts. Check your
Internet connection or proxy settings

Last login: Wed Nov 13 14:34:20 2024
/usr/bin/xauth: file /home/mininet/.Xauthority does not exist
mininet@mininet-vm:~$ logout
Connection to 192.168.56.102 closed.

Ivan@DESKTOP-08NN2QL MINGW64 ~/.ssh
$
```

Рис. 3: Подключение к виртуальной машине из терминала хостовой машины

Работа с Mininet из-под Windows



```
Администратор: Windows PowerShell
Windows PowerShell
(C) Корпорация Майкрософт (Microsoft Corporation). Все права защищены.

Попробуйте новую кроссплатформенную оболочку PowerShell (https://aka.ms/powershell)

PS C:\Windows\system32> choco install putty -y
Chocolatey v2.3.0
Installing the following packages:
putty
By installing, you accept licenses for the packages.
Downloading package from source 'https://community.chocolatey.org/api/v2/'
Progress: Downloading putty.portable 0.81.0... 100%

putty.portable v0.81.0 [Approved]
putty.portable package files install completed. Performing other installation steps.
Extracting 64-bit C:\ProgramData\chocolatey\lib\putty.portable\tools\putty_x64.zip to C:\ProgramData\chocolatey\lib\putty.portable\tools...
C:\ProgramData\chocolatey\lib\putty.portable\tools
ShimGen has successfully created a gui shim for PAGEANT.EXE
ShimGen has successfully created a shim for PLINK.EXE
ShimGen has successfully created a shim for PSCP.EXE
ShimGen has successfully created a shim for PSFTP.EXE
ShimGen has successfully created a gui shim for PUTTY.EXE
ShimGen has successfully created a gui shim for PUTTYGEN.EXE
The install of putty.portable was successful.
  Deployed to 'C:\ProgramData\chocolatey\lib\putty.portable\tools'
Downloading package from source 'https://community.chocolatey.org/api/v2/'
Progress: Downloading putty 0.81.0... 100%

putty v0.81.0 [Approved]
putty package files install completed. Performing other installation steps.
The install of putty was successful.
  Deployed to 'C:\ProgramData\chocolatey\lib\putty'

Chocolatey installed 2/2 packages.
See the log for details (C:\ProgramData\chocolatey\logs\chocolatey.log).
PS C:\Windows\system32>
```

Рис. 4: Установка putty


```
PS C:\Windows\system32> choco install vcxsrv -y
Chocolatey v2.3.0
Installing the following packages:
vcxsrv
By installing, you accept licenses for the packages.
Downloading package from source 'https://community.chocolatey.org/api/v2/'
Progress: Downloading vcxsrv 21.1.10... 100%

vcxsrv v21.1.10 [Approved]
vcxsrv package files install completed. Performing other installation steps.
Installing 64-bit vcxsrv...
vcxsrv has been installed.
  vcxsrv may be able to be automatically uninstalled.
The install of vcxsrv was successful.
  Software installed as 'EXE', install location is likely default.

Chocolatey installed 1/1 packages.
  See the log for details (C:\ProgramData\chocolatey\logs\chocolatey.log).
PS C:\Windows\system32>
```

Рис. 5: Установка putty VcXsrv Windows X Server

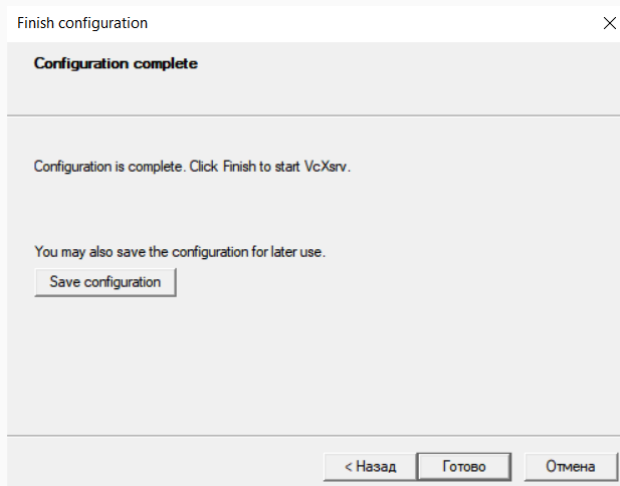


Рис. 6: Запуск и настройка Xserver

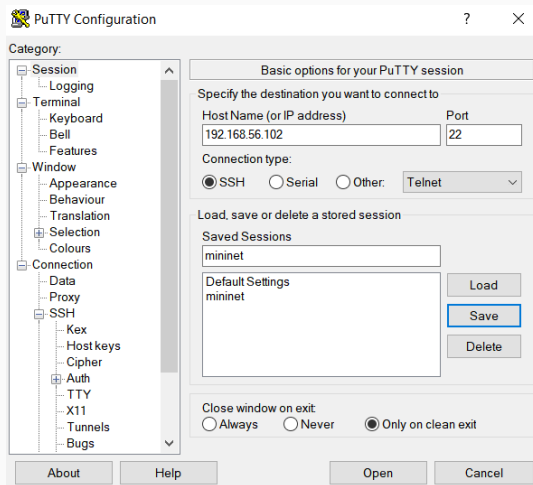
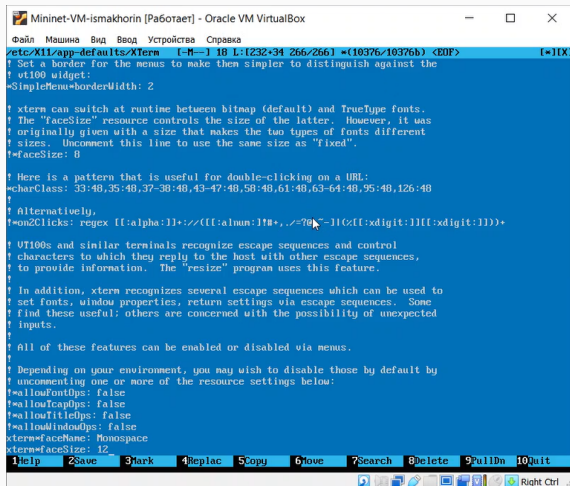


Рис. 7: Запуск putty и добавление опции перенаправления X11

Настройка параметров XTerm



```
Mininet-VM-ismakhorin [Работает] - Oracle VM VirtualBox
Файл  Машина  Вид  Ввод  Устройства  Справка
/etc/X11/app-defaults/XTerm  [-M--] 18 L:(232*34 266/266) *(10376/10376b) <EOF>  [*]IX
! Set a border for the menus to make them simpler to distinguish against the
! vt100 widget:
*SimpleMenu*borderWidth: 2

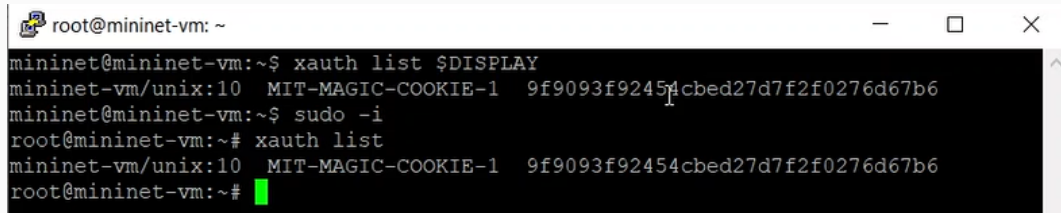
! xterm can switch at runtime between bitmap (default) and TrueType fonts.
! The "faceSize" resource controls the size of the latter.  However, it was
! originally given with a size that makes the two types of fonts different
! sizes.  Uncomment this line to use the same size as "fixed".
!*faceSize: 8

! Here is a pattern that is useful for double-clicking on a URL:
*charClass: 33:48,35:48,37-38:48,43-47:48,58:48,61:48,63-64:48,95:48,126:48
!
! Alternatively,
!*on2Clicks: regex [[:alpha:]]+://([[:alnum:]]!#+,./=?@%-][[:xdigit:]]{1:xdigit:})+

! VT100s and similar terminals recognize escape sequences and control
! characters to which they reply to the host with other escape sequences,
! to provide information.  The "resize" program uses this feature.
!
! In addition, xterm recognizes several escape sequences which can be used to
! set fonts, window properties, return settings via escape sequences.  Some
! find these useful; others are concerned with the possibility of unexpected
! inputs.
!
! All of these features can be enabled or disabled via menus.
!
! Depending on your environment, you may wish to disable those by default by
! uncommenting one or more of the resource settings below:
*allowFontOps: false
*allowTcapOps: false
*allowTitleOps: false
*allowWindowOps: false
xterm*faceName: Monospace
xterm*faceSize: 12
1!help 2!save 3!mark 4!Replac 5!Copy 6!move 7!Search 8!Delete 9!PullDn 10!quit
Right Ctrl
```

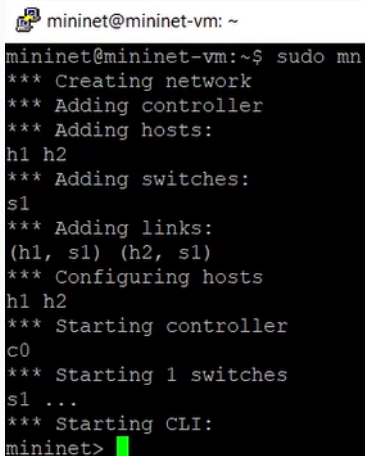
Рис. 8: Увеличение размера шрифта и применение векторного шрифта

Настройка соединения X11 для суперпользователя

A terminal window titled 'root@mininet-vm: ~' with standard window controls. The terminal shows a sequence of commands and their outputs. The first command 'xauth list \$DISPLAY' is run as 'mininet' and shows a single entry. Then 'sudo -i' is run, switching to 'root'. Finally, 'xauth list' is run as 'root', showing the same entry. A green cursor is visible at the end of the last line.

```
root@mininet-vm: ~  
mininet@mininet-vm:~$ xauth list $DISPLAY  
mininet-vm/unix:10  MIT-MAGIC-COOKIE-1  9f9093f92454cbed27d7f2f0276d67b6  
mininet@mininet-vm:~$ sudo -i  
root@mininet-vm:~# xauth list  
mininet-vm/unix:10  MIT-MAGIC-COOKIE-1  9f9093f92454cbed27d7f2f0276d67b6  
root@mininet-vm:~#
```

Рис. 9: Заполнения файла полномочий /root/ .Xauthority

A terminal window with a dark background. The prompt is 'mininet@mininet-vm: ~'. The user enters 'sudo mn'. The output shows the creation of a network topology with hosts h1, h2, switch s1, and controller c0. The prompt changes to 'mininet>' with a green cursor.

```
mininet@mininet-vm: ~  
mininet@mininet-vm:~$ sudo mn  
*** Creating network  
*** Adding controller  
*** Adding hosts:  
h1 h2  
*** Adding switches:  
s1  
*** Adding links:  
(h1, s1) (h2, s1)  
*** Configuring hosts  
h1 h2  
*** Starting controller  
c0  
*** Starting 1 switches  
s1 ...  
*** Starting CLI:  
mininet> █
```

Рис. 10: Вызов Mininet с использованием топологии по умолчанию

Работа с Mininet с помощью командной строки

```
mininet> help

Documented commands (type help <topic>):
=====
BOF      gterm  iperfudp nodes      pingpair    py          switch  xterm
dpctl    help   link    noecho    pingpairfull quit        time
dump     intfs  links   pingall   ports       sh         wait
exit     iperf  net     pingallfull px          source     x

You may also send a command to a node using:
  <node> command {args}
For example:
  mininet> h1 ifconfig

The interpreter automatically substitutes IP addresses
for node names when a node is the first arg, so commands
like
  mininet> h2 ping h3
should work.

Some character-oriented interactive commands require
noecho:
  mininet> noecho h2 vi foo.py
However, starting up an xterm/gterm is generally better:
  mininet> xterm h2

mininet> █
```

Рис. 11: Отображение списка команд и примеров их использования

```
mininet> nodes  
available nodes are:  
c0 h1 h2 s1  
mininet> █
```

Рис. 12: Отображение доступных узлов


```
mininet> net
h1 h1-eth0:s1-eth1
h2 h2-eth0:s1-eth2
s1 lo: s1-eth1:h1-eth0 s1-eth2:h2-eth0
c0
mininet> █
```

Рис. 13: Просмотр доступных линков

```
mininet> h1 ifconfig
h1-eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
    inet 10.0.0.1  netmask 255.0.0.0  broadcast 10.255.255.255
    ether 62:3a:54:ac:ff:7d  txqueuelen 1000  (Ethernet)
    RX packets 0  bytes 0 (0.0 B)
    RX errors 0  dropped 0  overruns 0  frame 0
    TX packets 0  bytes 0 (0.0 B)
    TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

lo:  flags=73<UP,LOOPBACK,RUNNING>  mtu 65536
    inet 127.0.0.1  netmask 255.0.0.0
    loop txqueuelen 1000  (Local Loopback)
    RX packets 0  bytes 0 (0.0 B)
    RX errors 0  dropped 0  overruns 0  frame 0
    TX packets 0  bytes 0 (0.0 B)
    TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

mininet> █
```

Рис. 14: Выполнение команды для устройства h1

Работа с Mininet с помощью командной строки

```
mininet> h1 ping 10.0.0.2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=1.87 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.173 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.071 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=0.048 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=0.422 ms
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=0.042 ms
64 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=0.039 ms
64 bytes from 10.0.0.2: icmp_seq=8 ttl=64 time=0.045 ms
^C
--- 10.0.0.2 ping statistics ---
8 packets transmitted, 8 received, 0% packet loss, time 7126ms
rtt min/avg/max/mdev = 0.039/0.338/1.866/0.590 ms
mininet> exit
*** Stopping 1 controllers
c0
*** Stopping 2 links
..
*** Stopping 1 switches
s1
*** Stopping 2 hosts
h1 h2
*** Done
completed in 220.242 seconds
mininet@mininet-vm:~$
```

Рис. 15: Проверка связи между узлами h1 и h2

```
mininet@mininet-vm:~$ sudo mn -c
*** Removing excess controllers/ofprotocols/ofdatapaths/pings/noxes
killall controller ofprotocol ofdatapath ping nox_corelt-nox_core ovs-openflowd
ovs-controllerovs-testcontroller udpbwtest mnexec ivs ryu-manager 2> /dev/null
```

Рис. 16: Очистка предыдущего экземпляра Mininet

Построение и эмуляция сети в Mininet с использованием графического интерфейса

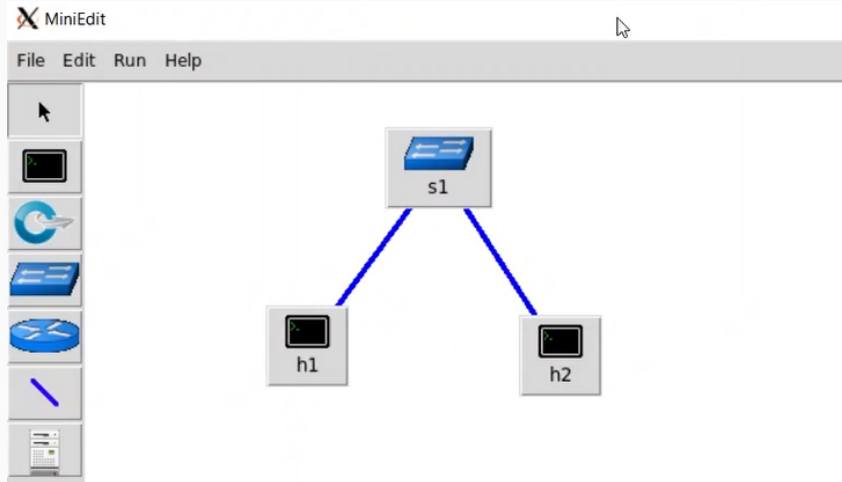


Рис. 17: Добавление двух хостов и одного коммутатора

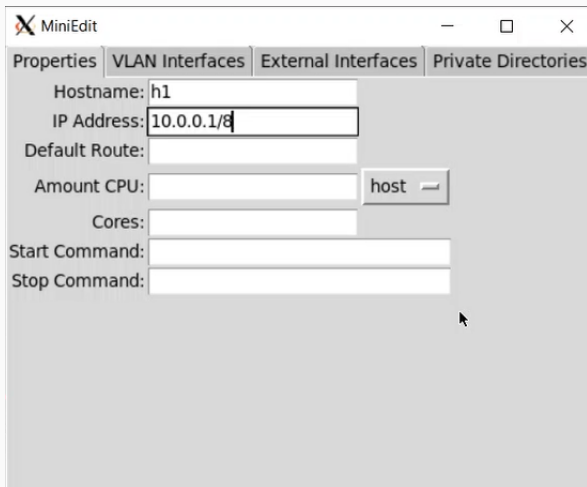


Рис. 18: Настройка IP-адреса на хосте h1

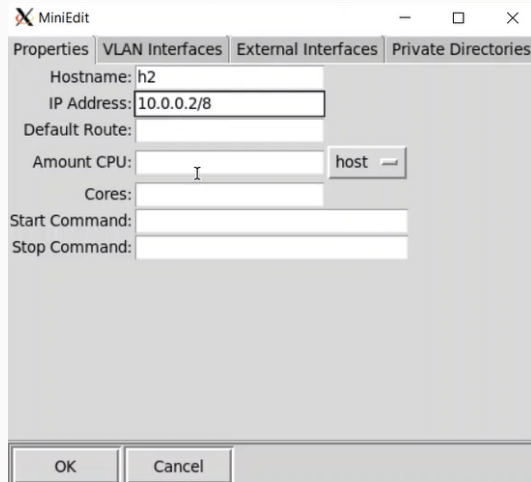
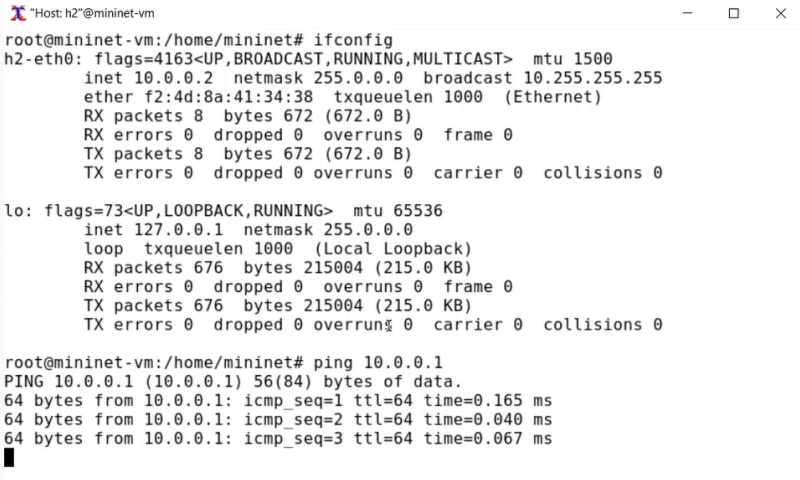


Рис. 19: Настройка IP-адреса на хосте h2

Построение и эмуляция сети в Mininet с использованием графического интерфейса



```
Host: h2'@mininet-vm
root@mininet-vm:/home/mininet# ifconfig
h2-eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
    inet 10.0.0.2  netmask 255.0.0.0  broadcast 10.255.255.255
    ether f2:4d:8a:41:34:38  txqueuelen 1000  (Ethernet)
    RX packets 8  bytes 672 (672.0 B)
    RX errors 0  dropped 0  overruns 0  frame 0
    TX packets 8  bytes 672 (672.0 B)
    TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

lo: flags=73<UP,LOOPBACK,RUNNING>  mtu 65536
    inet 127.0.0.1  netmask 255.0.0.0
    loop txqueuelen 1000  (Local Loopback)
    RX packets 676  bytes 215004 (215.0 KB)
    RX errors 0  dropped 0  overruns 0  frame 0
    TX packets 676  bytes 215004 (215.0 KB)
    TX errors 0  dropped 0 overrun% 0  carrier 0  collisions 0

root@mininet-vm:/home/mininet# ping 10.0.0.1
PING 10.0.0.1 (10.0.0.1) 56(84) bytes of data.
64 bytes from 10.0.0.1: icmp_seq=1 ttl=64 time=0.165 ms
64 bytes from 10.0.0.1: icmp_seq=2 ttl=64 time=0.040 ms
64 bytes from 10.0.0.1: icmp_seq=3 ttl=64 time=0.067 ms
```

Рис. 20: Проверка назначенных IP-адресов для h2 и проверка соединения между хостами

Построение и эмуляция сети в Mininet с использованием графического интерфейса

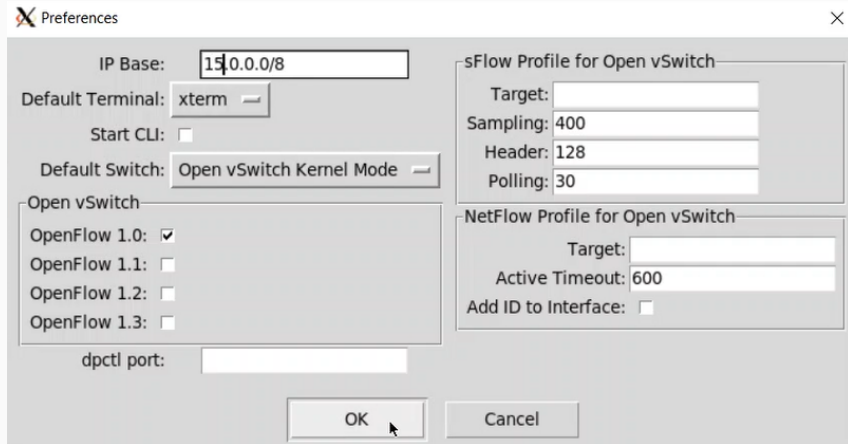
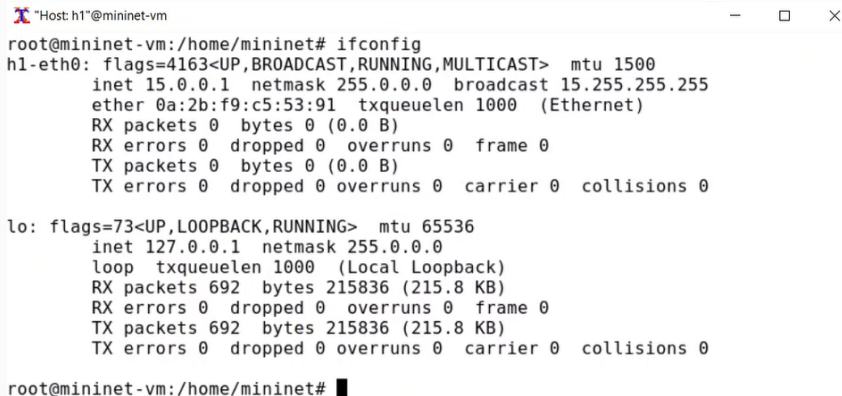


Рис. 21: Проверка автоматического назначения адресов

Построение и эмуляция сети в Mininet с использованием графического интерфейса



A terminal window titled "Host: h1"@"mininet-vm" with standard window controls. The terminal shows the output of the 'ifconfig' command for two interfaces: h1-eth0 and lo. The h1-eth0 interface is configured with IP 15.0.0.1, netmask 255.0.0.0, and broadcast 15.255.255.255. The lo interface is the loopback address 127.0.0.1. The prompt at the bottom is root@mininet-vm:/home/mininet#.

```
"Host: h1"@"mininet-vm"
root@mininet-vm:/home/mininet# ifconfig
h1-eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
    inet 15.0.0.1  netmask 255.0.0.0  broadcast 15.255.255.255
    ether 0a:2b:f9:c5:53:91  txqueuelen 1000  (Ethernet)
    RX packets 0  bytes 0 (0.0 B)
    RX errors 0  dropped 0  overruns 0  frame 0
    TX packets 0  bytes 0 (0.0 B)
    TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

lo: flags=73<UP,LOOPBACK,RUNNING>  mtu 65536
    inet 127.0.0.1  netmask 255.0.0.0
    loop txqueuelen 1000  (Local Loopback)
    RX packets 692  bytes 215836 (215.8 KB)
    RX errors 0  dropped 0  overruns 0  frame 0
    TX packets 692  bytes 215836 (215.8 KB)
    TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

root@mininet-vm:/home/mininet#
```

Рис. 22: Отображение IP-адреса, назначенного хосту h1

```
mininet@mininet-vm:~$ mkdir ~/work  
mininet@mininet-vm:~$
```

Рис. 23: Создание нового каталога

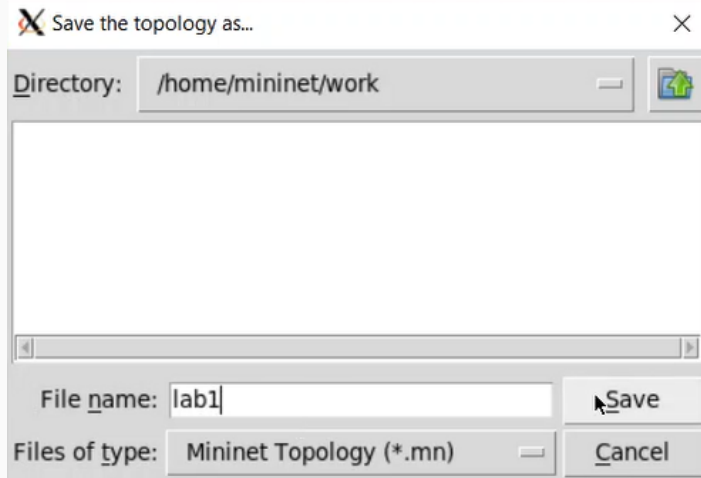


Рис. 24: Сохранение топологии

```
mininet@mininet-vm:~/work$ ls
lab1.mn
mininet@mininet-vm:~/work$ ls -Al
total 0
-rw-r--r-- 1 root root 0 Nov 13 15:27 lab1.mn
mininet@mininet-vm:~/work$ sudo chown -R mininet ~/work/
mininet@mininet-vm:~/work$
```

Рис. 25: Изменение прав доступа к файлам в каталоге проекта

Вывод

- В ходе выполнения лабораторной работы были получены навыки по развёртыванию в системе виртуализации (например, в VirtualBox) mininet, а также познакомились с основными командами для работы с Mininet через командную строку и через графический интерфейс.

Список литературы. Библиография

[1] Mininet: <https://mininet.org/>