

What is DYNAMIPS?

- Free and legal **Cisco Router emulator** software
- Runs **real** Cisco IOS software images
- Developed by Christophe Fillot from France
- Originally emulated only Cisco 7200 router
- Now can also emulate 1700, 2600, 2600XM, 3600, 3700, and 7200 series routers.
- Runs on Windows XP/2000, Linux X86/64
- Runs on Intel and AMD

Why use DYNAMIPS?

- Studying for CCNA, CCDP, CCNP, CCIE Routing & Switching, CCIE Security, CCIE Service Provider (useless for CCIE Voice and CCIE Storage)
- Quickly test Cisco IOS features for customers
- Test Cisco IOS configurations before deploying in production (QoS, routing, etc.)

What is DYNAMIPS?

- More powerful than Cisco's internal IOU tool (runs only on Sun SPARC and it's not available for public use)
- Current version of DYNAMIPS is 0.2.8-RC2
- Dynamips website:
http://www.ipflow.utc.fr/index.php/Cisco_7200_Simulator
- Download Dynamips from Chris's blog:
<http://www.ipflow.utc.fr/blog>

Cisco 1700 support

- Supports 1710, 1720, 1721, 1750, 1751 and 1760
- Interface Support
 - Onboard interfaces (according to the router model)
 - WIC-1T, WIC-2T, WIC-1ENET

Cisco 2600 support

- Supports 2610, 2611, 2620, 2621, 2610XM, 2620XM, 2621XM, 2650XM, 2651XM, 2691
- Interface Support
 - Onboard interfaces (according to the router model)
 - WIC-1T, WIC-2T
 - NM-1E, **NM-4E**, NM-1FE-TX
 - NM-16ESW
 - **NM-4T**

Cisco 3600 support

- Supports 3620, 3640, 3660
- Interface Support
 - No onboard interfaces
 - NM-1E, **NM-4E**, NM-1FE-TX
 - NM-16ESW
 - **NM-4T**

Cisco 3700 support

- Supports 3725 and 3745
- Interface Support
 - Onboard interfaces (according to the router model)
 - NM-1E, **NM-4E**, NM-1FE-TX
 - NM-16ESW
 - **NM-4T**

Cisco 7200 support

- Supports 7206 (VXR and non-VXR)
 - All NPEs including NPE-G1 and NPE-G2
- Interface Support
 - **C7200-IO-FE**, C7200-IO-2FE, PA-FE-TX, PA-2FE-TX
 - C7200-IO-GE-E and PA-GE
 - PA-4E and **PA-8E**
 - **PA-A1** (basic ATM card, not all ATM features are supported)
 - PA-4T+ and **PA-8T**
 - PA-POS-OC3 (Packet over Sonet)

What DYNAMIPS is NOT?

- Doesn't emulate Catalyst switches
- There are two solutions:
 - DYNAGEN has built-in basic virtual Ethernet switch. It is not configurable. It supports VLANs, DOT1Q tagging, and learning of MAC addresses.
 - Connect virtual router interface to the PC's physical NIC, then connect PC NIC to the real Cisco Catalyst switch.

What DYNAMIPS is NOT?

- Doesn't emulate Cisco PIX/ASA
- There is a solution:
 - PEMU Pix EMULATION
 - QEMU
 - It's outside of this presentations' scope, google it
 - DYNAGEN developer is working on tying PEMU into DYNAGEN. Soon you will be able to add PIX and ASA to the topology very easily.

What DYNAMIPS is NOT?

- Doesn't emulate Voice interfaces:
 - No VICs
 - No VWICs
 - You could still connect real IP phones to the PC running DYNAMIPS and test SRST and CME.

What is DYNAGEN?

- Front-end for DYNAMIPS
- Written in PYTHON
- Developed by Greg Anuzelli
- DYNAMIPS+DYNAGEN should always be used together
- DYNAMIPS is just one executable file, DYNAGEN has several files and a folder structure.
- DYNAGEN has a simple CLI interface to start, stop routers.
- DYNAGEN uses MAP file to create network topology

What is DYNAGEN?

- Requires WINPCAP 4.0 (Windows)
 - <http://www.winpcap.org/>
- Requires LIBCAP (Linux)
 - preinstalled
- Includes virtual Ethernet switch
- Includes virtual Frame-Relay switch
- Includes virtual ATM switch
- Can tie virtual router interfaces to PC's NICs

What is DYNAGEN?

- Latest version 0.11.0 (beta), 0.10.1 (stable)
- DYNAGEN website
 - <http://dynagen.org/>
- Download from
 - http://sourceforge.net/project/showfiles.php?group_id=160317
 - OSX and Windows DYNAGEN packages include DYNAMIPS
 - For LINUX, download DYNAGEN and DYNAMIPS separately
- Correlate DYNAGEN and DYNAMIPS versions, latest DYNAGEN requires latest DYNAMIPS.

Installing DYNAMIPS/DYNAGEN Windows 2000 and XP

- Download and install WinPcap 4.0
 - <http://www.winpcap.org/>
- Download and install DYNAMIPS+DYNAGEN Windows Installer Package (3.69MB) straight from:
 - http://sourceforge.net/project/showfiles.php?group_id=160317
- Everything is installed into:
 - C:\Program Files\Dynamips

Installing DYNAMIPS/DYNAGEN

Windows 2000 and XP

- C:\Program Files\Dynamips
 - dynamips.exe (814KB) – DYNAMIPS
 - Windows: never have to run this file manually
 - Linux: run this file manually
 - dynagen.exe (45KB) – DYNAGEN
 - Windows: never have to run this file manually
 - Linux: run this file manually
 - dynamips-start.cmd – Windows: starts dynamips.exe **Hypervisor** process locally on TCP port 7200

Installing DYNAMIPS/DYNAGEN

Windows 2000 and XP

- C:\Program Files\Dynamips\images
 - Store here all Cisco IOS images that you are planning on using
 - Download images from www.cisco.com (CCO account required)
 - Cisco IOS .bin file is compressed, it will take a long time for DYNAMIPS to uncompress image for each virtual router.
 - Instead, uncompress .bin file into, for example, .image file. Use unzip.exe or WinRAR to uncompress. WinZIP won't work.

Installing DYNAMIPS/DYNAGEN

Windows 2000 and XP

- C:\Program Files\Dynamips\sample_labs
 - Each folder corresponds to a topology you want to run. It contains:
 - <filename>.net – Dynagen network file (your topology)
 - The rest of the files are created automatically:
 - <router_name>_nvram – NVRAM contents for every router (startup configuration)
 - <router_name>_ram – RAM contents
 - <router_name>_bootflash – Bootflash of the router
 - several other files
 - You can delete them safely (**don't delete _nvram**) files after stopping topology to save harddrive space.
 - all_config_options.txt
 - Lists all possible Dynagen network file options

.NET file – Example 1



Global Parameter

```
ghostios = true # Always set it to true to improve performance. Default is false.
```

Hypervisor Host Parameter

```
# [localhost] or [127.0.0.1] or [PCs_IP_address] (make sure hostname is resolvable)
# This is where dynamips hypervisor is running. Can be on a remote machine.
```

```
[localhost]
```

```
console = 2000 # Optional. Base console port. Default is 2000. (R1 = TCP 2000, R2 = TCP 2001)
```

Router Template Parameter

```
[[7200]]
```

```
# Parameter for all 7200's. You can also specify these parameters under each router.
```

```
image = \Program Files\Dynamips\images\c7200-p-mz.120-32.S6.image
```

```
# Specify RAM size required by the IOS image
```

```
ram = 64
```

```
# Default NPE is NPE200. You can change to NPE 400 with "npe = npe-400"
```

```
# IDLEPC parameter is extremely important, we'll discuss it later
```

```
idlepc = 0x6065bddc
```

```
[[ROUTER R1]]
```

```
# Default router model is 7200, you can change to a different model with a "model = XXXX"
```

```
S1/0 = R2 s1/0
```

Router Parameter

```
[[router R2]]
```

```
# No need to specify connections here, it's already taken care of under R1
```

.NET file – Example 2

ghostios = true

[localhost]

[[7200]]

image = \Program Files\Dynamips\images\c7200-p-mz.123-24a.image

ram = 96

idlepc = 0x60cbe1b8

[[3620]]

image = \Program Files\Dynamips\images\c3620-i-mz.123-23.image

ram = 48

idlepc = 0x603edc84

[[ROUTER R1]]

S1/0 = R2 S1/0

E2/0 = R3 F0/0

[[ROUTER R2]]

E4/1 = S1 1

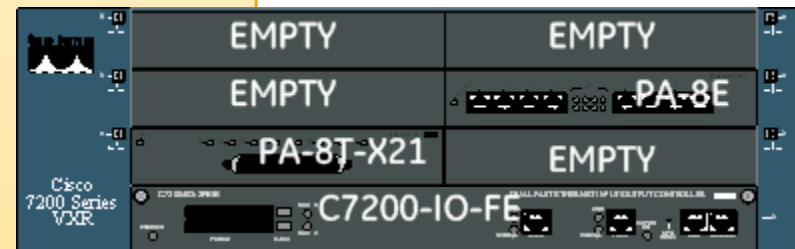
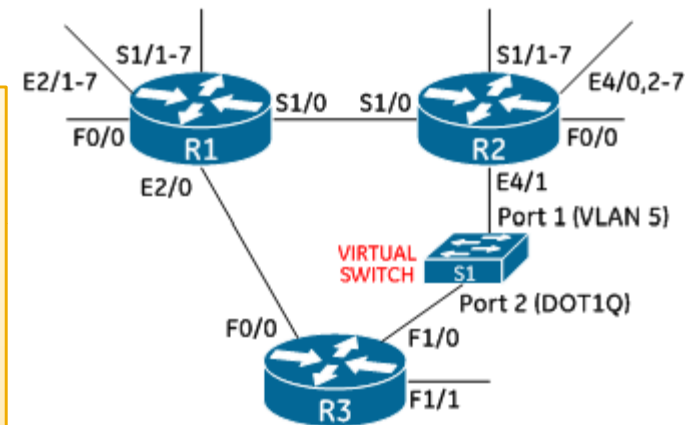
[[ROUTER R3]]

F1/0 = S1 2

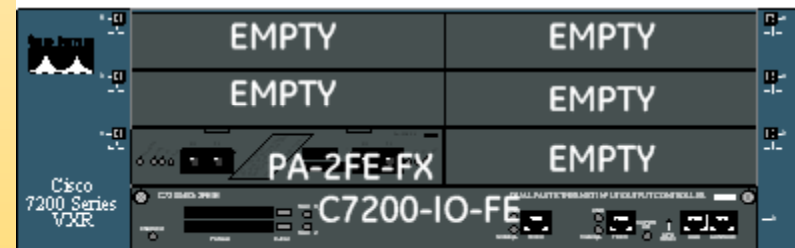
[[ETHSW S1]]

1 = access 5

2 = dot1q 1



R2



R3

.NET file – Example 3

```

autostart = true      # default is true
ghostios = true      # default is false

[192.168.5.6:7201]
console = 2100       # default is 2000
udp = 11000          # default is 10000
workingdir = /var/www/html/dynagen/labs/lab24

[[7200]]
image = /var/www/html/dynagen/images/c7200-p-mz.120-32.S6.image
ram = 64
npe = npe-400
idlepc = 0x6065bd84

[[3620]]
image = /var/www/html/dynagen/images/c3620-is-mz.123-21.image
ram = 64
idlepc = 0x604c9b80

[[ROUTER PE1]]
F0/0 = S1 1
S1/0 = RR S1/0
P2/0 = P P3/0

[[ROUTER PE2]]
F0/0 = S1 2
P2/0 = PE1 P4/0
P3/0 = PE3 P2/0

[[ROUTER PE3]]
F0/0 = S1 3
A1/0 = CE3 A1/0

[[ROUTER PE4]]
F0/0 = S1 4
S1/0 = CE4 S1/0

[[ROUTER PE5]]
F0/0 = S1 5

[[ROUTER PE6]]
F0/0 = S1 6
S1/0 = CE1 S1/0
S1/1 = CE1 S1/1

[[ROUTER RR]]
F0/0 = S1 7

[[ROUTER P]]
F0/0 = S1 8

[[ROUTER CE1]]
model = 3620
F0/0 = S1 9

[[ROUTER CE2]]
model = 3620
F0/0 = S1 10

[[ROUTER CE3]]
F0/0 = S1 11
F2/0 = S1 15
F3/0 = S1 16
F4/0 = S1 18

[[ROUTER CE4]]
F0/0 = S1 12
F3/0 = S1 17
F4/0 = S1 19

[[ROUTER CE5]]
model = 3620
F0/0 = S1 13

[[ROUTER CE6]]
model = 3620
image = /var/www/html/dynagen/images/c3620-is-mz.123-19.image
ram = 64
idlepc = 0x6456ac0
F0/0 = S1 14

[[ethsw S1]]
1 = dot1q 1 # PE1 F0/0
2 = dot1q 1 # PE2 F0/0
3 = dot1q 1 # PE3 F0/0
4 = dot1q 1 # PE4 F0/0
5 = dot1q 1 # PE5 F0/0
6 = dot1q 1 # PE6 F0/0
7 = dot1q 1 # RR F0/0
8 = dot1q 1 # P F0/0
9 = access 111 # CE1 F0/0
10 = access 122 # CE2 F0/0
11 = dot1q 1 # CE3 F0/0
12 = dot1q 1 # CE4 F0/0
13 = dot1q 1 # CE5 F0/0
14 = dot1q 1 # CE6 F0/0
15 = access 133 # CE3 F2/0
16 = access 34 # CE3 F3/0
17 = access 34 # CE4 F3/0
18 = access 43 # CE3 F4/0
19 = access 43 # CE4 F4/0

```

.NET file – Example 4

```

autostart = true
ghostios = true

[127.0.0.1]

  [[7200]]
  image = /var/www/html/dynagen/images/c7200-p-mz.120-32.S6.image
  ram = 64
  npe = npe-400
  disk0 = 0
  disk1 = 0
  idlepc = 0x6065bddc

  [[FRSW FR]]
  3:305 = 5:503
  3:306 = 6:603
  4:406 = 6:604
  4:416 = 6:614
  4:436 = 6:634
  4:446 = 6:644
  4:456 = 6:654
  4:466 = 6:664
  4:476 = 6:674
  5:506 = 6:605

  [[ROUTER R1]]
  E1/0 = R2 E1/0
  E1/1 = R4 E1/1
  E1/2 = R3 E1/2
  E1/3 = CE1 E1/0
  E1/4 = CE4 E1/0

  [[ROUTER R2]]
  E1/1 = R3 E1/1
  E1/2 = R4 E1/2
  E1/3 = CE2 E1/0

  [[ROUTER R3]]
  E1/0 = R4 E1/0
  S2/0 = FR 3

  [[ROUTER R4]]

  S2/0 = FR 4

  [[ROUTER R5]]
  E1/0 = CE3 E1/0
  S2/0 = FR 5

  [[ROUTER R6]]
  image = /var/www/html/dynagen/images/c7200-spservicesk9-mz.124-
15.T1.image
  idlepc = 0x61190280
  ram = 192
  E1/0 = CE5 E1/0
  E1/1 = BB1 E1/0
  S2/0 = FR 6

  [[ROUTER CE1]]
  E1/1 = CE2 E1/1
  E1/2 = CE4 E1/2

  [[ROUTER CE2]]

  [[ROUTER CE3]]
  E1/1 = CE5 E1/1

  [[ROUTER CE4]]
  E1/1 = CE5 E1/2

  [[ROUTER CE5]]
  #image = /var/www/html/dynagen/images/c7200-js-mz.123-24a.image
  #idlepc = 0x607595e8
  #ram = 96
  image = /var/www/html/dynagen/images/c7200-spservicesk9-mz.124-
15.T1.image
  idlepc = 0x61190280
  ram = 128

  [[ROUTER BB1]]
  model = 3620
  image = /var/www/html/dynagen/images/c3620-is-mz.123-21.image
  ram = 64
  idlepc = 0x604c9b80

```


Running DYNAMIPS/DYNAGEN Windows 2000 and XP

- Launch **dynamips-start.cmd**
 - If you need to launch it with a non-7200 TCP port, make a copy of dynamips-start.cmd and modify “-H” parameter
 - Dynamips Hypervisor is now running and ready to accept commands from Dynagen
- Launch your **topology.net** file in Dynagen
 - It will launch Dynagen with your topology and provide you with Dynagen CLI

Installing DYNAMIPS/DYNAGEN Linux

- Run on any Linux distribution
- Best performance with Ubuntu Server (not Ubuntu Desktop)
- Download Dynagen and Dynamips
 - http://sourceforge.net/project/showfiles.php?group_id=160317
- You need to know Unix to know how to install everything
- .net file image parameter will look different, example:
 - image = /opt/dynagen/images/c7200-p-mz.120-32.S5.image

Running DYNAMIPS/DYNAGEN Linux

- Launch DYNAMIPS Hypervisor in the background
 - `./dynamips -H 7200 &`
- Launch DYNAGEN topology
 - `./dynagen labs/mytopology/topology.net`
 - If you are connected remotely to Linux and you want to close the session and continue running your topology, then you can launch your topology in the background. Specify "&" at the end of the command. **Make sure you don't have "autostart = false" configured in the .NET file.**
- Kill DYNAMIPS process
 - `ps aux | grep dyna`
 - `kill -9 <PROCESS_ID>`

System Requirements

- At least Intel Core 2 Duo (or AMD equivalent)
 - Don't try this on Intel Celeron processor
- Have at least 2GB of RAM
 - with 1GB you could run around 5 routers
- Performance depends on three things:
 - How much RAM each router is configured for in the .net file
 - How “good” the **idlepc** value is. If it's bad, your CPU will be at 60-100% for just one router.
 - When you start turning on more features on the routers (BGP, multicast, accounting, MPLS, OSPF, IS-IS), the CPU starts to rise, but not by much.

System Requirements

- Windows XP/VISTA
 - You won't run as many routers as on Linux
 - It's better to have at least 2GB of RAM
 - Performance on Vista is even worse
 - Dynamips on Windows is unstable, it can easily crash after running for a few hours
 - Not suitable for running remotely
 - It's ok for quick testing of IOS features, or studying for couple of hours

System Requirements

- Linux
 - Tested on Linux RedHat, Linux Fedora Core, Linux Ubuntu Desktop, **Linux Ubuntu Server edition**
 - **Best performance on Linux Ubuntu Server edition**
 - Free <http://www.ubuntu.com/getubuntu/download>
 - Linux Ubuntu Server edition **idle memory usage is <100MB**
 - Linux Ubuntu Desktop **idle memory usage is around 800MB** (because of XWindows and other components)
 - **Perfect for remote studying. It can run for weeks without crashing.**
- You must have a good balance of CPU and Memory. Most powerful CPU is not needed, because your memory will probably max out before CPU does.

System Requirements

- Windows XP (Laptop)
 - Intel Core 2 Duo and 1 GB of RAM
 - 5-6 routers

- Low cost remote (PC)
 - PC with Intel Core 2 Duo and 2 GB of RAM
 - 15 routers

- Extreme (Server)
 - Server with dual 4-core Intel Xeon 3.0GHZ (combined 24Ghz)
 - 16 GB of RAM
 - 170 routers
 - Utilization: 16GB of RAM and CPU 24% with base IOS config

Let's try it!!

- Install Dynamips/Dynagen
- Download IOS image
- Download and install SecureCRT 6.0
- Configure .net as in Example 1
- Run Dynamips
- Run .net file
- Telnet to R1 port 2000 and R2 port 2001

IDLEPC value

- Parameter which helps Dynamips to emulate virtual router's idle CPU state
- Without it or with an incorrect value...
 - ... your PC's CPU will run at around 60-100% for just one router (dependant on how powerful your PC's CPU is)
- With the correct value...
 - ... your PC's CPU will run at 1-10% for just one router (dependant on how powerful your PC's CPU is)

IDLEPC value

- This value is **tied** to the IOS image you are using (and obviously Router's model)
 - If you change IOS image release (even from 12.0.32S5 to 12.0.32S6), you need a new idlepc value.
- This value is **tied** to the version of Dynamips
 - If you change dynamips/dynagen version, you might need to find a new good idlepc value for each IOS image. Usually, it doesn't change between RC released.
- This value is **not tied** to the PC you are using, or how much RAM you have, or what OS you are running
 - You can copy the topology to another PC and/or OS, and be sure that your idlepc value is still good.

IDLEPC value

- How to find it?
 - Create a topology with **one router** running IOS image for which you are trying to find good idlepc value.
 - ... or use existing multi-router topology, but **disable autostart** in the .net file (autostart = false)
 - **Make sure** .net file doesn't already specify the idlepc value (comment it out)
 - Run topology and access Dynagen CLI
 - In Dynagen CLI, **start one router**, if it's not already started.
 - **Watch your PC CPU**, it should get up to 60-100% (use command "top" in Linux)

IDLEPC value

- How to find it?
 - Make sure only one router is running
 - Telnet to this router, and get to the Router's console prompt where you can type commands (don't proceed if the router hasn't finished booting)
 - In Dynagen CLI, run command:
 - `idlepc get <ROUTER_NAME>`

IDLEPC value

- How to find it?
 - You will get about 10 possible values that look like this:

```
=> idlepc get R1
Please wait while gathering statistics...
  1: 0x607f83d0 [70]
  2: 0x607f8fc4 [41]
  3: 0x607f8ffc [23]
  4: 0x607f9000 [34]
  5: 0x60712df4 [64]
  6: 0x60712e88 [25]
  7: 0x60712e98 [34]
  8: 0x6089b8d4 [29]
  9: 0x6089b8d8 [25]
* 10: 0x607f5d10 [54]
Potentially better idlepc values marked with "*"
Enter the number of the idlepc value to apply [1-10] or ENTER for no change:
```

IDLEPC value

- How to find it?
 - You can potentially ignore values with *, because most other non-* values are good, too.
 - There're total of about 30 possible idlepc values for each IOS image. Running "idlepc get R1" several times will result in a different, but similar list.
 - Most values are "bad", they will result in no change of your PC CPU.
 - **Other "good" idlepc values will result in your PC CPU utilization drop from around 60-100% to 2-10%**
 - There are some "super" idlepc values (not for all IOS images) that will result in a PC CPU utilization even lower than with "good" idlepc value.

IDLEPC value

- How to find it?
 - Apply one of the idlepc values from the list
 - Watch your PC CPU. Did it drop? By how much?
 - Exit, and run topology again, run “idlepc get <ROUTER_NAME>” command again.
 - Repeat until you find good idlepc value
 - Once you find it, copy paste it into .net file
 - Repeat for every IOS image you are using in your topology

Performance tips

- Try to use IOS image with smallest RAM requirements that has just enough features you need
 - Don't use 12.4T if you don't need it (256RAM), try using 12.3 (128RAM), or 12.0S (64RAM).
- If one router with good idlepc value is using 10% of CPU, then you can run maximum of 10 routers with that IOS image (but 9 is better), until performance drastically hinders.

Performance tips

- In previous example, if you only have 1GB of RAM, then your RAM will max out before you even get to 10 routers.
 - watch your RAM usage
 - Windows: task manager, performance, physical memory available
 - Linux: top
 - Once there's not enough RAM, it will start using page file (linux: swap partition), and CPU utilization will start growing at faster rate. Router CLI will become slow, routing IGP and BGP sessions will start flapping.

Performance tips

- After you start a topology, your CPU utilization will be high.
- Connect to every router and get to Router> prompt by hitting <enter> a few times
- Once you get a prompt on every router, CPU utilization will drop.
- Configure “exec-timeout 0 0” under “line con 0” to prevent consoles from timing out which will cause CPU to go back to 100% until you reconnect to every router.

Recommended base IOS config

- You can use the following base IOS config for every router in your topology.

```
no ip domain-lookup
hostname XXXX
!
line con 0
  exec-timeout 0 0
  privilege level 15
  logging synchronous
```

Multiserver

- You can run one topology on several PCs.
 - It's a simple way to distribute processing if not enough RAM or CPU on one PC.

```
[192.168.0.1] # Windows XP PC

[[7200]]
image = \Program Files\Dynamips\images\c7200-ik9o3s-mz.122-15.T17.image
ram = 96

[[ROUTER R1]]
# Connect to s1/0 on R2 running on a different server
s1/0 = R2 s1/0

[192.168.0.2] # Linux server
workingdir = /home/user/labs/mytopology

[[7200]]
image = /opt/7200-images/c7200-ik9o3s-mz.122-15.T17.image
ram = 96

[[ROUTER R2]]
```

Multitopology on one server

- You can run multiple topologies on one PC
 - Start several dynamips hypervisor instances (7200, 7201, 7202, etc.)
 - Configure a separate folder for each topology
 - .net file and nvram files can be the same in each folder
 - only make the following change in every .net file, X is the dynamips instance number:

```
[localhost:720X]  
console = 2X00  
udp = 1X000
```

NIC

- You can connect Router interface or virtual Ethernet switch port to a NIC on a PC.
 - run **Network device list.cmd** to find NIC name

```
NIO_gen_eth:\Device\NPF_GenericDialupAdapter
Description: Adapter for generic dialup and VPN capture

NIO_gen_eth:\Device\NPF_{8845110C-0C09-4157-98D5-109CA18D75E1}
Name       : Local Area Connection
Description: NVIDIA nForce MCP Networking Adapter Driver
```

```
[[ROUTER R1]]
E1/0 = NIO_gen_eth:\Device\NPF_{8845110C-0C09-4157-98D5-109CA18D75E1}

[[ETHSW S1]]
1 = dot1q 1 NIO_gen_eth:\Device\NPF_{8845110C-0C09-4157-98D5-109CA18D75E1}
```