

## **How to teach computer networks using simulation software**

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The abbreviation ICT (Information and Communication Technology) is very often used as a synonym for term IC (Information Technology). However, its meaning is much wider, because it does not describe only information technologies, but also characterizes relations between them and telecommunication technologies. The main idea of ICT is the unified communication, which means the integration of many different services such as transmission of computer data, voice and video through the one unified network (Dye, 2007). A modern implementation of these assumptions is a very complicated task and requires well-educated specialists. On the other hand the increasing number of computer networks and their growth have created a shortage of people which are able to design, construct and administrate such telecommunication infrastructures. Therefore computer networks are one of the most interesting subject to study for people who would like to improve their technical skills and broaden career prospects.

The increasing complexity of modern telecommunication systems causes difficulties in both teaching and learning computer networks. Students have to learn theories and specifications of different technologies but also need to practise configurations of specialized routers, switches and wireless access point which are not common devices. Usually such equipment is accessible only during classes and laboratory activities, thus students can use it in limited period of time. Network simulation software can resolve this problem.

Nowadays, there are many different network simulation programs such as CNET (CNET), INET Framework (INET) with OMNeT++ library (OMNeT++) or GNS3 (GNS3) which can be useful for learning computer networks. However, one of the most universal one is Cisco Packet Tracer, which is an advanced tool for simulation and visualization of different aspects of computer networks. This software is widely used by the students participating in

CCNA (Cisco Certified Network Associate) courses offered by Cisco Networking Academy. It allows students to create different types of virtual networks from a small isolated environment consists of a few computers and hubs (Figure 1), to complex unified computer networks with many routers and switches (Figure 2).

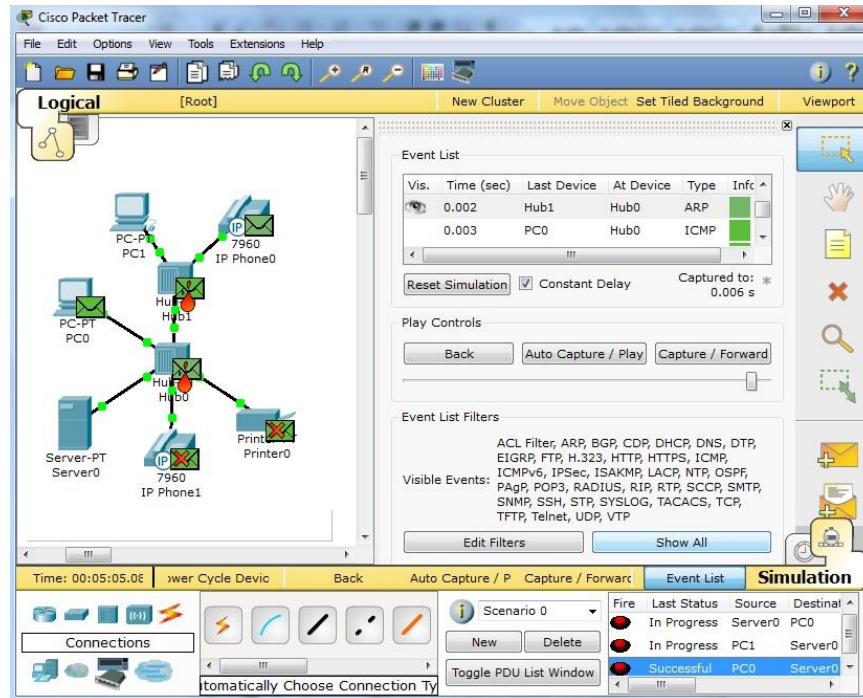


Figure 1: Cisco Packet Tracer, simulation of a small isolated network.

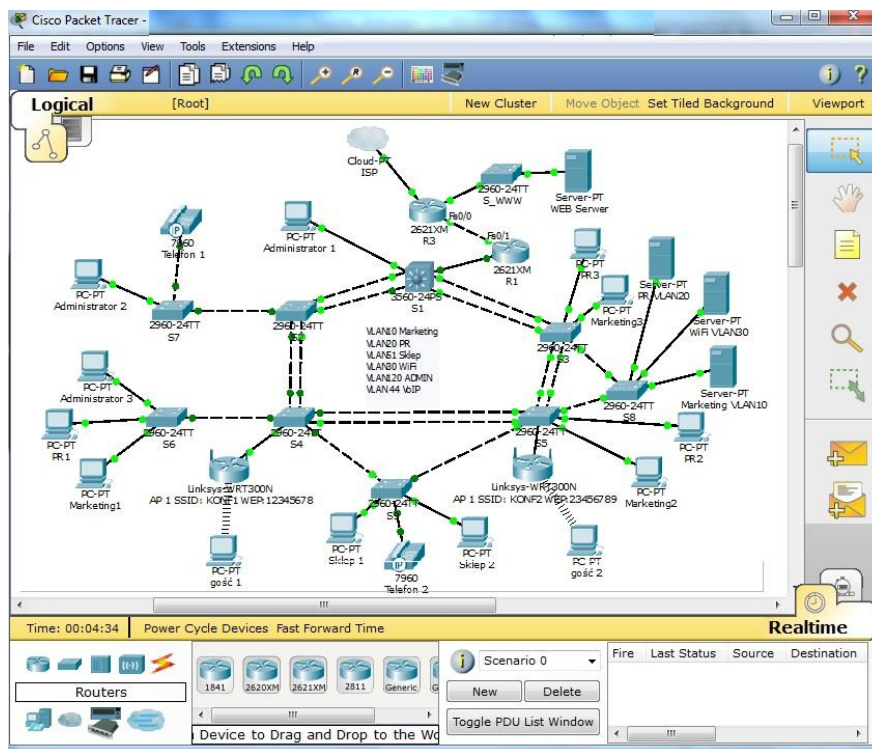


Figure 2: E-laboratory in Cisco Packet Tracer, simulation of an unified computer network.

During e-laboratories students configure network devices, test their capabilities and try to find and resolve all existing problems. Cisco Packet Tracer provides for all simulated devices both the graphical user interface (GUI) (Figure 3) and the command line interface (CLI), typically used by more advanced users (Figure 4).

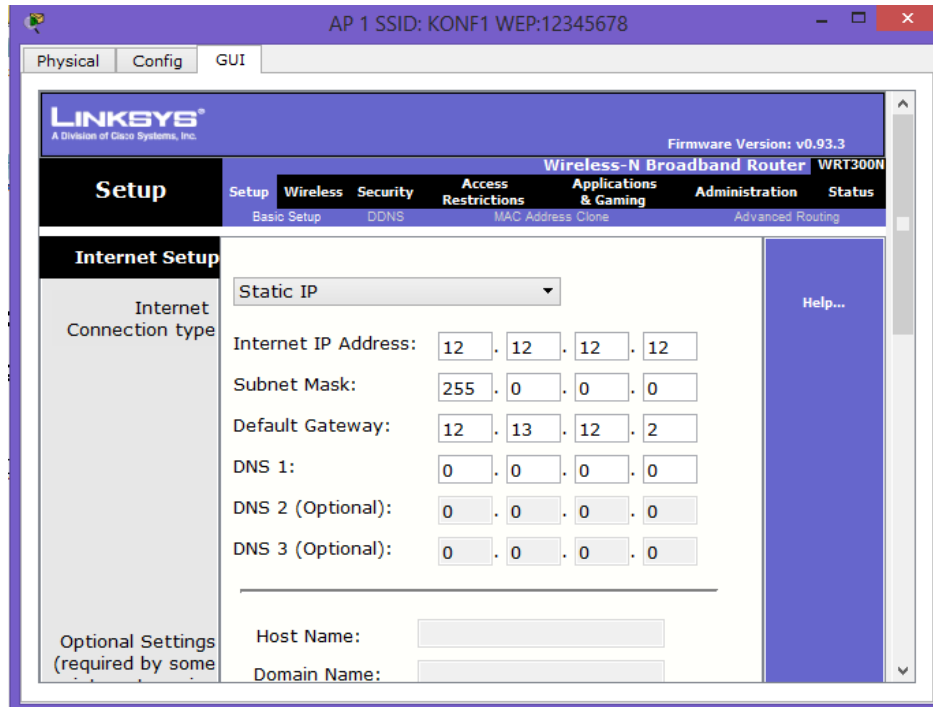


Figure 3: Graphical User Interface (GUI) of the Wireless-N Broadband Router WRT300N in Cisco Packet Tracer.

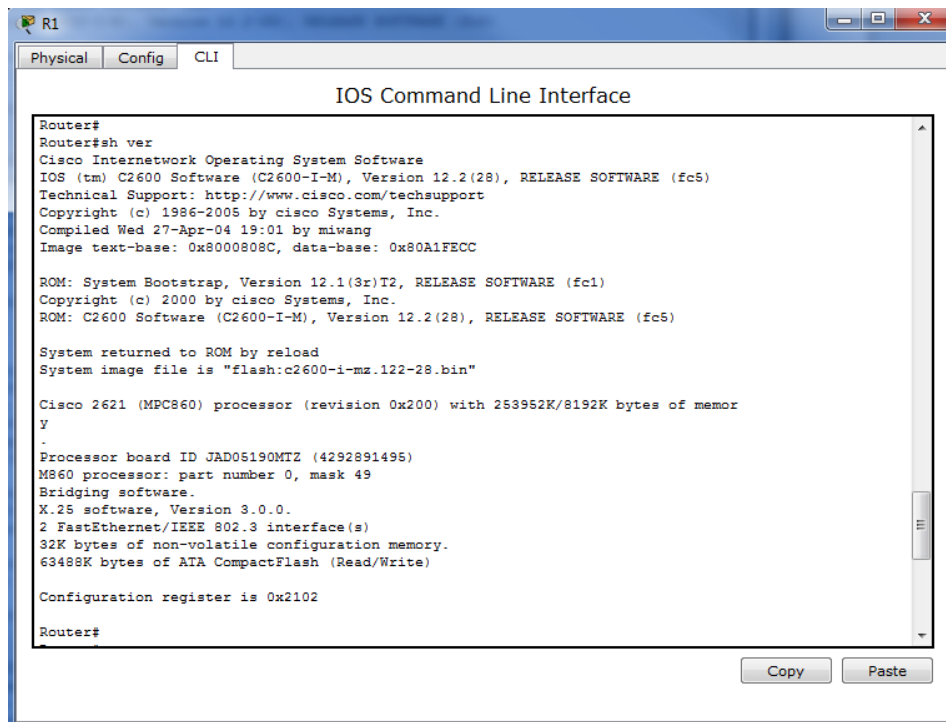
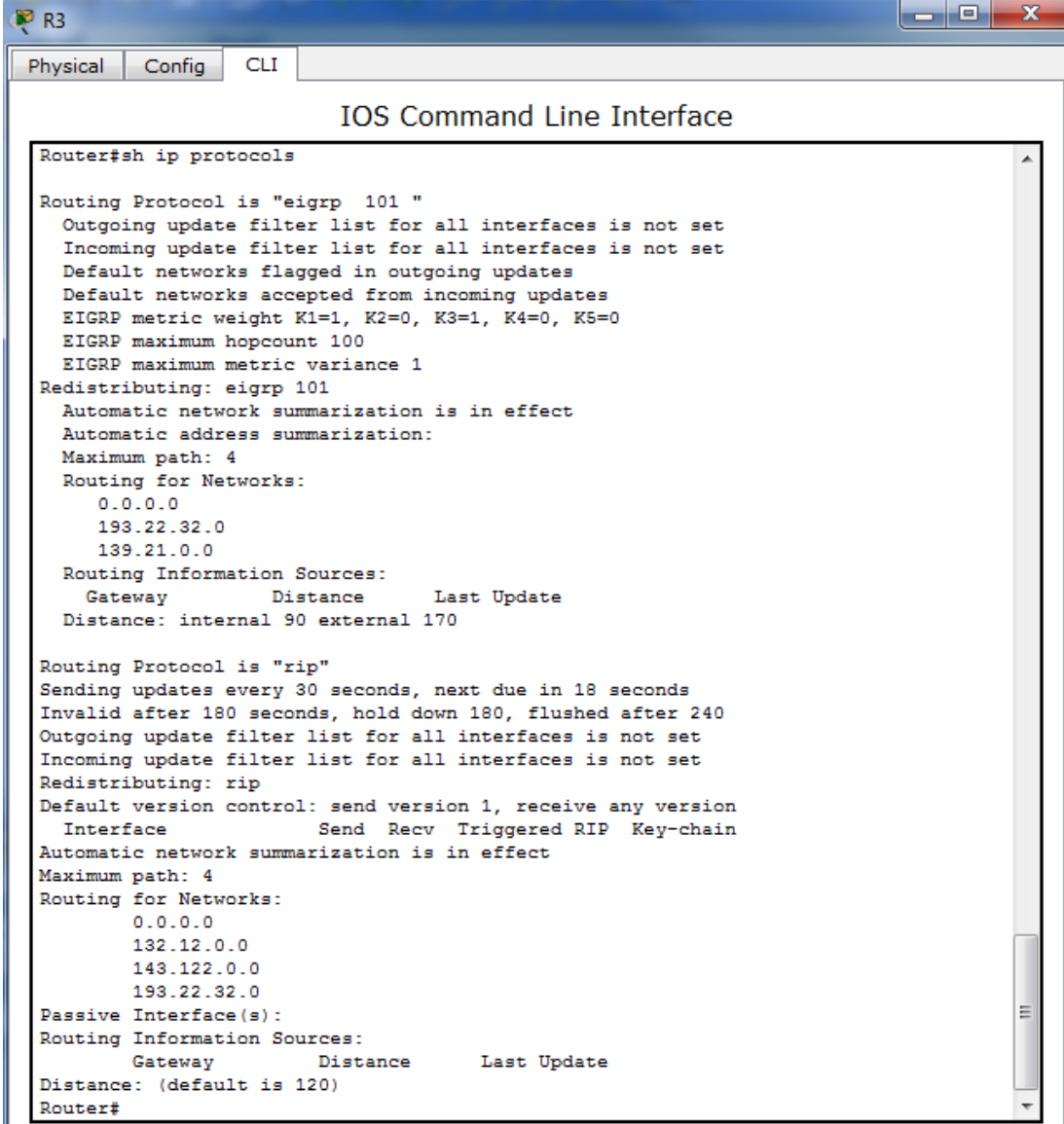


Figure 4: Command Line Interface of the 2620XM Router in Cisco Packet Tracer.

The network devices can be used in different network topologies and configured with various network protocols such as routing protocols (EIGRP, OSPF, RIP) (Figure 5), Vlan Trunking Protocol (VTP) (Figure 6) or Spanning-Tree Protocol (STP) which can be analysed in both Real-time and Simulation mode (Figure 7).

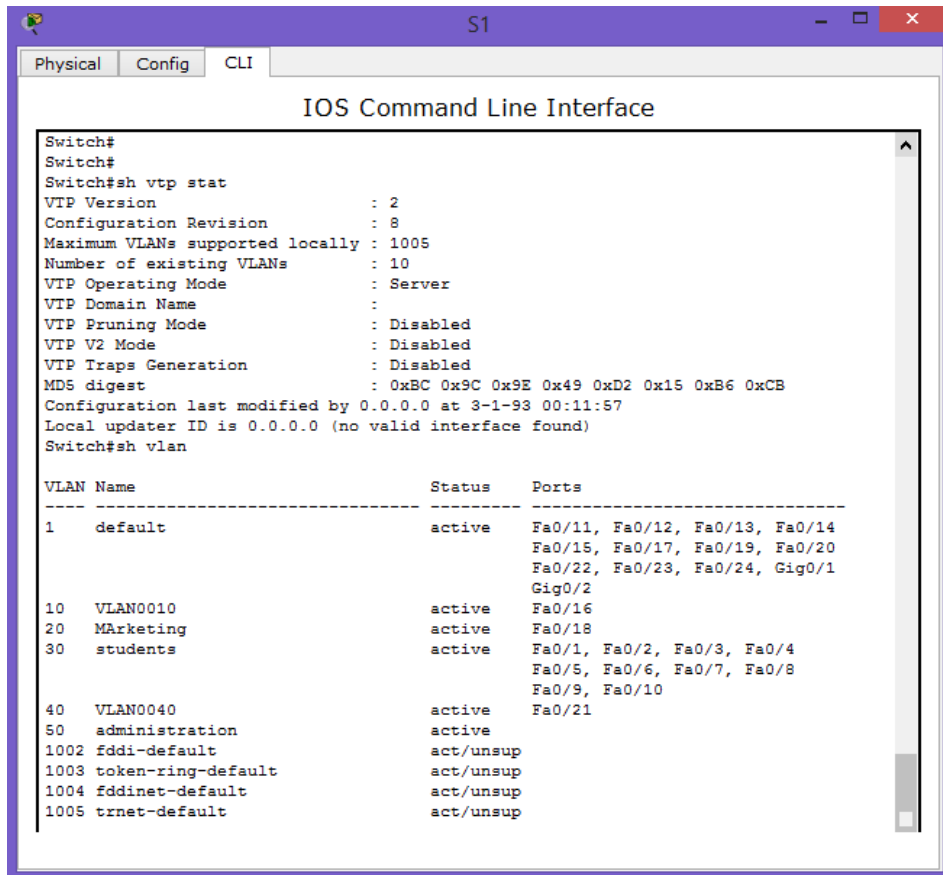


```
Router#sh ip protocols

Routing Protocol is "eigrp 101 "
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Default networks flagged in outgoing updates
  Default networks accepted from incoming updates
  EIGRP metric weight K1=1, K2=0, K3=1, K4=0, K5=0
  EIGRP maximum hopcount 100
  EIGRP maximum metric variance 1
  Redistributing: eigrp 101
    Automatic network summarization is in effect
  Automatic address summarization:
    Maximum path: 4
  Routing for Networks:
    0.0.0.0
    193.22.32.0
    139.21.0.0
  Routing Information Sources:
    Gateway         Distance      Last Update
  Distance: internal 90 external 170

Routing Protocol is "rip"
  Sending updates every 30 seconds, next due in 18 seconds
  Invalid after 180 seconds, hold down 180, flushed after 240
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Redistributing: rip
  Default version control: send version 1, receive any version
    Interface          Send Recv Triggered RIP Key-chain
  Automatic network summarization is in effect
  Maximum path: 4
  Routing for Networks:
    0.0.0.0
    132.12.0.0
    143.122.0.0
    193.22.32.0
  Passive Interface(s):
  Routing Information Sources:
    Gateway         Distance      Last Update
  Distance: (default is 120)
Router#
```

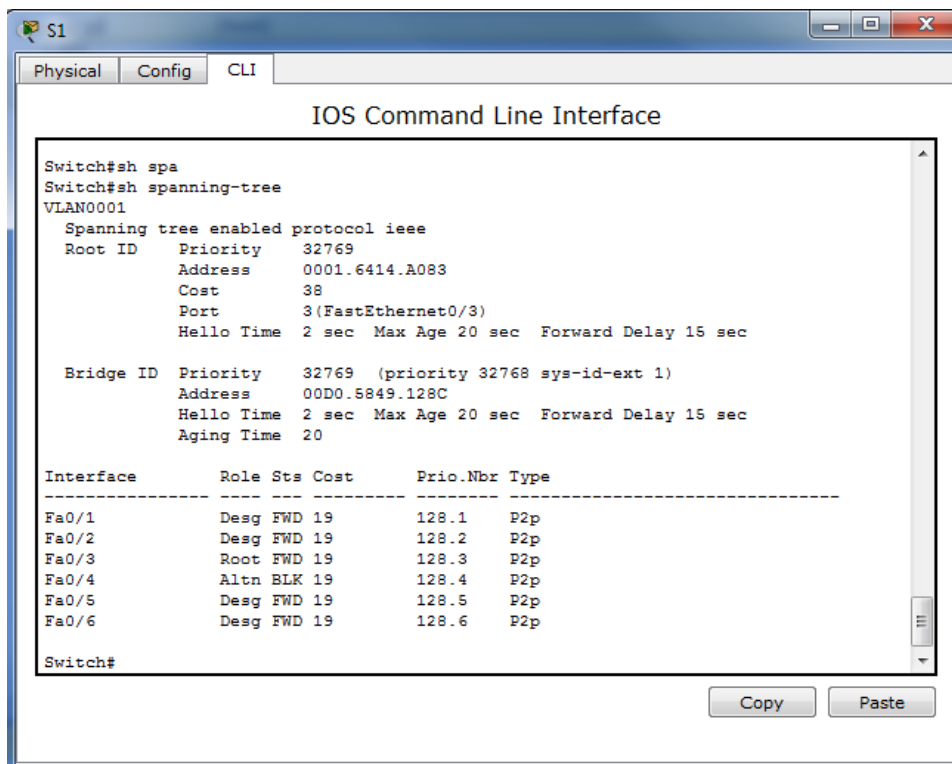
Figure 5: Verification of the configured ip routing protocols (RIP and EIGRP) on the router in Cisco Packet Tracer.



```
Switch#
Switch#
Switch#sh vtp stat
VTP Version : 2
Configuration Revision : 8
Maximum VLANs supported locally : 1005
Number of existing VLANs : 10
VTP Operating Mode : Server
VTP Domain Name :
VTP Pruning Mode : Disabled
VTP V2 Mode : Disabled
VTP Traps Generation : Disabled
MDS digest : 0xBC 0x9C 0x9E 0x49 0xD2 0x15 0xB6 0xCB
Configuration last modified by 0.0.0.0 at 3-1-93 00:11:57
Local updater ID is 0.0.0.0 (no valid interface found)
Switch#sh vlan

VLAN Name                Status    Ports
-----
1    default                 active    Fa0/11, Fa0/12, Fa0/13, Fa0/14
                                           Fa0/15, Fa0/17, Fa0/19, Fa0/20
                                           Fa0/22, Fa0/23, Fa0/24, Gig0/1
                                           Gig0/2
10   VLAN0010                active    Fa0/16
20   Marketing               active    Fa0/18
30   students                active    Fa0/1, Fa0/2, Fa0/3, Fa0/4
                                           Fa0/5, Fa0/6, Fa0/7, Fa0/8
                                           Fa0/9, Fa0/10
40   VLAN0040                active    Fa0/21
50   administration          active
1002 fddi-default             act/unsup
1003 token-ring-default    act/unsup
1004 fddinet-default        act/unsup
1005 trnet-default         act/unsup
```

Figure 6: Verification of the VTP and VLAN's configured on the switch in Cisco Packet Tracer.



```
Switch#sh spa
Switch#sh spanning-tree
VLAN0001
Spanning tree enabled protocol ieee
Root ID    Priority    32769
Address    0001.6414.A083
Cost       38
Port       3(FastEthernet0/3)
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID   Priority    32769 (priority 32768 sys-id-ext 1)
Address    00D0.5849.128C
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Aging Time 20

Interface  Role Sts Cost    Prio.Nbr Type
-----
Fa0/1     Desg FWD 19      128.1   P2p
Fa0/2     Desg FWD 19      128.2   P2p
Fa0/3     Root FWD 19      128.3   P2p
Fa0/4     Altn BLK 19      128.4   P2p
Fa0/5     Desg FWD 19      128.5   P2p
Fa0/6     Desg FWD 19      128.6   P2p

Switch#
```

Figure 7: Verification of the Spanning-Tree Protocol configured on the switch in Cisco Packet Tracer.

Moreover, the universality of this tool enables every teacher to prepare own virtual laboratories with different scenarios, which can also automatically evaluate student's practical skills and knowledge (Figure 8). All these Cisco Packet Tracer capabilities make this simulation software very useful tool for both students and teachers.

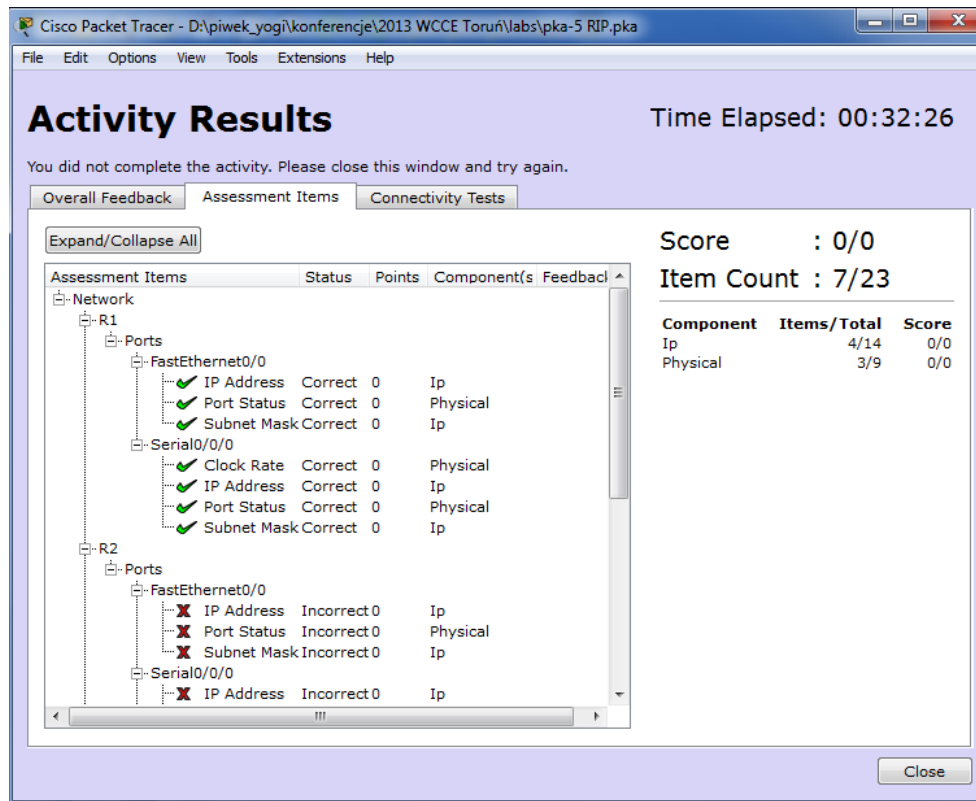


Figure 8: Student result of virtual laboratory activity in Cisco Packet Tracer.

## REFERENCES

- Dye, M. & McDonald, R. & Ruff, A. (2007) Network Fundamentals: CCNA Exploration Companion Guide. Indianapolis, Indiana: Cisco Press
- CNET Network Simulator, <http://www.csse.uwa.edu.au/cnet3/>
- INET Framework project, <http://inet.omnetpp.org/>
- OMNeT++ project, <http://www.omnetpp.org/>
- GNS3 graphical network simulator, <http://www.gns3.net/>