Politechnika Łódzka
Instytut Elektroniki

LABORATORY: „TELECOMMUNICATION SYSTEMS & NETWORKS”

PART 1
NCTUNS PROGRAM

INTRODUCTION

1 NCTUns Program In General

NCTUns Program is an extensible network simulator and emulator for teleinformatic networks. NCTUns directly uses the real-life Linux's TCP/IP protocol stack to generate high-fidelity simulation results. By using the novel kernel re-entering simulation methodology, a real life UNIX kernel's protocol stack is directly used to generate high-fidelity simulation results. In NCTUns, all real-life existing or to-be-developed UNIX application programs can be run up on a node in a simulated network. In NCTUns, the configuration and operation for a simulated network are exactly the same as those for a real-life IP network.
NCTUns simulates Ethernet-based IP networks with fixed nodes and point-to-point links. It simulates IEEE 802.11 (a)(b) wireless LAN networks, including both the ad-hoc and infrastructure modes. It simulates GPRS cellular networks. It simulates optical networks, including traditional circuit switching optical network and more advanced optical burst switching (OBS) networks and many more…
NCTUns simulates various protocols such as IEEE 802.3 CSMA/CD MAC, IEEE 802.11 (a)(b)(e)(p) CSMA/CA MAC, the learning bridge protocol used by switches, the spanning tree protocol used by switches, IP, Mobile IP, RIP, OSPF, UDP, TCP, HTTP, FTP, Telnet, etc. It simulates the DiffServ QoS protocol suite, the optical light-path setup protocol, the RTP/RTCP/SDP protocol suite. It simulates the IEEE 802.16(d)(e)(j) WiMAX PMP protocol suites and the 802.16(d) mesh mode protocol suite, and DVBRCST.
A user may add his/her own protocol thanks to the open structure.

2 NCTUns - Getting Started

To start the work with **NCTUns** the student should::

- log in as the user *student* (password: *telekomunikacja* – IN POLISH!);

- start Sun VirtualBox program;

- select Fedora12 virtual engine and start it by pressing ***Uruchom*** button(Fig. 1);

- When Fedora system is starting a window appears with selecting the system kernel; then the student should select the option: *NCTUns (2.6.31.6-nctuns20091227)* and confirm by ***Enter*** (Fig. 2);

- When the system is on, LOG IN as the user *nctuns* (password: *nctuns*);

- Before starting **NCTUns** klient program one should start **dispatcher** and **coordinator** programs, which are in **/usr/local/nctuns/bin/ directory**. To make this one should start terminal (its abbreviation is on the board screen) and perform the command: **./run_nctuns**;

- then one can start **nctunsclient** program that is in **/usr/local/nctuns/bin/ directory**. Its abbreviation is on the board screen;

- When the above steps are completed correctly the GUI of **NCTUns** program appears (Fig. 3).

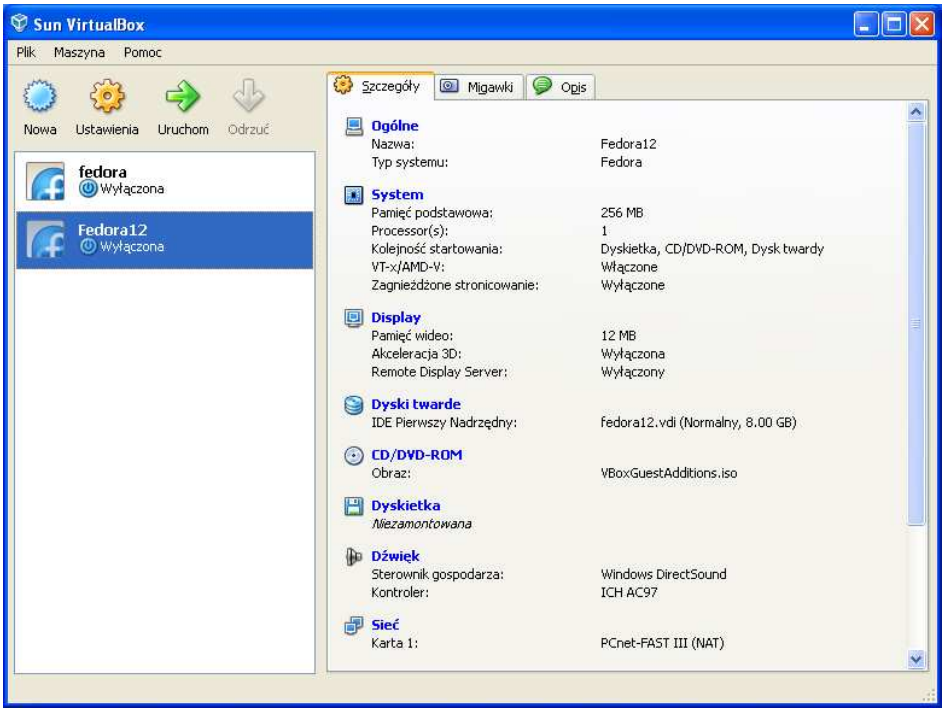

Fig. 1 VirtualBox window – selecting the virtual engine to be started

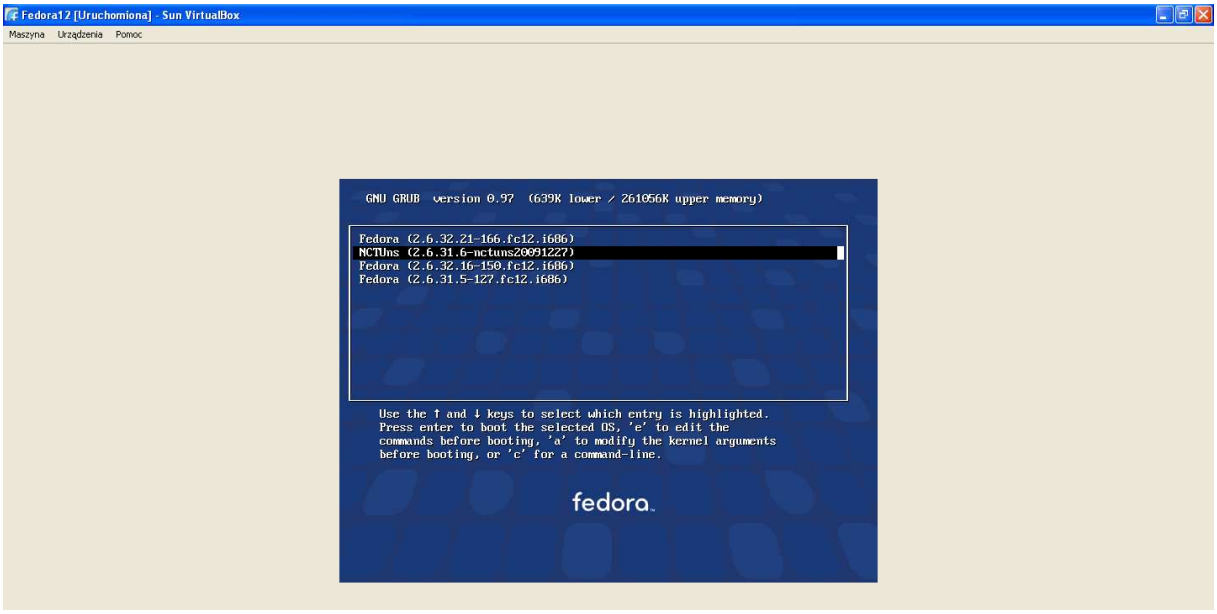

Fig. 2 Selecting the Linux Fedora system kernel

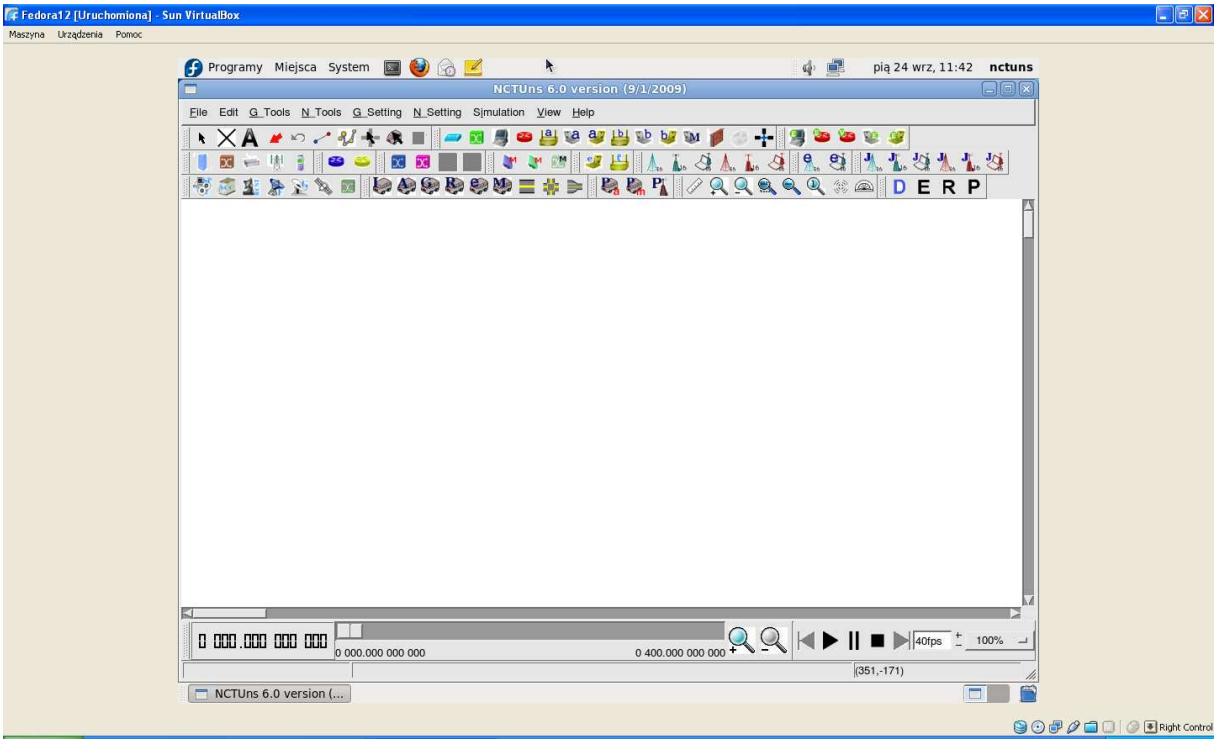

Fig. 3 GUI of NCTUns program

3 Basic Elements of NCTUns program GUI

NCTUns program GIU consists of following elements:

- menu that allows to enter into program functions (Fig. 4 – M);

- tool bars that allow, among others, to define a network topology (icons represent different device classes) or to change the active mode of the program (Fig. 4 – PN);
- work area, where the topology of the analysed network is defined (Fig. 4 – OR);

- status bar, where the information on the run simulation is placed together with press-buttons to control the replay of the simulation results. (Fig. 4 – ST).

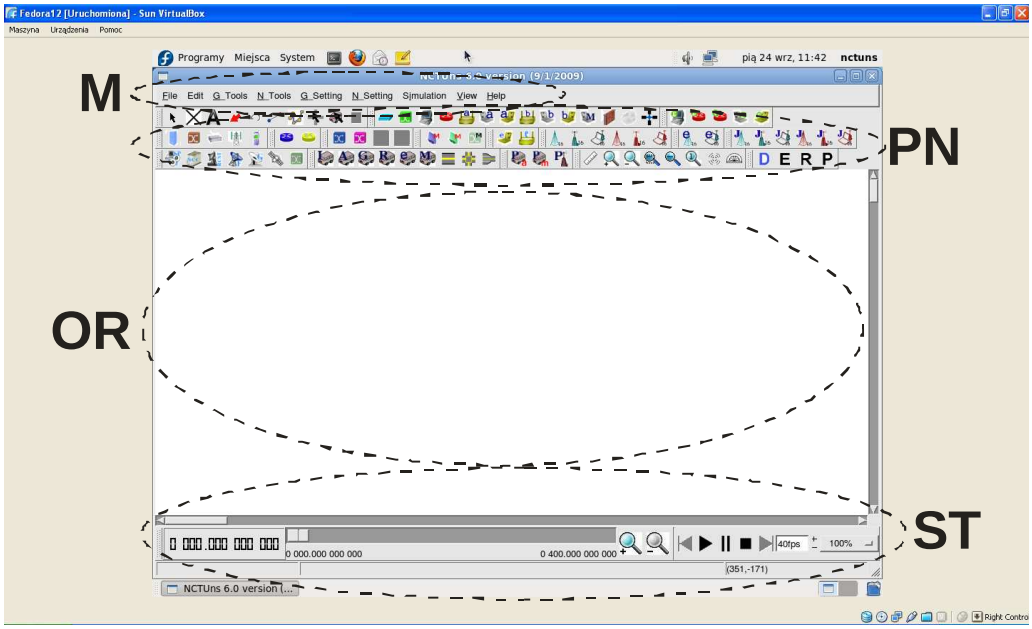

Fig. 4 Main elements of NCTUns program GUI

4 Starting the work with NCTUns program

The projekt work consists of four stages, with them suitable program modes are connected:

- stage No. 1 – network topology editor (***D*** button on the tool bar D E R P or in menu: ***File->Operating Mode->Draw Topology***);

- stage No. 2 - Attribute Dialog Box (***E*** button on the tool bar D E R P or in menu ***File->Operating Mode->Edit Property***);
- stage No. 3 - simulation of the network work (***R*** button on the tool bar D E R P or in menu ***File->Operating Mode->Run Simulation***);

- stage No. 4 – animation plater and simulation results' visualisation (***P*** button on the tool bar D E R P or in menu ***File->Operating Mode->Play Back***).

To open any existing project – one should select menu ***File->Open*** and then indicate the project file (*.tpl*).

To make a new network project – one should select menu ***File->New***. When the new project is initiated, an empty work area appears in the screen, when elements of the modeled network can be put. Make sure that the valid mode is Topology Editor (***D*** button on the tool bar D E R P or in menu ***File->Operating Mode->Draw Topology***) and then select a network element from the tool bar, show the place in the work area with the cursor and press the mouse left button (left-click).

When the topology is defined, the user may enter the next stage where node attributes must be determined. To make this, the program mode must be changed into Editing Nodes' Properties (***E*** button on the tool bar D E R P or in menu ***File->Operating Mode->Edit Property***). When changing the mode the program will ask to indicate the file localization and the name for the project and generate the basic settlements for the network, in these IP addresses for the devices. In this mode one can determine more advanced parameters of the devices' operation, as for example:

- delays and error bit rates in transmitting links;
- applications (traffic generators) operating on indicated nodes;
- routing protocols;
- buffer sizes;
- work parameters to be saved in log files;
- on and off limes of devices;

Editing network nodes' properties can be done in two steps. In the first step, a user can use the mouse to double-click a node's icon. A dialog box will appear in which a user can set parameter values or option values (Fig. 5).

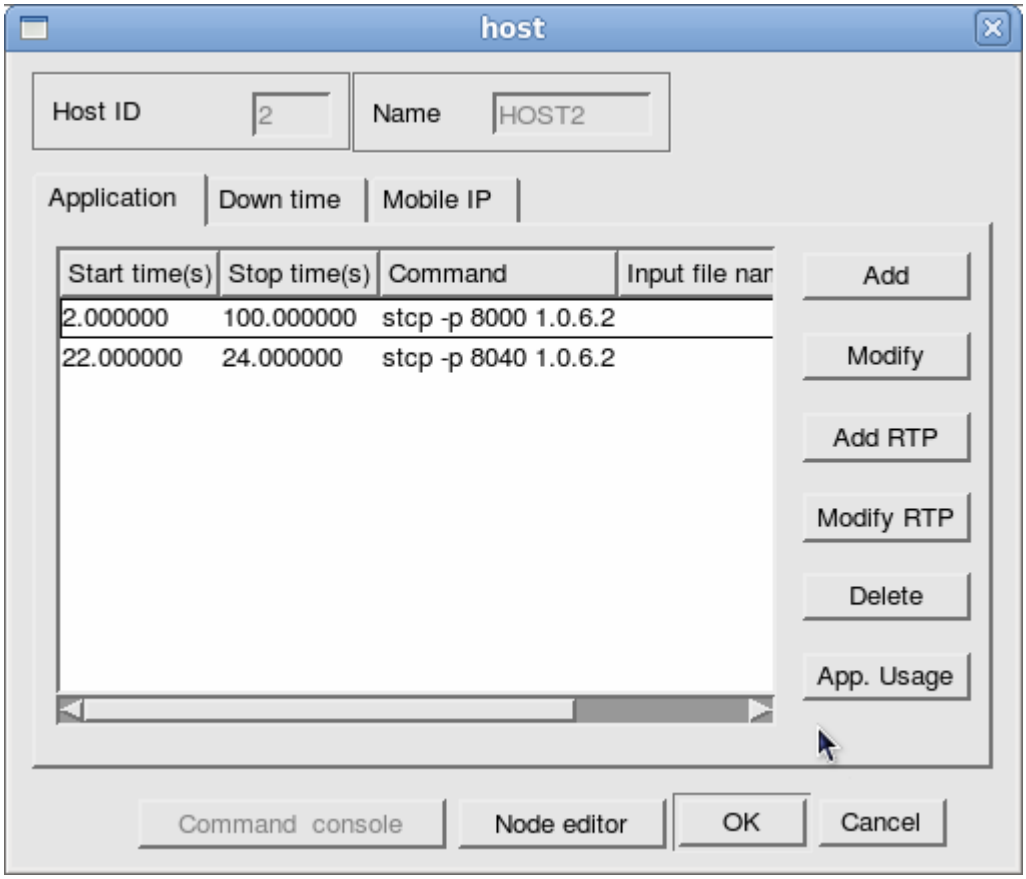

Fig. 5 The window to define node parameters – In this example: *host* – defining applications (traffic generators setting)

Then the user may double-click the ***Node editor*** in the dialog box to hale the access to more advanced setting (Fig. 6). For example by selecting the MAC 802.3 layer box, one can modify IP address of the host and indicate the node work parameters to be saved in log files during the simulation (Fig. 7).

WARNING! Each change of the work modes from editing topology to properties and back, results in generating basic settings of the network from the beginning. As new IP addresses are attributed to the nodes, some other settings may need being changed as well, for example parameters of applications on some nodes.

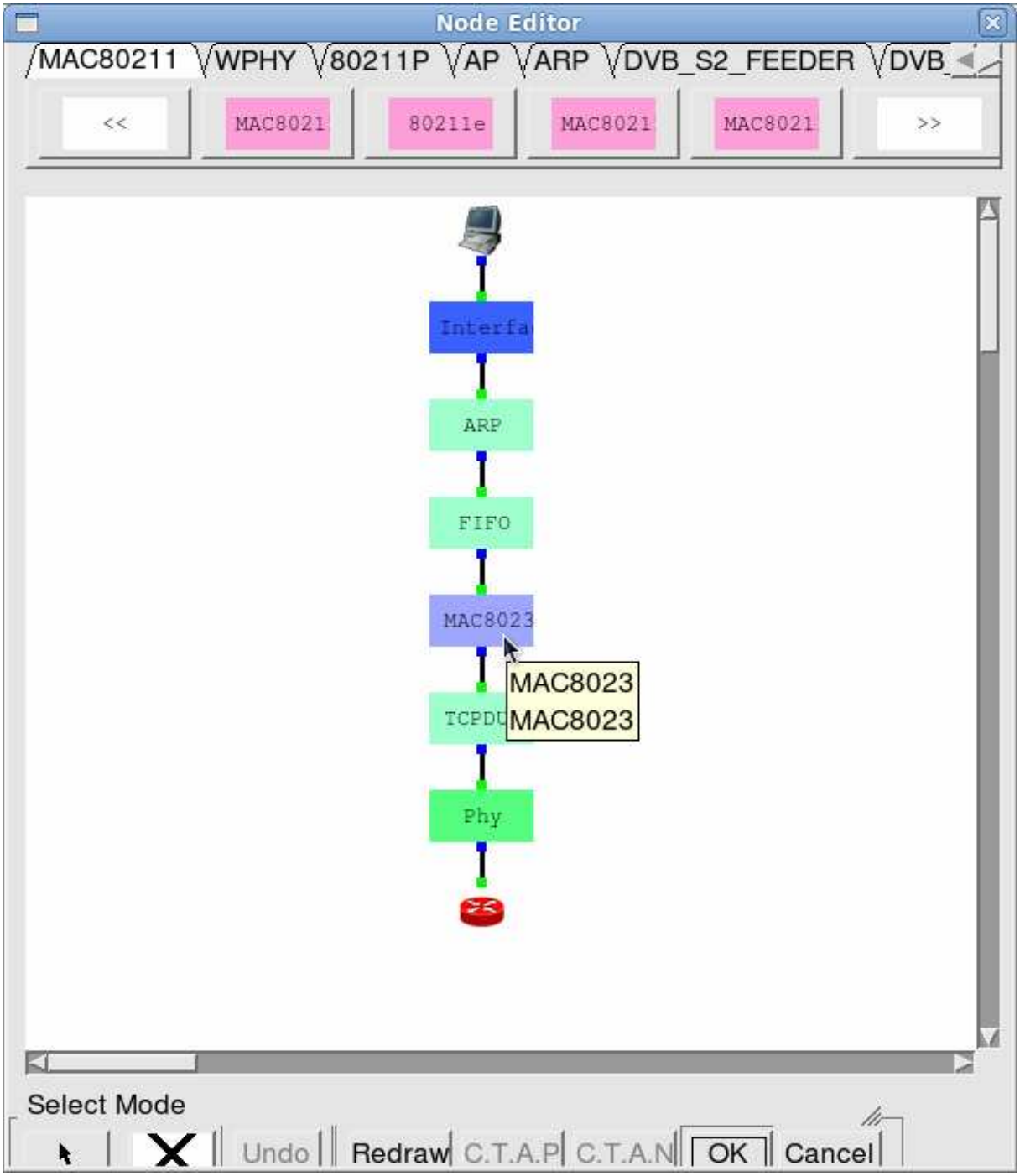

Fig. 6 Access to advanced settings of the network node

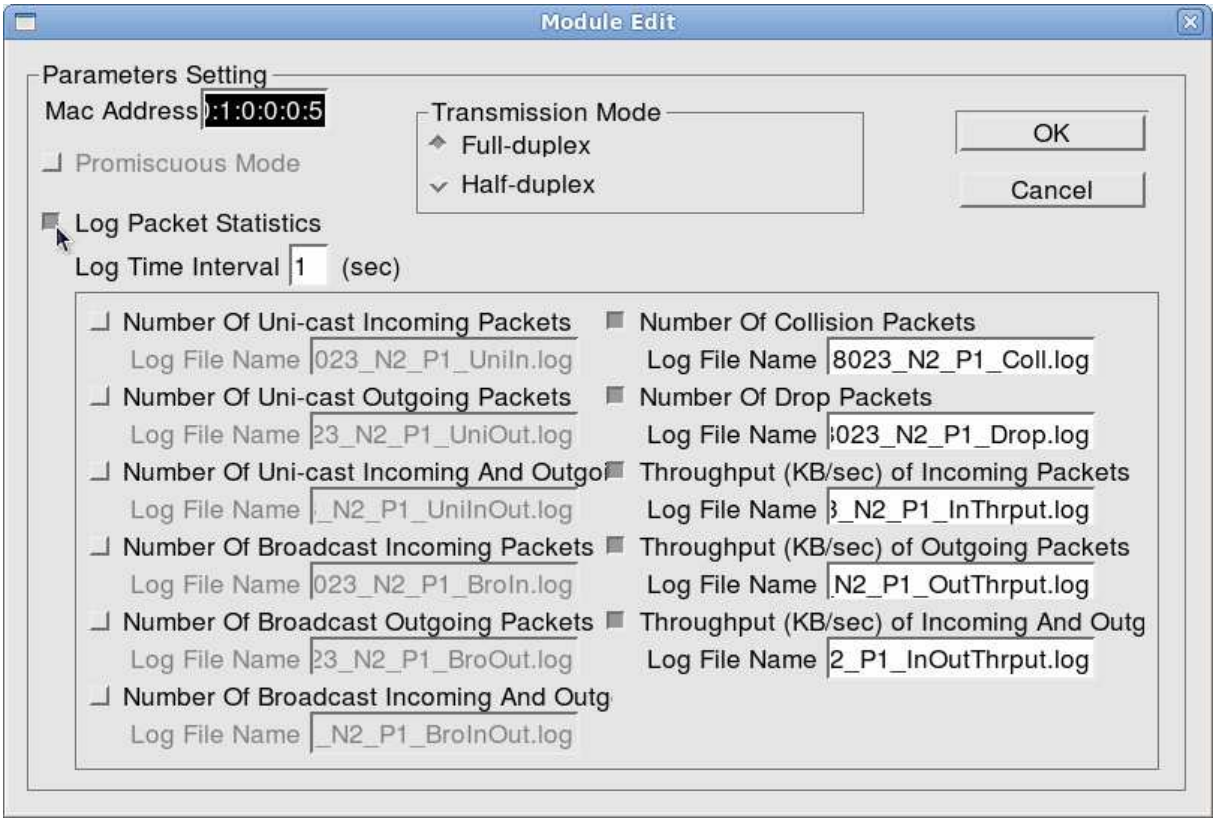

Fig. 7 Selecting work parameters of *host* to save in log files

When a user finishes editing the properties of network nodes and specifying application programs to be executed during a simulation, he (she) can start to run the simulation. To do so, the user must switch the mode explicitly from "Edit Property" to "Run Simulation." (R button on the tool bar D E R P or in menu ***File->Operating Mode->Run Simulation***). Entering this mode indicates that no more changes can (should) be made to the simulation case, which is reasonable. The simulation is about to be started. At this moment, of course, no settings should be changed.

After the simulation is finished, the simulation server will send back the simulation result files to the GUI program and will then automatically switch to the "Play Back" mode (P button on the tool bar D E R P). Then one can open the animation that shows the data flow and plot graphs with selected parameters of the network work parameters versus time (Fig. 8).

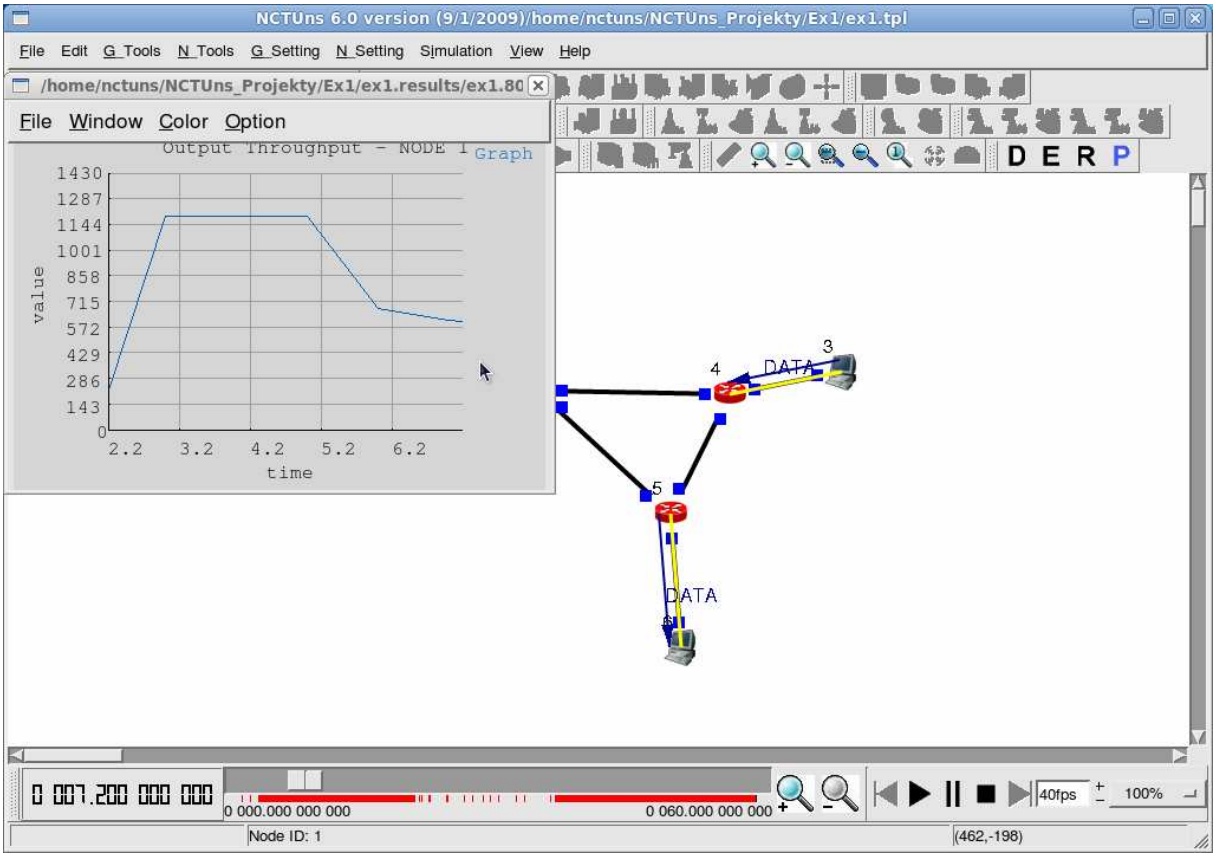

Fig. 8 Visualization of the simulation results – packet animation with the graph of a chosen parameter function versus time

5 Tools to Visualize The Results

During simulation the result file generated by the simulation engine with the events' list is stored automatically. This file is used for the animation to demonstrate the network work then.

When the user defines the network nodes' parameters, he/she may force recording work parameters of selected devices to be stored in suitable log files and being ready to be used in graphs. Here one has the number of lost packets, the number of collisions, link bandwidth etc.

5.1 Log Files

To display the log file that consists information on the packet transfer within the network one should choose the menu ***G_Tools->View Packet Trace*** (Fig. 9). One can see the meaning of successive columns by the menu ***G_Tools->Show Packet Trace Format***.

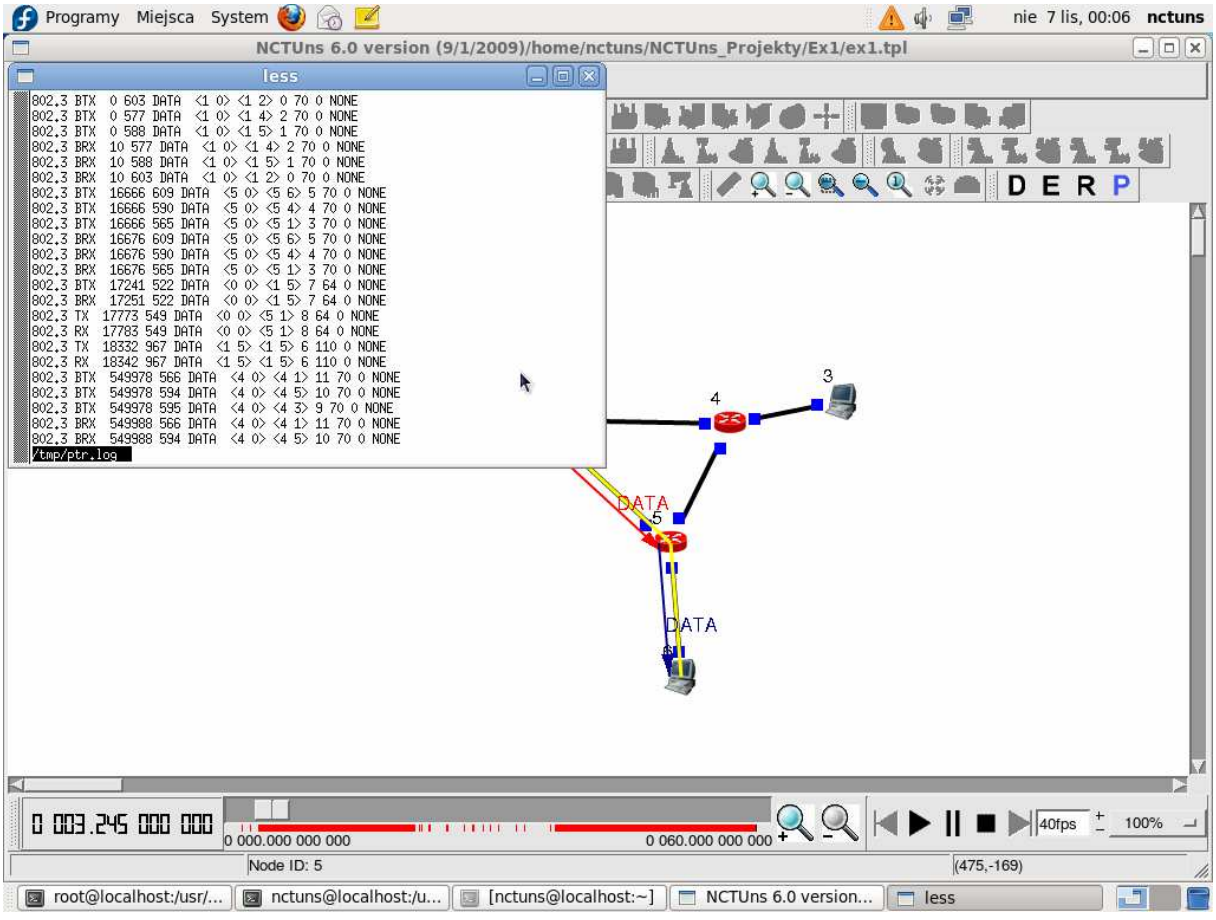

Fig. 9 Log file with information on changed packets of data

5.2 Animation Player

Files with simulation results are used by the animation player that shows the flow of packets in the network (Fig. 10). The player is activated automatically when the program is switched to the simulation results replay mode. The animations may be also switched on when the simulation is running in real time.

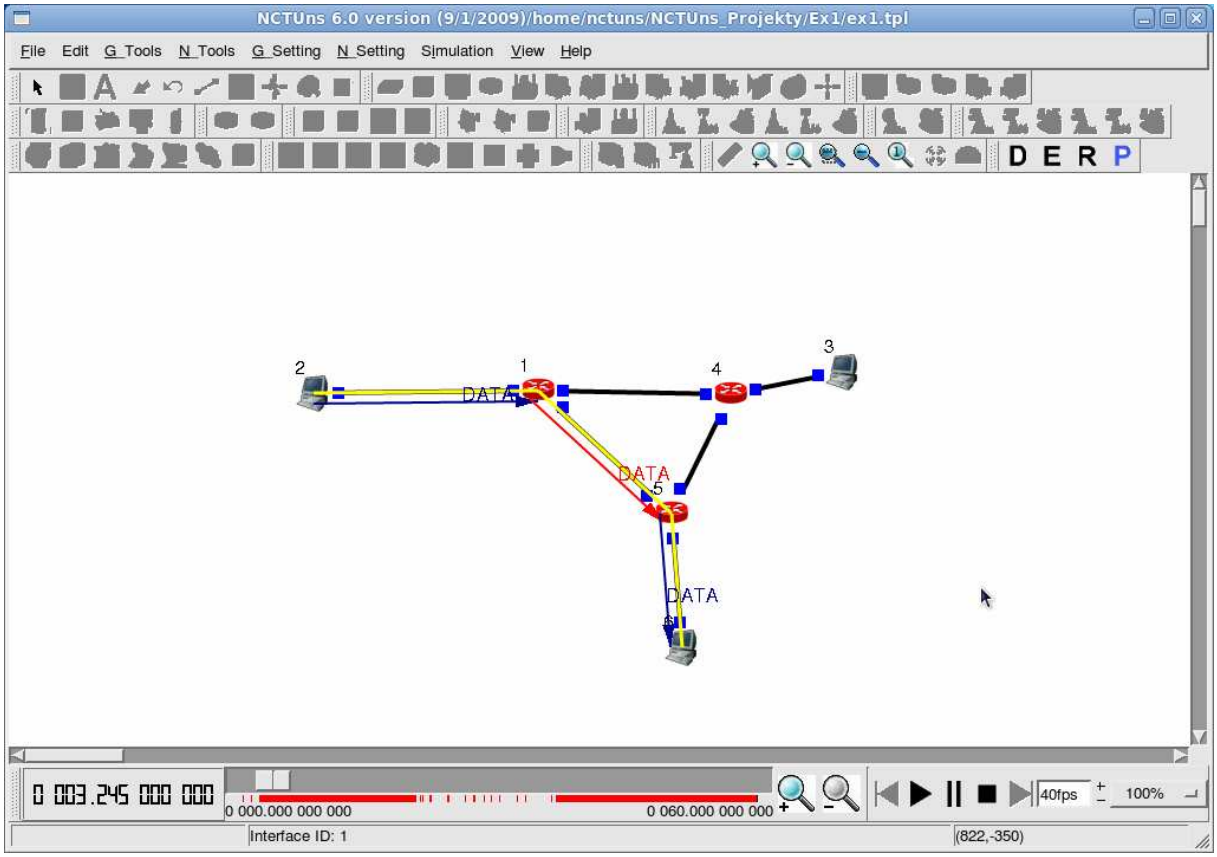

Fig. 10 Packet Animation of data flow in the network

5.3 Performance Monitor

A user can execute the Menu menu ***G_Tools->Plot Graph*** (Fig. 11) command to launch the performance monitor. From the performance monitor window, a user can select (menu ***File->Open)*** a desired log file to open.

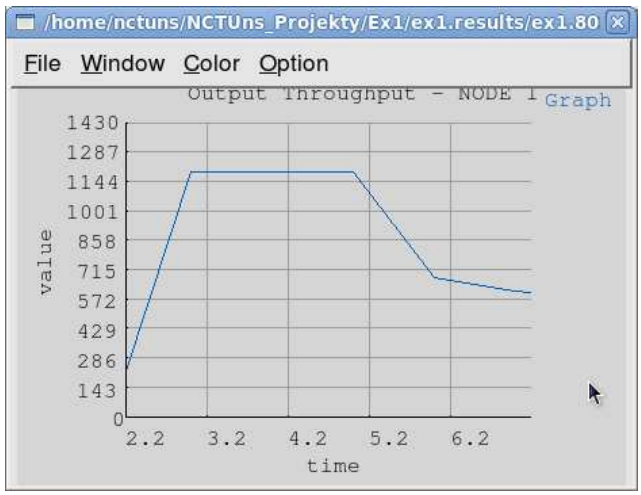

Fig. 11 Example graph with the host bandwidth dependence versus time

6 Emulation of An Example Network Operation

6.1 D – Defining network topology

1. Create a New network project (menu ***File->New***).

2. Make sure that the valid mode is *Drawing* (***D*** button on the tool bar is marked D E R P or in the menu ***File->Operating Mode->Draw Topology***).

3. Select the router symbol on the tool bar and left-click in the work area of the program. As the result the router should be added to the topology and its symbol should be visible in the work area.

4. Select the host symbol on the tool bar and left-click in several (as many times as many hosts one wants to add to the network topology) places in the work area.

5. Select the link icon on the tool bar and keeping the mouse left button pressed, connect network elements one to the other (for example successive hosts with router).
   As the result of 1÷5 steps the network as in Fig. 12 is visible.

6. Save the project file (menu ***File->Save As***).

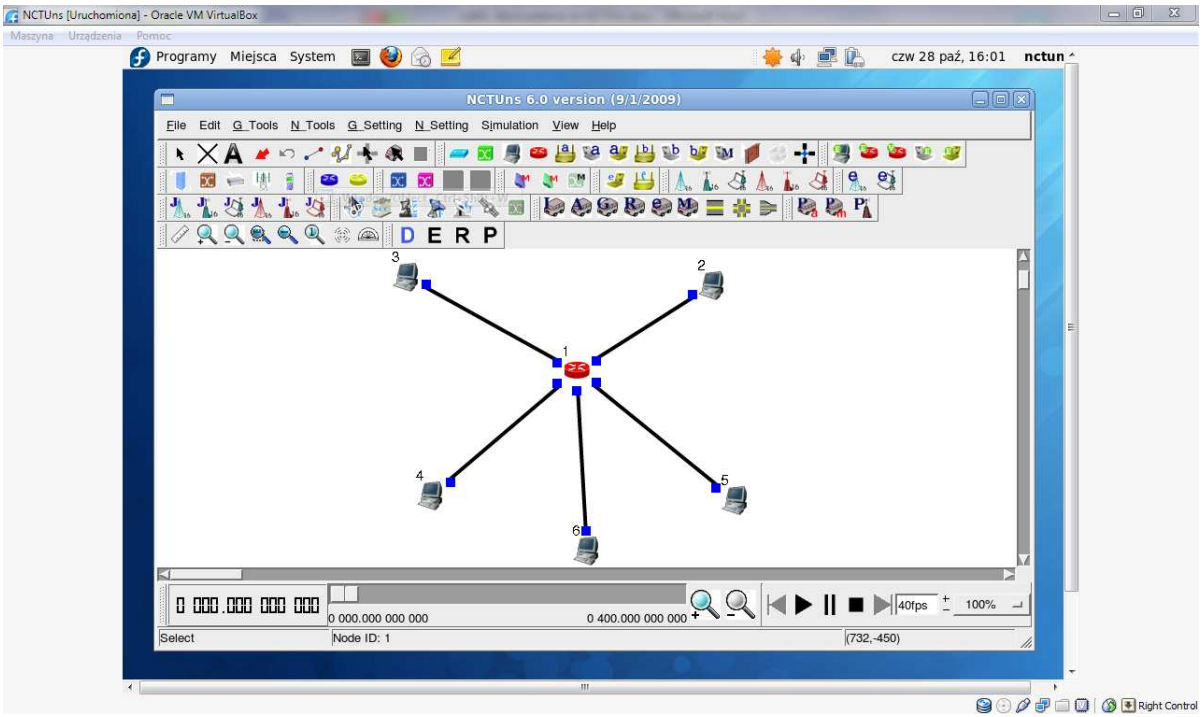

Fig. 12 Example topology of the network that consists of one router and five hosts

6.2 E – Editing parameters of networks elements

1. Switch the program mode into edit property (mark ***E*** button on the tool bar D E R P or in menu ***File->Operating Mode->Edit Property***). At the moment of modes' switching devices addresses will be generated automatically for the defined network. They can be seen when one indicates blue boxes on the links' terminals between successive elements. One can set

many parameters of the devices in this mode, define the traffic characterization, set on and off times, etc. The set of possible parameters depends on a given device type.

2. Double click on the host icon with the IP address 1.0.1.2. In the dialog box choose *Application* and press *Add* button. Write '5' in the box *Start time* and in *Stop time* – '**50'**, in *Command* – **stcp -p 8000 1.0.2.2** (within 5 and 50 second of the simulation the device will send TCP packets to the station addressed 1.0.2.2).

3. Double click on the host icon with the IP address 1.0.3.2. In the dialog box of the device properties choose *Application* and press *Add* button. Write '15' in the box *Start time* and in *Stop time* – '**70'**, in *Command* – **stcp -p 9000 1.0.2.2** (within 15 and 70 second of the simulation the device will send TCP packets to the station addressed 1.0.2.2).

4. Double click on the host icon with the IP address 1.0.2.2. In the dialog box of the device properties choose *Application* and press *Add* button. Write '0' in the box *Start time* and in, *Stop time* – '**100'**, in *Command* – **rtcp -p 8000**. Press *Add* button again. In *Start time* write '0', and in *Stop time* –'100', in *Command* – **rtcp -p 9000** (the device will receive TCP packets on 8000 and 9000 ports).

5. Save the changes in the projects.

6.3 R – Calculations

1. Switch the mode to the emulation of the network (mark ***R*** button on the tool bar 

or in the menu ***File->Operating Mode->Run Simulation***).

2. Check **dispatcher** settings. Select menu ***G_Setting->Dispatcher*** the value **127.0.0.1** should be visible in the *IP address* box in the dialog window and the value **9800** in *Port* (Fig. 13).

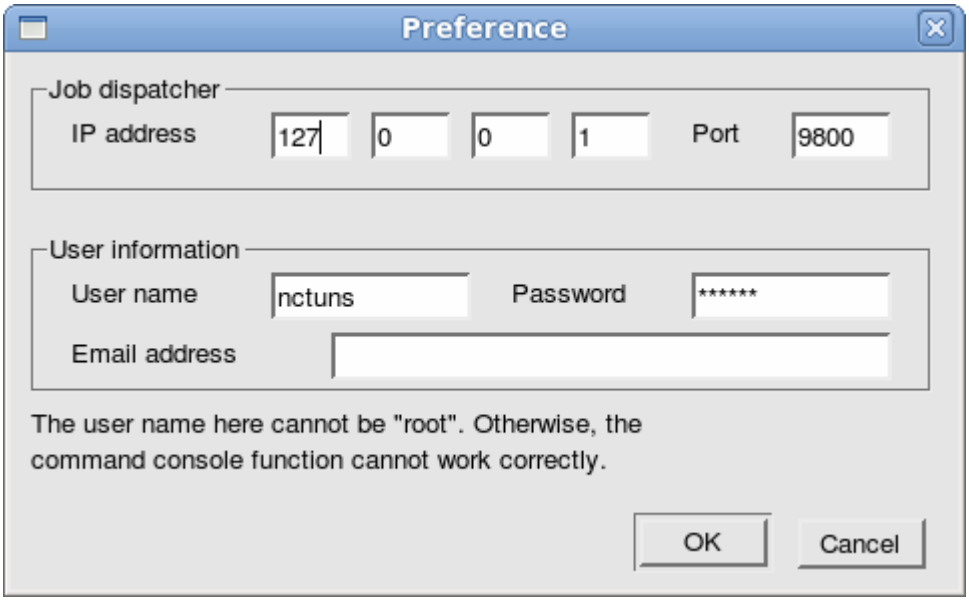

Fig. 13 Dispatcher settings

3. Start calculations in the menu ***Simulation->Run***. When the simulation is started correctly the time counter in the bottom part of the interface should show the progress of calculations.

The speed of the simulation may vary from the real time. More parameters relating to the speed of calculations may be set in the menu ***G_Setting->Simulation->Speed***.

6.4 P – Looking At The Results – Tools To Visualize

1. When the simulaion is completed, the program should switch automatically to play back mode. When required one may change the mode (mark ***P*** button on the tool bar 

or in the menu ***File->Operating Mode->Play Back***).

2. Using control buttons placed in the bottom parto f the screen, one may play back the network operation. Data that is saved in the *.ptr* file (*Packet Animation Trace*) will be showed as the animation presenting the data exchange among successive nodes (Fig. 10).

3. Select menu ***G_Tools->View Packet Trace*** and indicate.*ptr* file named with the same name as the projekt, to put its cotent to the screen. Successive lines show successive events that occurred during the simulated period of operation (Fig. 9).

7 Simulating The Devices' Failures

NCTUns Simulator makes possible testing the network behavior when a failure of the selected device happens. To model such a scenario, that one of the elements fails, one should switch to the edit mode (E). Then he/she should indicate the node or the link with the cursor and double left-click. The ranges when the device is inactive during the simulation can be defined (***Down time*** section, press ***Add*** and indicate start and stop times of the range (Fig. 14).

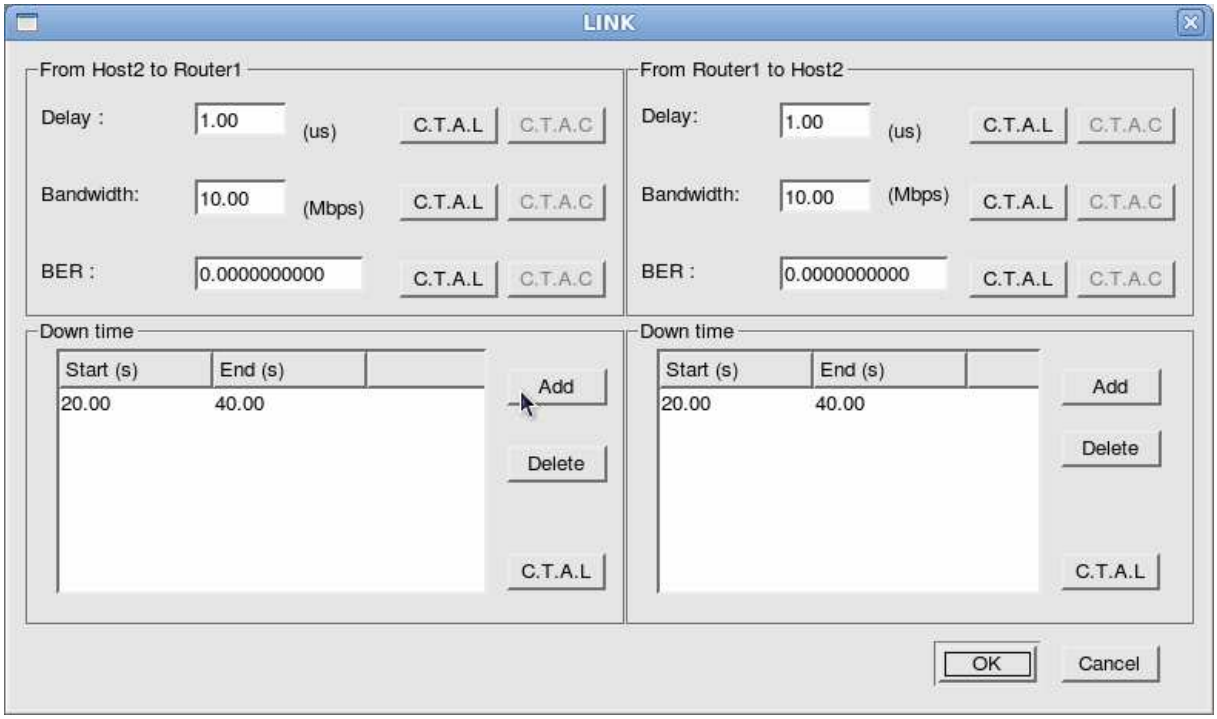

Fig. 14 Setting the inactive time of the link

8 Real Time Simulations

Among the options of NCTUns program there is a possibility performing the network simulation in redl time. The advantage of such a simulation is that one can log in to the selected node and give commands during the time when the simulation is on (for example *ping*, *tcpdump, traceroute, ifconfig, route, netstat*) from the level of the modeled device. Also the packet animation may be switched on during this mode.

To switch the mode into redl time one should choose menu ***G_Tools->Simulation*** then ***Speed*** and mark the option *As fast as the real-world clock* (Fig. 15).

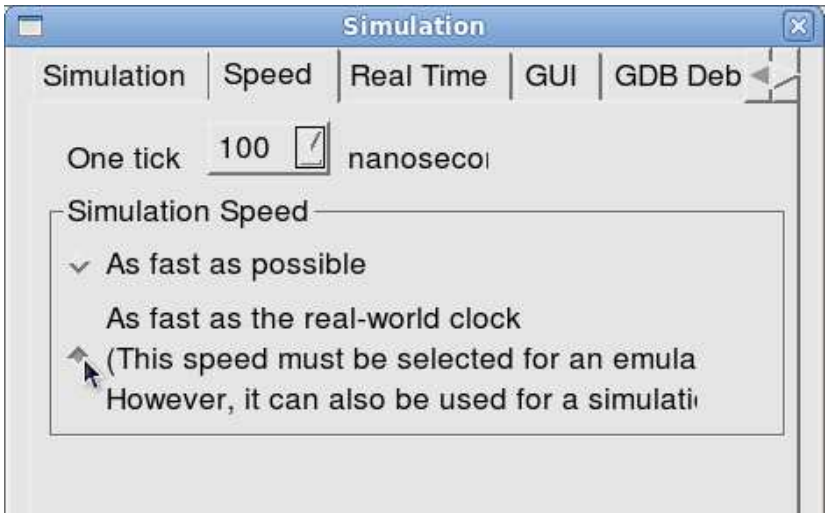

Fig. 15 Switching the real time simulation on

To start the command console for the selected node, indicate it with the cursor (when the simulation is on) and double left-click. Then choose the ***Command console*** button in the dialog box (Fig. 16). The terminal window should appear, which enables to execute commands from the chosen node level (Fig. 17).

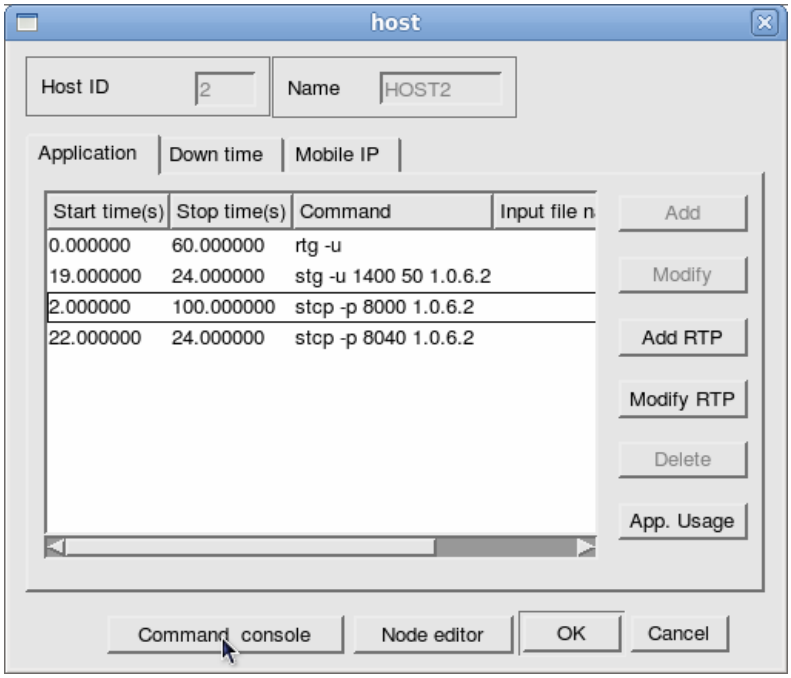

Fig. 16 Starting the command console when the simulation is on

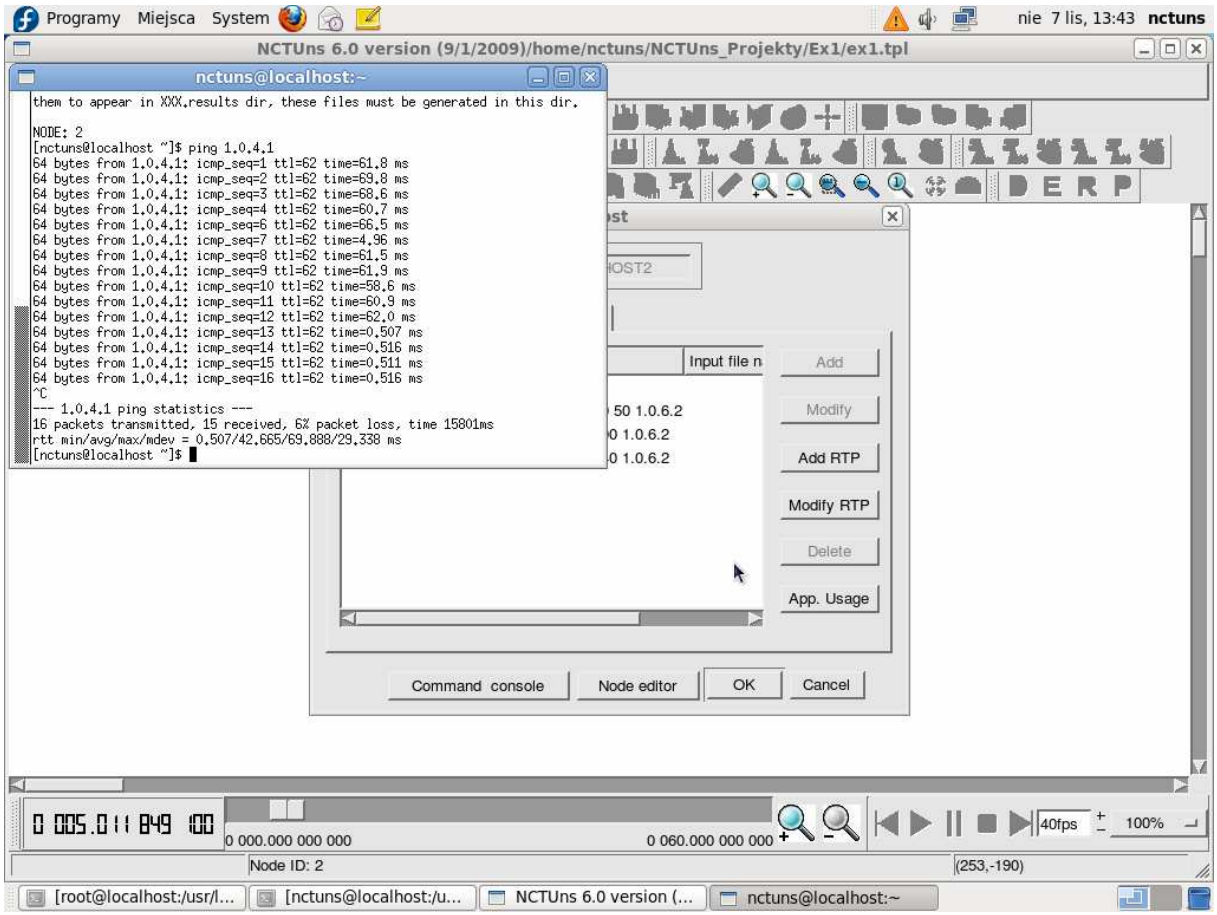

Fig. 17 Executing the system commands when the simulation is on

9 Experiments to be made

1. Get acquainted with accessible models of basic devices (hub, switch, router, host, sub-network, point-to-point link). Modify the network model made before with these elements. Check what parameters can be set for successive components.

2. Test traffic generators defining for a selected pair of hoss (stcp, rtcp, stg, rtg, rtp, rtcp).

3. Check what parameters of basic notes may be monitorem and saved in log files. Try the grach tool for any node (for example a host).

4. Switch the real time simulation for a simple network. Log in to a chosen host. Test using the command window (perform example commands, as *ping*).

5. Get acquainted with example projects (/home/nctuns/Pobrane/nctuns-6.0/examples/). They may serve as the base to build own network projects.

10 References

[1] Shie-Yuan Wang, Chih-Liang Chou, Chih-Che Lin, *The GUI User Manual for the NCTUns 6.0 Network Simulator and Emulator*, National Chiao Tung University, Tajwan 2010

[2] Shie-Yuan Wang, Chih-Liang Chou, Chih-Che Lin, Chih-Hua Huang, *The Protocol Developer Manual for the NCTUns 6.0 Network Simulator and Emulator*, National Chiao Tung University, Tajwan 2010