



MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
Ukrainian State University of Science and Technology

Department «Electronic Computers»

LOCAL NETWORKS

Methodical recommendations for laboratory works

ЕЛЕКТРОННИЙ АНАЛОГ ДРУКОВАНОГО ВИДАННЯ

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Methodological recommendations are aimed at preparing and doing individual
laboratory tasks in the discipline «Local Networks» for foreign applicants of
Bachelor's Degree of specialties 123 «Computer Engineering» and 125
«Cybersecurity».

Fig. 75. Table. 3. Bibliogr. titles. 5.

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Preface

Methodical recommendations for laboratory work in the "Local Networks" discipline are intended for candidates of the degree "Bachelor" of specialties "Computer Engineering" and "Cybersecurity" of foreign origin.

The guidelines present seven laboratory tasks devoted to the study of local networks based on simulation models created in NetCracker Professional using different technologies: Ethernet, Switched Ethernet, Fast Ethernet, Switched Fast Ethernet, Token Ring, Switched Token Ring, FDDI. Methodical recommendations contribute to the achievement of the following learning outcomes:

- development of local area network structures using various technologies;
- implementation of physical and logical structuring of local networks;
- performing local network configuration assessment;
- organization of research of parameters and characteristics of local networks on the basis of created simulation models;
- analysis of the application of various network technologies on the basis of research on appropriate simulation models.

Each laboratory work provides an example (based on option № 43) to create a simulation model of the relevant technology, as well as report requirements, control tasks and questions on the protection of laboratory work. Preparation for laboratory work involves the development of lecture material on the "Local Networks" subject and the implementation of tests for self-control in the distance learning "Lider" system [2]. As the main source, the textbook [3] is recommended, as an additional source - [1] and videos on the creation of simulation models, set out in [2]. The teacher developed a methodology for the formation of competencies of degree training of IT professionals in the railway industry and presented in [5], in particular the formation of competencies in bachelors in distance learning in the "Local Networks" discipline, which is presented in [4].

Laboratory Work № 1

CONSTRUCTION OF A SIMULATION MODEL OF A LOCAL NETWORK WITH THE USE OF THE ETHERNET TECHNOLOGY

- Objective:
1. Getting acquainted with the Ethernet technology.
 2. Learning the specifications limitations of the Ethernet physical layer.
 3. Mastering the method of calculation of PDV and PVV.
 4. Acquiring practical skills of physical structuring of Ethernet network.

1. Individual task

Task description: on the basis of the given infrastructure (according to the variant of the individual task, Tab. 1.1–1.3) by means of the NetCracker Pro program, design a network on the basis of the Ethernet technology, estimate its loading, response time and cost.

Table 1.1

Variants of individual tasks

| Variant № | Infrastructure type | Traffic type | Variant № | Infrastructure type | Traffic type | Variant № | Infrastructure type | Traffic type |
|-----------|---------------------|--------------|-----------|---------------------|--------------|-----------|---------------------|--------------|
| 1 | 1 | 1 | 28 | 4 | 4 | 55 | 7 | 7 |
| 2 | 2 | 1 | 29 | 5 | 4 | 56 | 8 | 7 |
| 3 | 3 | 1 | 30 | 6 | 4 | 57 | 1 | 8 |
| 4 | 4 | 1 | 31 | 7 | 4 | 58 | 2 | 8 |
| 5 | 5 | 1 | 32 | 8 | 4 | 59 | 3 | 8 |
| 6 | 6 | 1 | 33 | 1 | 5 | 60 | 4 | 8 |
| 7 | 7 | 1 | 34 | 2 | 5 | 61 | 5 | 8 |
| 8 | 8 | 1 | 35 | 3 | 5 | 62 | 6 | 8 |
| 9 | 1 | 2 | 36 | 4 | 5 | 63 | 7 | 8 |
| 10 | 2 | 2 | 37 | 5 | 5 | 64 | 8 | 8 |
| 11 | 3 | 2 | 38 | 6 | 5 | 65 | 1 | 9 |
| 12 | 4 | 2 | 39 | 7 | 5 | 66 | 2 | 9 |
| 13 | 5 | 2 | 40 | 8 | 5 | 67 | 3 | 9 |
| 14 | 6 | 2 | 41 | 1 | 6 | 68 | 4 | 9 |
| 15 | 7 | 2 | 42 | 2 | 6 | 69 | 5 | 9 |
| 16 | 8 | 2 | 43 | 3 | 6 | 70 | 6 | 9 |
| 17 | 1 | 3 | 44 | 4 | 6 | 71 | 7 | 9 |
| 18 | 2 | 3 | 45 | 5 | 6 | 72 | 8 | 9 |
| 19 | 3 | 3 | 46 | 6 | 6 | 73 | 1 | 10 |
| 20 | 4 | 3 | 47 | 7 | 6 | 74 | 2 | 10 |
| 21 | 5 | 3 | 48 | 8 | 6 | 75 | 3 | 10 |
| 22 | 6 | 3 | 49 | 1 | 7 | 76 | 4 | 10 |
| 23 | 7 | 3 | 50 | 2 | 7 | 77 | 5 | 10 |
| 24 | 8 | 3 | 51 | 3 | 7 | 78 | 6 | 10 |

| | | | | | | | | |
|----|---|---|----|---|---|----|---|----|
| 25 | 1 | 4 | 52 | 4 | 7 | 79 | 7 | 10 |
| 26 | 2 | 4 | 53 | 5 | 7 | 80 | 8 | 10 |
| 27 | 3 | 4 | 54 | 6 | 7 | | | |

Table 1.2

Infrastructure type

| Vari- ant № | Number of buildings | Distance between buildings | Number of floors | Number of rooms on the floor |
|----------------|------------------------|-------------------------------|---------------------|---------------------------------|
| 1 | 2 | 300 | 4 | 4 |
| 2 | 2 | 250 | 3 | 3 |
| 3 | 3 | 200 | 3 | 3 |
| 4 | 3 | 150 | 2 | 4 |
| 5 | 4 | 150 | 2 | 3 |
| 6 | 4 | 200 | 3 | 2 |
| 7 | 5 | 100 | 3 | 2 |
| 8 | 5 | 150 | 2 | 3 |

Table 1.3

Simulated traffic type

| Vari- ant № | Number of file servers | Number of <i>HTTP</i> - servers | Number of <i>FTP</i> - servers | Number of data bases servers |
|----------------|---------------------------|------------------------------------|-----------------------------------|---------------------------------|
| 1 | 3 | 1 | 2 | 4 |
| 2 | 3 | 2 | 1 | 3 |
| 3 | 3 | 1 | 2 | 2 |
| 4 | 2 | 2 | 1 | 1 |
| 5 | 2 | 1 | 2 | 4 |
| 6 | 2 | 2 | 1 | 3 |
| 7 | 4 | 1 | 2 | 2 |
| 8 | 4 | 2 | 1 | 1 |
| 9 | 4 | 1 | 2 | 4 |
| 10 | 2 | 2 | 1 | 3 |

2. Sequence of execution

1. Get acquainted with Ethernet technology (access method to the CSMA/CD transmission environment, MAC-sublayer parameters, restrictions on physical layer standards).

2. Study the purpose of the communication equipment of physical structuring of the network, the general and distinctive properties of the repeater and hub.

3. Get from the teacher a variant of the individual task (Table 1.1–1.3).

4. Choose a physical environment for horizontal, vertical and campus subsystems; justify the choice.

5. Perform an analysis of all the limitations of the standards in accordance with the chosen physical environment; justify the choice of communication equipment for the physical structuring of the Ethernet network.

6. Check the configuration the correctness of the received Ethernet network.

7. Determine the "threshold" of Ethernet on the simulation model: the number of workstations, the intensity of requests, the length of the frame.

8. Calculate the cost of the built Ethernet network.

9. Run on the Ethernet simulation model. Analyse the average load of the network equipment and the data transmission environment as well as the response time for the data flow. Specify areas of the network that are vulnerable to overloads.

10. Make a report on laboratory work:

- theme and objective of laboratory work;

- initial and additional data;

- substantiation of the required amount of communication equipment and its brief characteristics;

- Ethernet network structure (with indication of distances, servers locations and communication equipment);

- calculation of PDV and PVV (if necessary);

- found the "threshold" of Ethernet performance;

- calculation of the cost of Ethernet;

- printout of the report with the definition of the average load of the network equipment and data transmission environment as well as the response time for the data flow;

- conclusions.

3. Example of laboratory work execution

3.1. Development of the Ethernet structure. According to the variant (see Table 1.1): the type of the infrastructure – 3 (see Table 1.2); the type of the simulated traffic is 6 (see Table 1.3). Additional information: floor width is 18 m; floor height is 3 m. For the campus subsystem (external environment) the best type of cable is fiber-optic; the distance between houses is 200 m which does not exceed the limit on the length of the physical segment of 2000 m. For vertical and horizontal subsystems, one of the possible options is using UTP Cat 3. The structure of the designed computer network is shown in Figure 1.1.

It is advisable to place all servers in one room (server room); let it be in the Building (floor 2, room 2).

Since the Ethernet computer network (see Figure 1.1) uses different types of segments, it is necessary to evaluate its configuration.

1. The total number of workstations is 35 that does not exceeding 1024.

2. The length of the physical segments of the fiber-optic cable is 200 m (campus subsystem), and the twisted pair from 3 m to 11 m (vertical and horizontal subsystem) that does not exceeding the limit of 2000 m and 100 m accordingly (see Table 1.1) .

3. Calculate the value of PDV between the most remote stations Workstation 22 and Workstation 21 (see Figure 1.1).

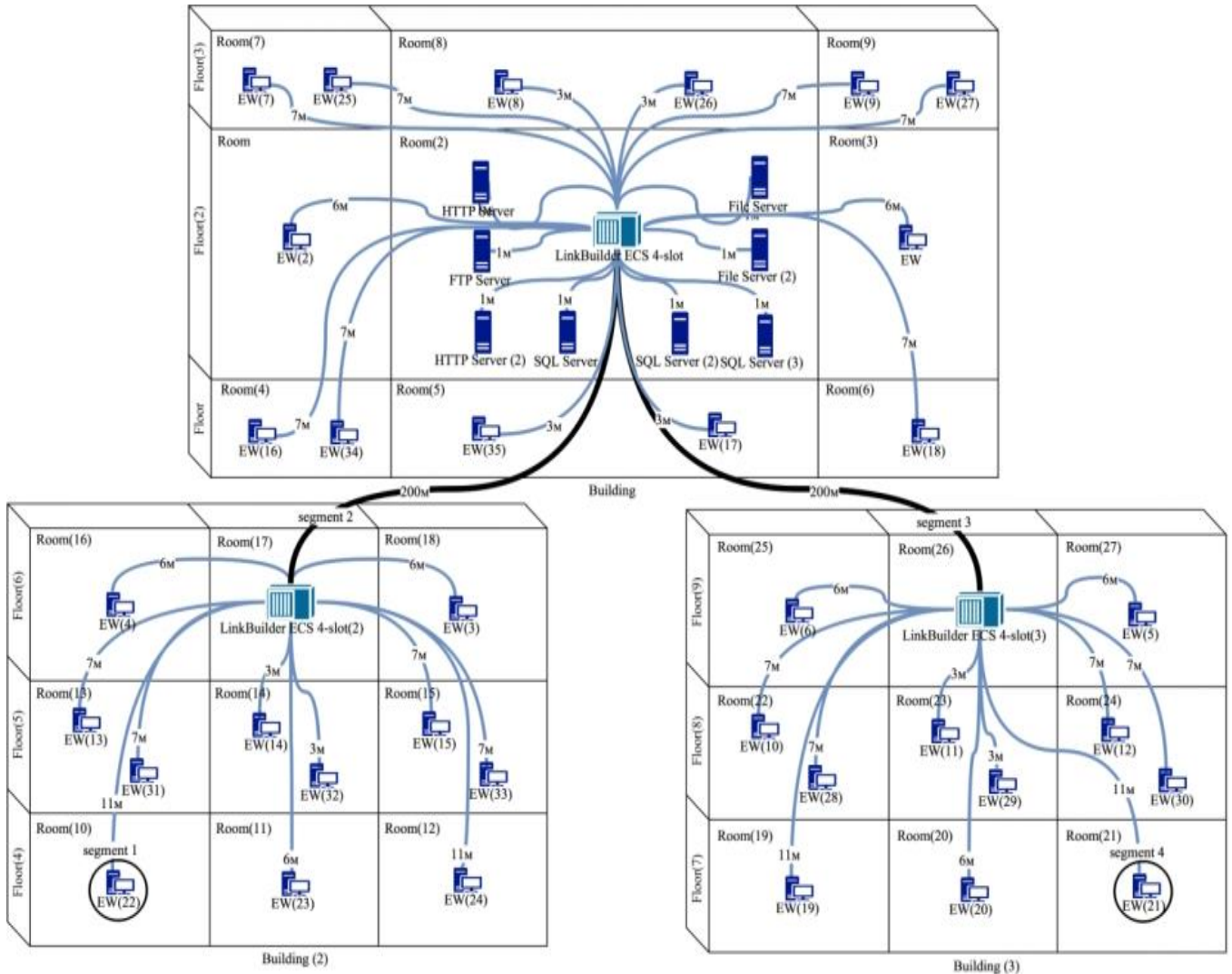


Fig. 1.1. The structure of the designed computer Ethernet network

Since the left and right segments are of the same nature, the calculation is performed only once (from left to right).

I segment (left) on 10Base-T, 11 m:

$$15,3 + 11 \cdot 0,113 = 16,543 \text{ bt};$$

II segment (intermediate) on 10Base-FL, 200 m:

$$33,5 + 200 \cdot 0,1 = 53,5 \text{ bt};$$

III segment (intermediate) on 10Base-FL, 200 m:

$$33,5 + 200 \cdot 0,1 = 53,5 \text{ bt};$$

IV segment (right) on 10Base-T, 11 m:

$$165 + 11 \cdot 0,113 = 166,243 \text{ bt.}$$

The total value of PDV is:

$$16,543 + 53,5 + 53,5 + 166,243 = 289,786 \text{ bt} < 575 \text{ bt.}$$

4. Calculate the PVV value between Workstation (22) and Workstation (21) (see Figure 1.1):

I segment (transmitting) on 10Base-T: 10,5 bt;



II segment (intermediate) on 10Base-FL: 8 bt;

III segment (intermediate) on 10Base-FL: 8 bt.


PVV calculation is also performed once (from left to right). The total value of PVV is:

$$10,5 + 8 + 8 = 26,5 \text{ bt} < 49 \text{ bt.}$$

All conditions are met, i.e. the configuration of the projected computer network is correct.

3.2. Building a simulation model of Ethernet in NetCracker Pro. Launch the program. Create a new project: File → New (). Save a new project at once: File → Save (), choose a storage folder and press OK. When creating a project, the *Top* window is opened. In the *Devices* (on the left panel) choose *Buildings*, *Campuses* and *LAN Workgroups*. From the bottom of the window, drag the *Campus*



to the clear field of the *Top* window (). To place houses on *Campus*, click the right button of the mouse on *Campus* and select *Expand* from the context menu. A





new *Campus* window will be opened. From the bottom panel of *Devices* drag  on a clear field of the *Campus* window. Thus, the result of the action is presented in Figure 1.2.



Fig. 1.2. Creating the *Campus* subsystem

By analogy, three floors are needed to be made in each house ( , Figure

1.3.), with three rooms on each floor ( , Figure 1.4).

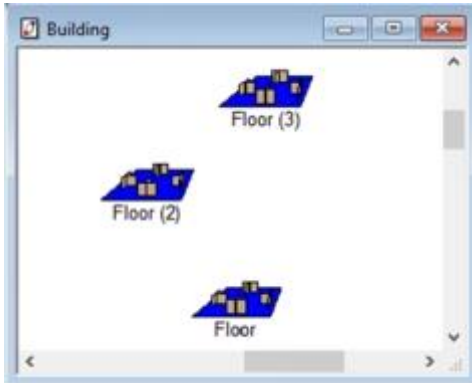


Fig. 1.3. Creating a vertical subsystem

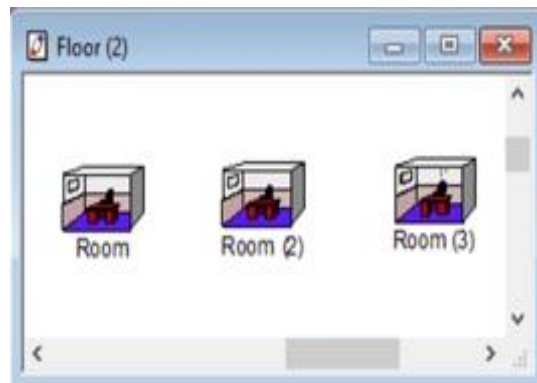


Fig. 1.4. Creating a horizontal subsystem

The structure of the network can be viewed on the *Project Hierarchy* (the left panel), as it is shown in Figure 1.5.

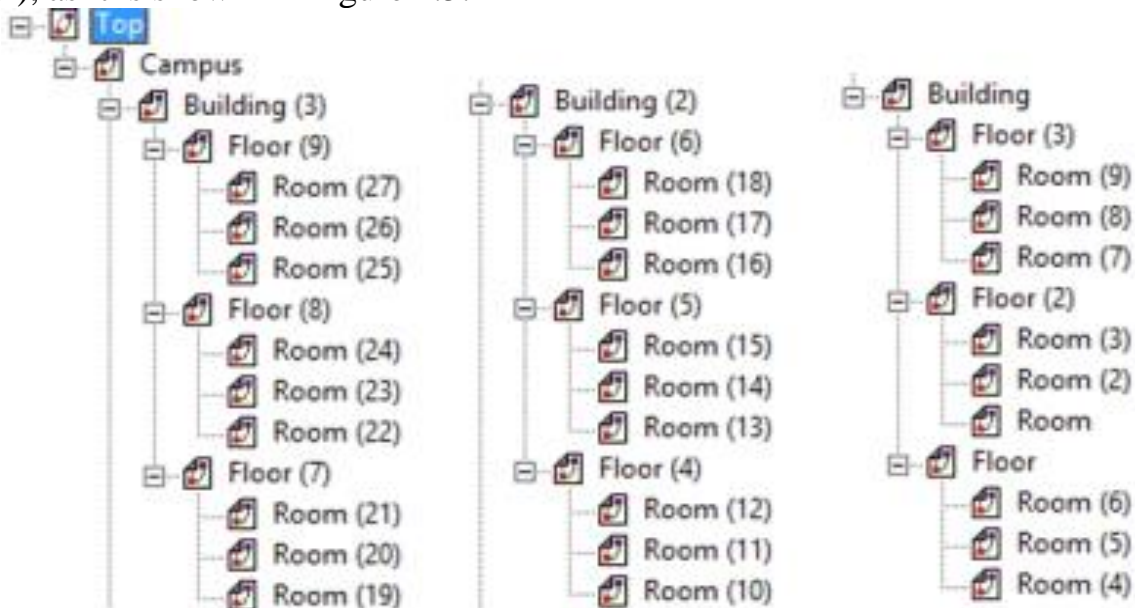


Fig. 1.5. The structure of the network

In the server room (with the *Expand* command), put the hub *LinkBuilder ECS 4-slot* (left panel: Hubs → Shared media → Ethernet → 3Com Corp. → LinkBuilder ECS 4-slot); click on the name once and drag the hub from the bottom to the room. You need to add modules with slots to the hub: two modules 12-Port 10BaseT Repeater Mode; one 6-Port FOIRL Repeate Module, IMF ST. To add a module to the hub, you need to drag the module from the bottom panel to the hub. For viewing, do the double-click on the hub with the left button of the mouse or click the right button using the *Configuration* command. As a result, the LinkBuilder ECS 4-slot hub has three modules, as it is shown in Figure 1.6.

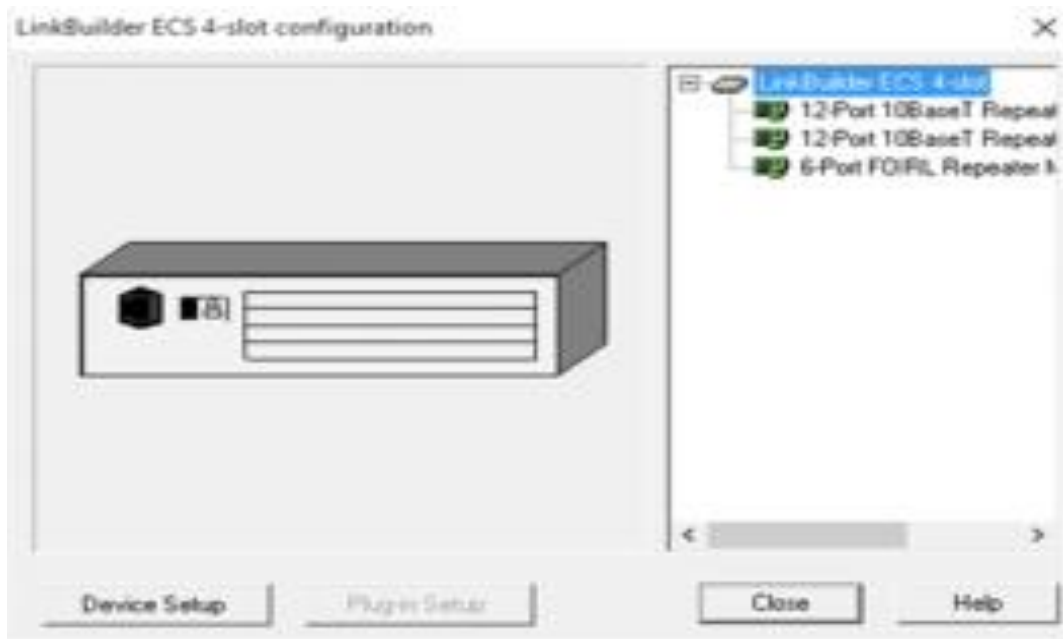


Fig. 1.6. The structure of LinkBuilder ECS 4-slot hub

Eight Ethernet Servers (optional) from the *LAN servers* panel (on left) must be located in the server room.

Click once on LAN servers; drag the Ethernet Server from the bottom part eight times into the room. Now you need to make servers for a specific purpose. To do this, insert a disk into the server: Network and enterprise software → Server software. Click once on Server software with the left button, several disks will appear at the bottom part, we need: two File servers, one FTP server, two HTTP servers and three Small office database servers. Add one disk to each server and rename the server accordingly (to rename, do double-click on the name with the left mouse button, the *Text Editor* window will appear, then rename, click OK). The structure of the server room is presented in Figure 1.7.

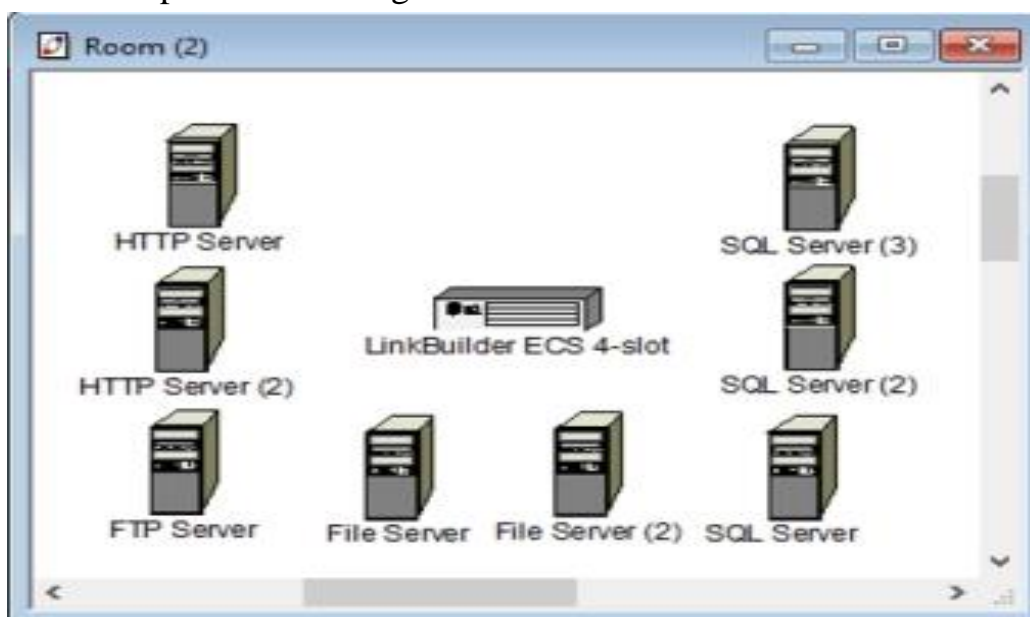


Fig. 1.7. The structure of the server room

Let's connect the hubs and the servers. According to the structure of the network (see Figure 1.1), place all the hubs. According to the 10BaseFL standard, the physical topology is a star, so we connect the hubs from Building 2 and Building 3 to the hub in Building 1. To do this, open the rooms in which they are situated (Figure 1.8).

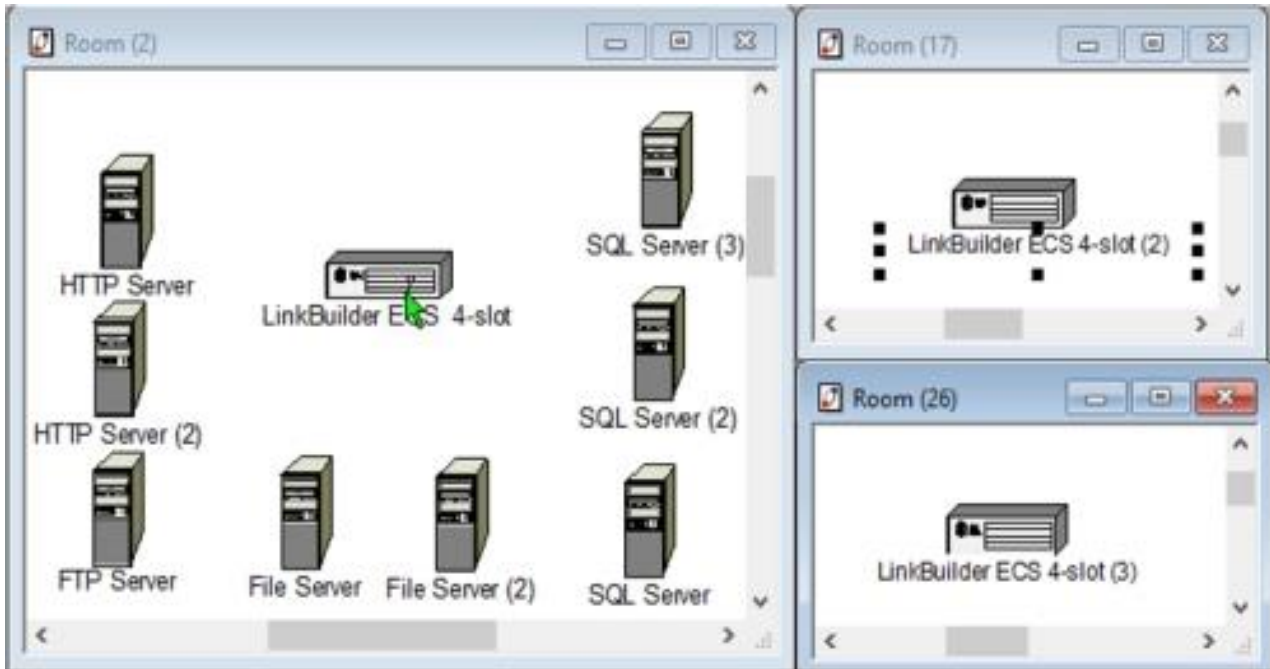



Fig. 1.8. Rooms with hubs

Click on  on the toolbar (above), click on one hub and then on the other; the *Link Assistant* window will be opened (Figure 1.9).

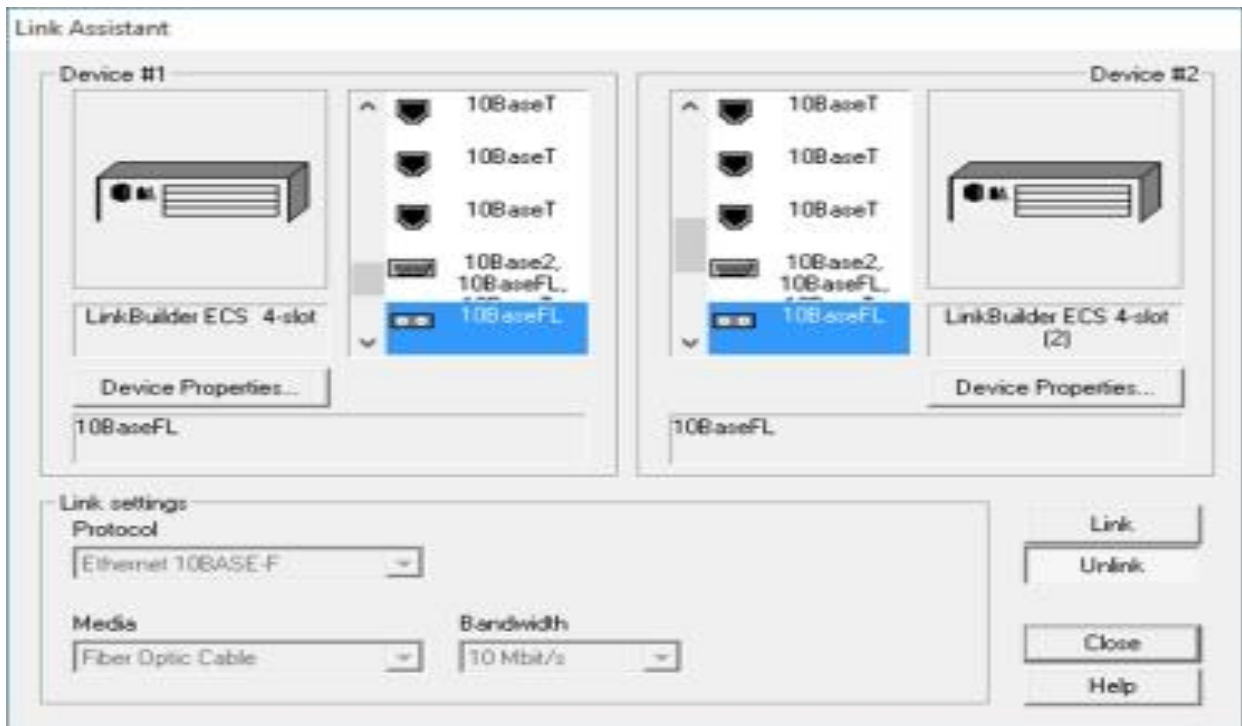


Fig. 1.9. Work with the *Link Assistant* window

In the *Link Assistant* window, choose 10BaseFL port for the first and second hubs and click *Link* button. The value of *Length* is set of 200 m (distance between houses 200 m); Protocol – Ethernet 10BASE-F; Media – Fiber Optic Cable; Bandwidth – 10 Mbit/s; click *Close* button, as shown in Figure 1.10.

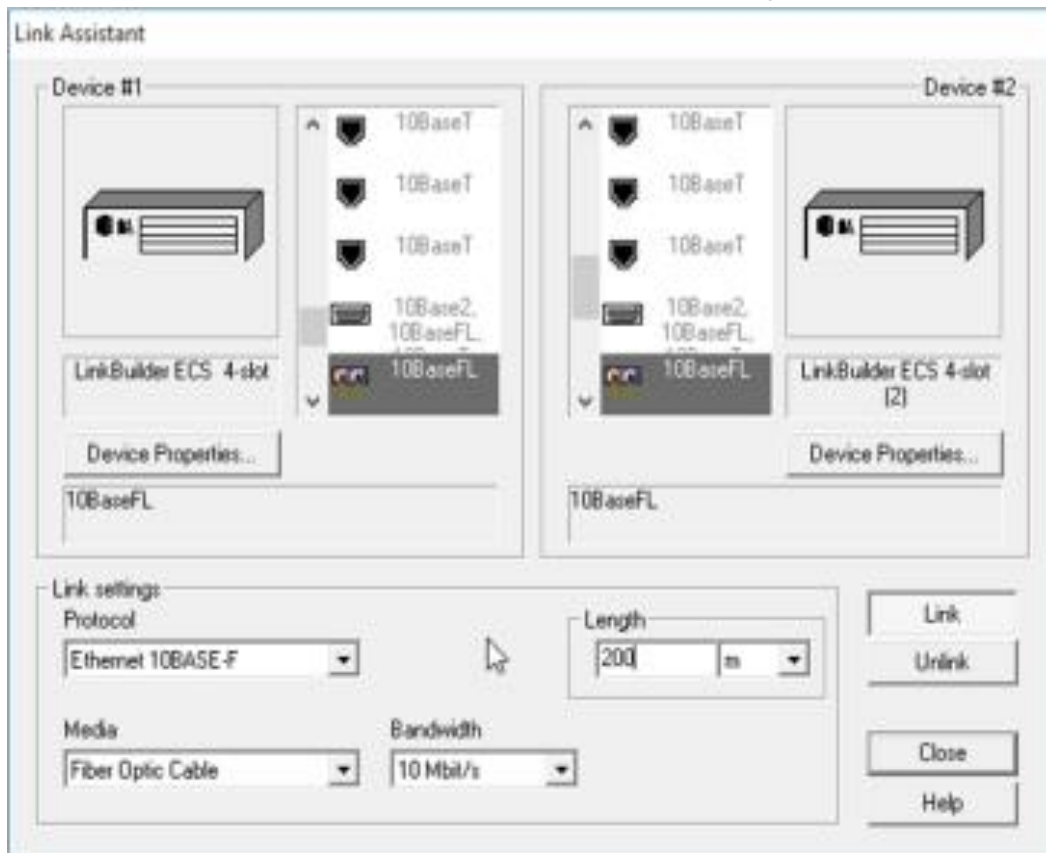


Fig. 1.10. Task parameters of the campus subsystem

Next, connect all servers to the hub (similar to connecting two hubs). The value of *Length* is set of 1 m (server and hub are situated in the same room); connect them with twisted-pair cable (Figure 1.11).

3.3. Determining the threshold of the network performance on the simulation model. To determine the performance threshold, you must add one workstation to the network and configure/adapt data transfer to the servers for each workstation. To add a workstation you need to go to a room, for example to Room 3 on the panel *Devices* (on left): *LAN workstation*, press once with the left mouse



button; drag the workstation into the room from the *Devices* panel

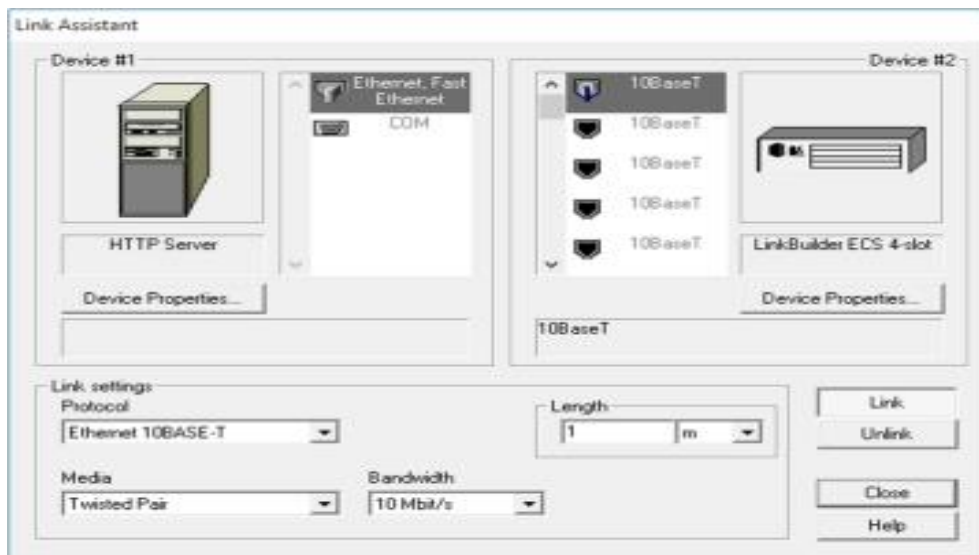



Fig. 1.11. Setting the parameters of the horizontal subsystem

Connect the workstation to the hub located in this building (similar to connecting the server to the hub). Taking into account the width and height of the floor, set the Length (according to the variant it is 3 m), using twisted-paired cable.

To configure/adapt data transfer on the toolbar (above), press ; then on the workstation, and on the server to which we send data; the *Profiles* window will be opened, which is shown in Figure 1.12.

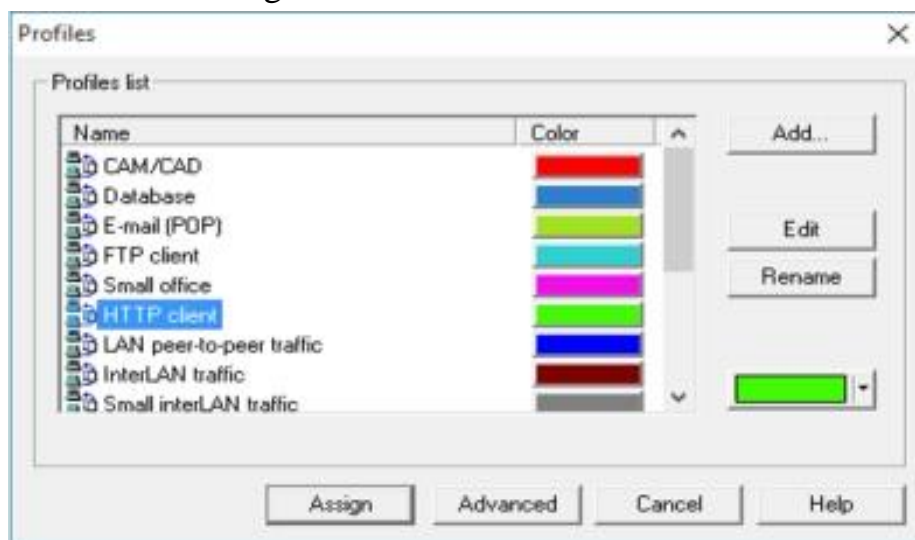




Fig. 1.12. Working with *Profiles* window

In the *Profiles* window, choose the item which name matches the name of the server, for example, *HTTP client*, then click *Assign*. To start the simulation model, press . The movement of the packets will be displayed on the model. If in the network appears  anywhere, it means that the network has fallen. In our case, the network fell with the number of stations 36 (Figure 1.13), i.e. the threshold of the network is 35 workstations.

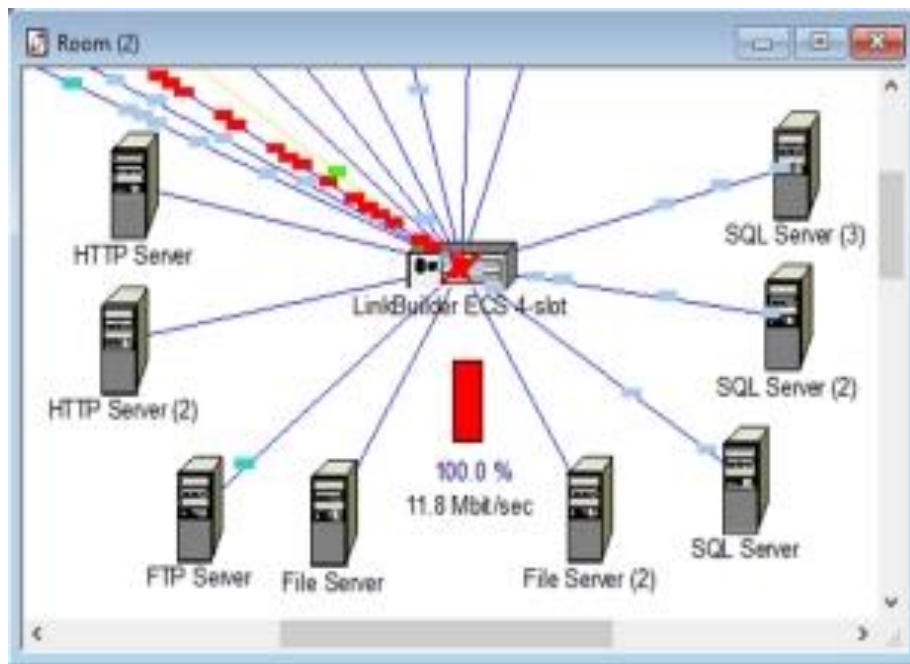


Fig. 1.13. The fall of the network on the simulation model

3.4. Conducting experiments on the Ethernet simulation model. The following conditions must be met during the experiment: the simulation model must work for 7 minutes; packets of volum from 500 to 1000 bytes are transmitted; every 0,02 s by exponential law. To adjust the sizes of the packets and their sending interval you should do the follows: *Global* (in the main menu) → *Data Flow*; choose the workstation, click *Edit*, *Profile* window will be opened in which you need to select the type of server (e.g. *Small office database server's client*) to which the traffic is assigned; click *Edit*, the window *Small office database server's client* will be opened, where you need to set the appropriate parameters, this is shown in Figure 1.14.

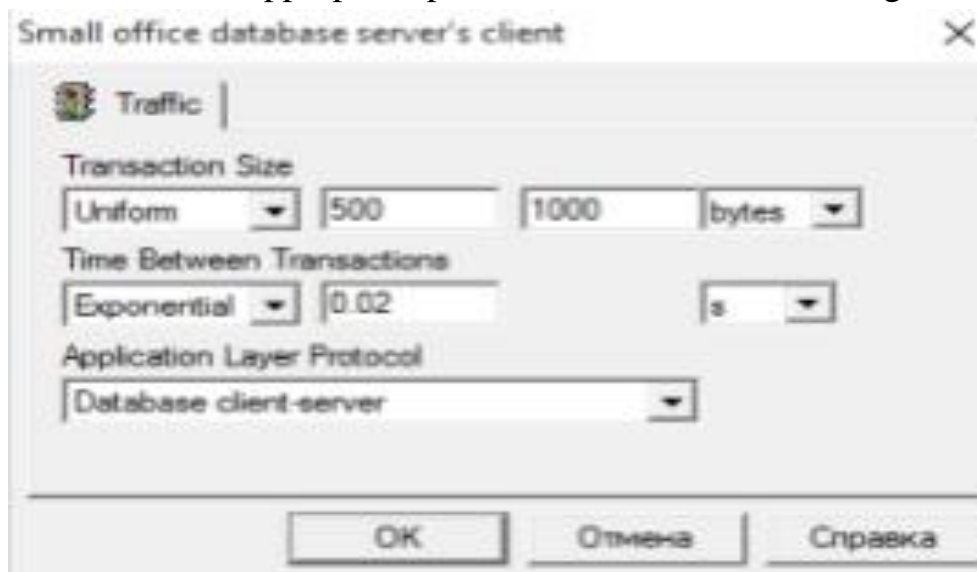


Fig. 1.14. Work with the window *Small office database server's client*

After all the settings you need to record the statistics. The conditions of the experiment must be maintained when running all subsequent simulation models.

To get statistics on the Ethernet simulation model you need opt in the main menu: Tools → Reports → Wizard; the *Select a report* window will appear, in which you should select Statistical → LAN → LAN Segments Statistics to obtain the statistics of the average load of network equipment; the corresponding window will be opened, in which without changing anything press the *Next* button three times, then click *Done* (Figure 1.15).

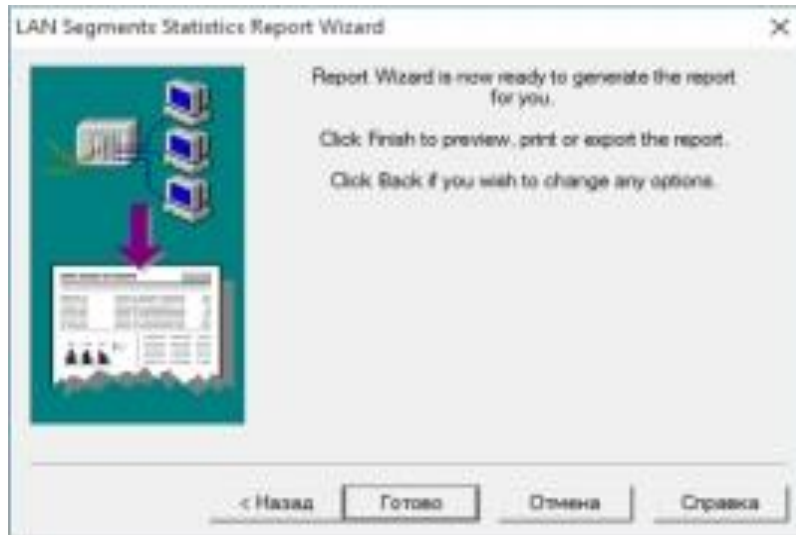


Fig. 1.15. Work with the LAN Segments Statistics Report Wizard

As a result, we obtain the report LAN Segments Statistics, Figure 1.16.

| Name | Vendor | Utilization | Workload | Packet delay |
|--|------------|-------------|-------------|--------------|
| LinkBuilder ECS 4-slot | 3Com Corp. | 100.0 % | 1 Mbyte/sec | 384.00 μs |
| 12-Port 10BaseT Repeater Module, Telco | 3Com Corp. | 0.0 % | 0 bit/sec | 0.00 μs |
| 12-Port 10BaseT Repeater Module, Telco (2) | 3Com Corp. | 0.0 % | 0 bit/sec | 0.00 μs |
| 6-Port FOIRL Repeater Module, MMF ST | 3Com Corp. | 30.0 % | 3 Mbit/sec | 383.00 μs |
| LinkBuilder ECS 4-slot (2) | 3Com Corp. | 30.0 % | 3 Mbit/sec | 383.00 μs |
| 12-Port 10BaseT Repeater Module, Telco | 3Com Corp. | 0.0 % | 0 bit/sec | 0.00 μs |
| 6-Port FOIRL Repeater Module, MMF ST | 3Com Corp. | 0.0 % | 0 bit/sec | 0.00 μs |
| LinkBuilder ECS 4-slot (3) | 3Com Corp. | 30.0 % | 3 Mbit/sec | 383.00 μs |
| 12-Port 10BaseT Repeater Module, Telco | 3Com Corp. | 0.0 % | 0 bit/sec | 0.00 μs |
| 6-Port FOIRL Repeater Module, MMF ST | 3Com Corp. | 0.0 % | 0 bit/sec | 0.00 μs |

Fig. 1.16. The report LAN Segments Statistics

The figure shows that the load on the central hub is 100 %, and the other two is 30 %. To determine the response time for the data flow and traffic destination, select: Statistical → Data Flows → Applications Statistics; the received report is shown in Figure 1.17.

| Name | Source | Destination | Travel time | Response time |
|------------------------------------|---------------------------|-----------------|----------------|---------------|
| Small office database server's cli | Ethernet Workstation | SQL Server (3) | 384.00 μ s | 17.00 min |
| Small office database server's cli | Ethernet Workstation (2) | SQL Server (3) | 385.00 μ s | 17.00 min |
| File server's client | Ethernet Workstation (3) | File Server (2) | 767.00 μ s | 19.00 min |
| File server's client | Ethernet Workstation (4) | File Server | 767.00 μ s | 21.00 min |
| HTTP client | Ethernet Workstation (5) | HTTP Server (2) | 757.00 μ s | 31.00 ms |
| HTTP client | Ethernet Workstation (6) | HTTP Server (2) | 725.00 μ s | 31.00 ms |
| FTP client | Ethernet Workstation (7) | FTP Server | 354.00 μ s | 31.00 ms |
| Small office database server's cli | Ethernet Workstation (8) | SQL Server (2) | 382.00 μ s | 23.00 min |
| Small office database server's cli | Ethernet Workstation (9) | SQL Server | 384.00 μ s | 17.00 min |
| HTTP client | Ethernet Workstation (10) | HTTP Server | 760.00 μ s | 31.00 ms |
| HTTP client | Ethernet Workstation (11) | HTTP Server | 750.00 μ s | 31.00 ms |
| HTTP client | Ethernet Workstation (12) | HTTP Server (2) | 776.00 μ s | 31.00 ms |
| File server's client | Ethernet Workstation (14) | File Server | 767.00 μ s | 21.00 min |
| File server's client | Ethernet Workstation (15) | File Server (2) | 767.00 μ s | 19.00 min |
| File server's client | Ethernet Workstation (13) | File Server (2) | 767.00 μ s | 19.00 min |
| Small office database server's cli | Ethernet Workstation (16) | SQL Server | 384.00 μ s | 17.00 min |
| Small office database server's cli | Ethernet Workstation (17) | SQL Server (2) | 384.00 μ s | 23.00 min |
| Small office database server's cli | Ethernet Workstation (18) | SQL Server (3) | 383.00 μ s | 17.00 min |
| HTTP client | Ethernet Workstation (19) | HTTP Server (2) | 762.00 μ s | 31.00 ms |
| HTTP client | Ethernet Workstation (20) | HTTP Server (2) | 800.00 μ s | 31.00 ms |
| HTTP client | Ethernet Workstation (21) | HTTP Server | 783.00 μ s | 31.00 ms |
| File server's client | Ethernet Workstation (22) | File Server | 767.00 μ s | 21.00 min |
| File server's client | Ethernet Workstation (23) | File Server (2) | 768.00 μ s | 19.00 min |
| File server's client | Ethernet Workstation (24) | File Server | 768.00 μ s | 21.00 min |
| FTP client | Ethernet Workstation (25) | FTP Server | 338.00 μ s | 29.00 ms |
| Small office database server's cli | Ethernet Workstation (26) | SQL Server (2) | 384.00 μ s | 23.00 min |
| Small office database server's cli | Ethernet Workstation (27) | SQL Server | 385.00 μ s | 17.00 min |
| HTTP client | Ethernet Workstation (28) | HTTP Server (2) | 744.00 μ s | 32.00 ms |
| HTTP client | Ethernet Workstation (29) | HTTP Server | 744.00 μ s | 31.00 ms |
| HTTP client | Ethernet Workstation (30) | HTTP Server (2) | 782.00 μ s | 31.00 ms |
| File server's client | Ethernet Workstation (31) | File Server | 766.00 μ s | 21.00 min |
| File server's client | Ethernet Workstation (32) | File Server (2) | 767.00 μ s | 19.00 min |
| File server's client | Ethernet Workstation (33) | File Server | 767.00 μ s | 21.00 min |
| Small office database server's cli | Ethernet Workstation (34) | SQL Server (2) | 383.00 μ s | 23.00 min |
| Small office database server's cli | Ethernet Workstation (35) | SQL Server (2) | 384.00 μ s | 23.00 min |

Fig. 1.17. Applications Statistics Report

The figure shows that the maximum response time is 23 minutes.

To remove the network characteristics of a particular part of the network (e.g. server room) select: Advanced → Modules → Module Statistical Items; the corresponding window appears (Figure 1.18).

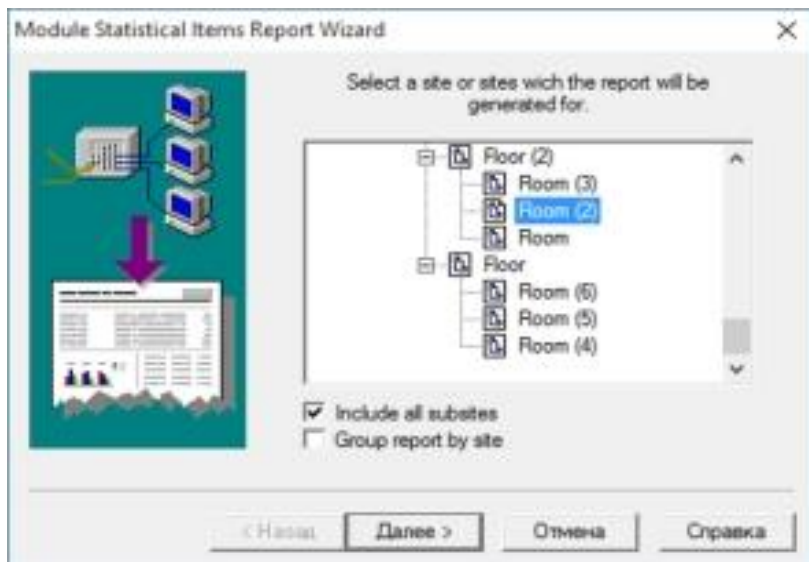


Fig. 1.18. Work with the *Module Statistical Items Report Wizard* window

Select the server room Room 2, and then opt *Devices*. As a result, the report *Module Statistical Items* is built, Figure 1.19.

| Name | Statistical Item | Value |
|-------------------------------------|-----------------------------------|-----------------|
| SQL Server | | |
| | Average workload | 162473 byte/sec |
| | Current workload | 159832 byte/sec |
| | Packets for last second | 324 packets |
| | Packets received | 689592 packets |
| | Transactions received | 459739 |
| | Transactions sent | 204278 |
| | Average transaction length, bytes | 750.076 bytes |
| | Number of server replies | 204279 |
| | Average reply size | 749.695 bytes |
| Small office database server | | |
| | Number of server replies | 204279 |
| | Average reply size | 749.695 bytes |

Fig. 1.19. The *Module Statistical Items* report

The Module Statistical Items report describes all the parameters of the Room 2 equipment.

In general, the following statistics are obtained on the simulation model of the designed Ethernet network (Figure 1.20).

| | |
|------------------------------|----------------------|
| Current utilization | 100 % |
| Average utilization | 100 % |
| Average packet transfer time | 0.00038359 s |
| Average workload | 11.7829 Mbit/sec |
| Current workload | 1.5435e+006 byte/sec |
| Packets for last second | 3068 packets |

Рис. 1.20. Statistics of the Ethernet network

Draw appropriate conclusions. Enter the values of the main characteristics (response time, network load, communication equipment load) obtained on the Ethernet simulation model to the summary table.

Laboratory work № 2

CONSTRUCTION OF LOCAL NETWORK SIMULATION MODEL USING SWITCHED ETHERNET TECHNOLOGY

- Objective:
1. Get acquainted with Switched Ethernet technology.
 2. To study the general and distinctive properties of the bridge and the switch.
 3. Acquire practical skills of logical structuring of Ethernet network.

1. Individual task

Problem statement: on the basis of the given infrastructure (according to the variant of the individual task), design with the help of the *NetCracker Pro* program a network on the basis of the *Switched Ethernet* technology, estimate its loading, response time, and cost.

2. The sequence of execution

1. Get acquainted with the Ethernet technology (frame formats, the necessary condition for recognizing the collision in the network, the collision domain).
2. Study the purpose of communication equipment of network logical structuring, general and distinctive properties of the bridge and switch.
3. Substantiate the need of solving the problem of logical structuring of the Ethernet network (from the Lab № 1).
4. Analyze the location of the required number of communication equipment for the logical structuring of the Ethernet network.
5. Calculate the cost of the built Switched Ethernet network.
6. Run on the simulated model of the *Switched Ethernet* network. Analyze the average load of network equipment and data transmission environment as well as the response time for the data flow.
7. Compare the obtained characteristics (cost, response time and load) of the Ethernet and Switched Ethernet networks.
8. Prepare a report on laboratory work:

- theme and purpose of laboratory work;
 - substantiation of the required amount of communication equipment and its brief characteristics;
 - the structure of the Switched Ethernet network (with indication of the distances, the locations of servers and the communication equipment);
 - calculation of the cost of the Switched Ethernet;
 - print out the report with the estimated average load of the network equipment and the data transmission environment as well as the response time for the data flow;
 - conclusions.
9. Present simulation models built in lab № 1–2 to the teacher on the computer.
10. Prepare to defend the topic *Ethernet Technology*.

3. Example of laboratory work (option № 43)

3.1. Development of the Switched Ethernet network structure. As the number of stations increases (see Lab № 1), the Ethernet network fails, so it is necessary to solve the problem of its logical structuring using a switch. We enter the switch into the Building, because there is the largest load; all hubs and servers are connected to the switch. The structure of the projected Switched Ethernet network is shown in Figure 2.1.

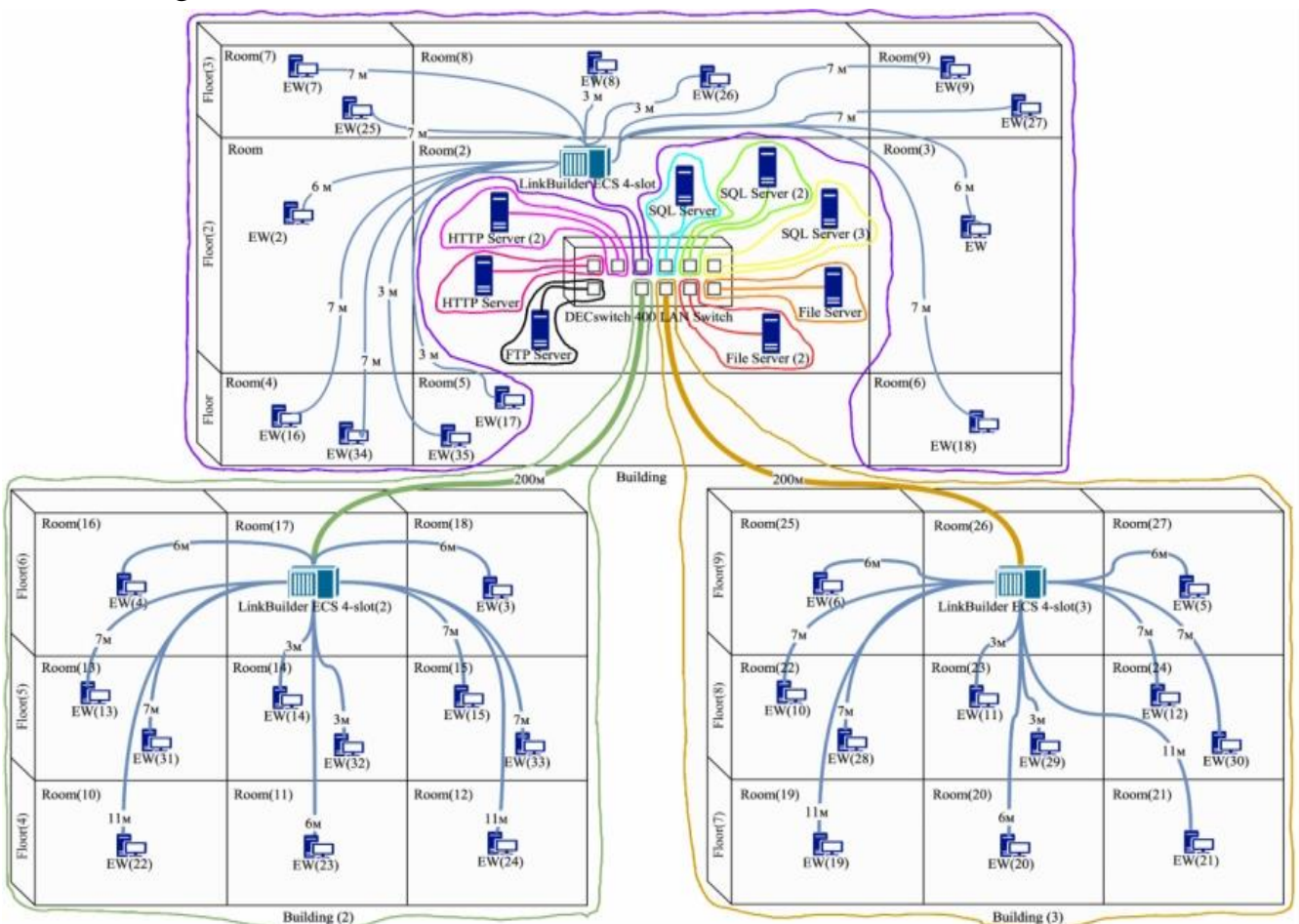



Fig.2.1. The structure of the projected network Switched Ethernet

When entering a switch with 11 ports, 11 collision domains are formed: 8 domains when connecting servers (each of the servers is connected directly to the port); 3 domains when connecting hubs (workstations are connected to the port through the appropriate hub).

3.2. Construction of a simulated Switched Ethernet network in the NetCracker package. Copy the file in which the Ethernet simulation model is located (Lab1). For logical structuring of the Ethernet network, the DEC switch 400 LAN Switch is selected with the following parameters: bandwidth is 2,5 Gbit/s; delay is 40 (мкс); promotion speed and packet filtering speed are 14880 packets/s; the total number of ports is 11 (9 are used for 10Base-T and 2 for 10Base-F).

To place the switch in Room 2 select the follows: Switches → Ethernet (token ring) to ATM → Digital Equipment → DEC switch 400 LAN Switch; click once

with the left mouse button on the name; drag the switch  to Room 2 from the *Devices* panel (on left). Add modules to the switch: DESSL-EA (8 10Base-T ports); DESSM-AA (1 port 10Base-T); 2 DESSM-AC modules (one 10Base-F port in each module). Disconnect the server and the hub from the hub in Room 2; this can be done by double-click of left button of the mouse on the cable that has to be removed. A window will appear in which you need to click *Unlink* (Figure 2.2); the connection will disappear. We run a simulation model; the model must work without failures.

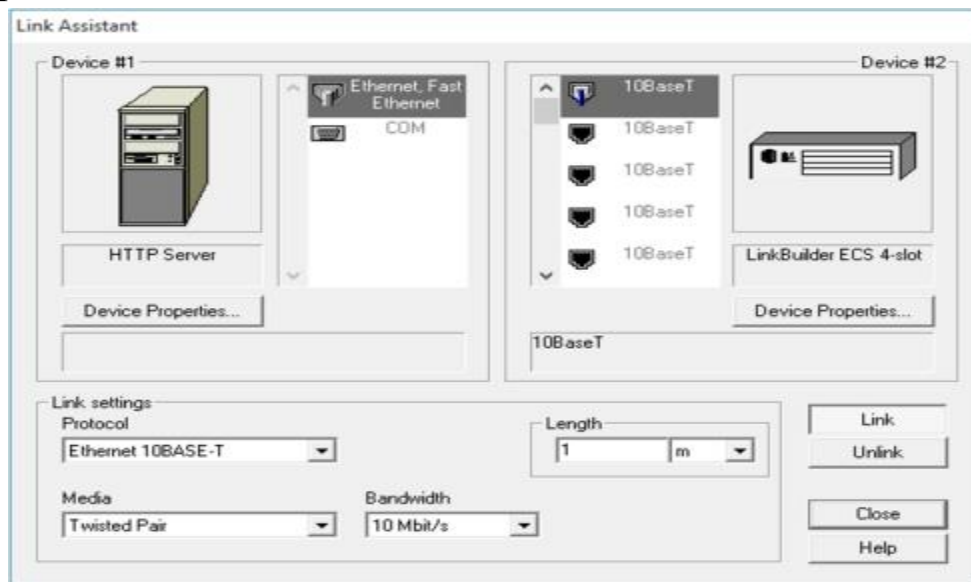


Fig. 2.2. Working in the "Link Assistant" window

3.3. Conducting experiments on the simulation model Switched Ethernet.

To compare the resulting characteristics of networks of different technologies, the start of the simulation model Switched Ethernet must be performed at a certain threshold of the Ethernet (number of workstations is 35). The conditions of the

experiments must coincide with the conditions of the experiment on the simulation model Ethernet (network time, size of the packets, packet sending intervals).

The LAN Segments Statistics report obtained on the Switched Ethernet simulation model is shown in Figure 2.3.

LAN Segments Statistics

| Name | Vendor | Utilization | Workload | Packet delay |
|----------------------------|------------|-------------|-------------|----------------|
| LinkBuilder ECS 4-slot | 3Com Corp. | 43.0 % | 4 Mbit/sec | 381.00 μ s |
| LinkBuilder ECS 4-slot (2) | 3Com Corp. | 44.0 % | 4 Mbit/sec | 383.00 μ s |
| LinkBuilder ECS 4-slot (3) | 3Com Corp. | 0.0 % | 4 Kbyte/sec | 385.00 μ s |

Fig. 2.3. LAN Segments Statistics Report

The figure shows that the load of the central hub in the Switched Ethernet network has dropped more than twice compared to the load of the same hub in the Ethernet network.. The Report Statistics report on the Switched Ethernet simulation model is shown in Figure 2.4. The figure shows that the maximum response time in the Switched Ethernet network is 12 minutes, which is about twice less than in the Ethernet network (where the maximum response time is 23 minutes).

| Name | Source | Destination | Travel time | Response time |
|------------------------------------|---------------------------|-----------------|----------------|---------------|
| Small office database server's cli | Ethernet Workstation | SQL Server (3) | 391.00 μ s | 9.00 min |
| Small office database server's cli | Ethernet Workstation (2) | SQL Server (3) | 390.00 μ s | 9.00 min |
| File server's client | Ethernet Workstation (3) | File Server (2) | 393.00 μ s | 10.00 min |
| File server's client | Ethernet Workstation (4) | File Server | 394.00 μ s | 11.00 min |
| HTTP client | Ethernet Workstation (5) | HTTP Server (2) | 383.00 μ s | 31.00 ms |
| HTTP client | Ethernet Workstation (6) | HTTP Server (2) | 405.00 μ s | 31.00 ms |
| FTP client | Ethernet Workstation (7) | FTP Server | 346.00 μ s | 31.00 ms |
| Small office database server's cli | Ethernet Workstation (8) | SQL Server (2) | 392.00 μ s | 12.00 min |
| Small office database server's cli | Ethernet Workstation (9) | SQL Server | 391.00 μ s | 9.00 min |
| HTTP client | Ethernet Workstation (10) | HTTP Server | 0.00 μ s | 0.00 μ s |
| HTTP client | Ethernet Workstation (11) | HTTP Server | 361.00 μ s | 30.00 ms |
| HTTP client | Ethernet Workstation (12) | HTTP Server (2) | 391.00 μ s | 30.00 ms |
| File server's client | Ethernet Workstation (14) | File Server | 391.00 μ s | 11.00 min |
| File server's client | Ethernet Workstation (15) | File Server (2) | 391.00 μ s | 10.00 min |
| File server's client | Ethernet Workstation (13) | File Server (2) | 392.00 μ s | 10.00 min |
| Small office database server's cli | Ethernet Workstation (16) | SQL Server | 390.00 μ s | 9.00 min |
| Small office database server's cli | Ethernet Workstation (17) | SQL Server (2) | 391.00 μ s | 12.00 min |
| Small office database server's cli | Ethernet Workstation (18) | SQL Server (3) | 391.00 μ s | 9.00 min |
| HTTP client | Ethernet Workstation (19) | HTTP Server (2) | 420.00 μ s | 31.00 ms |
| HTTP client | Ethernet Workstation (20) | HTTP Server (2) | 408.00 μ s | 31.00 ms |
| HTTP client | Ethernet Workstation (21) | HTTP Server | 369.00 μ s | 31.00 ms |
| File server's client | Ethernet Workstation (22) | File Server | 395.00 μ s | 11.00 min |
| File server's client | Ethernet Workstation (23) | File Server (2) | 392.00 μ s | 10.00 min |
| File server's client | Ethernet Workstation (24) | File Server | 391.00 μ s | 11.00 min |
| FTP client | Ethernet Workstation (25) | FTP Server | 435.00 μ s | 25.00 ms |
| Small office database server's cli | Ethernet Workstation (26) | SQL Server (2) | 392.00 μ s | 12.00 min |
| Small office database server's cli | Ethernet Workstation (27) | SQL Server | 393.00 μ s | 9.00 min |
| HTTP client | Ethernet Workstation (28) | HTTP Server (2) | 0.00 μ s | 0.00 μ s |
| HTTP client | Ethernet Workstation (29) | HTTP Server | 0.00 μ s | 0.00 μ s |
| HTTP client | Ethernet Workstation (30) | HTTP Server (2) | 400.00 μ s | 31.00 ms |
| File server's client | Ethernet Workstation (31) | File Server | 393.00 μ s | 11.00 min |
| File server's client | Ethernet Workstation (32) | File Server (2) | 391.00 μ s | 10.00 min |
| File server's client | Ethernet Workstation (33) | File Server | 393.00 μ s | 11.00 min |
| Small office database server's cli | Ethernet Workstation (34) | SQL Server (2) | 390.00 μ s | 12.00 min |
| Small office database server's cli | Ethernet Workstation (35) | SQL Server (2) | 392.00 μ s | 12.00 min |

Fig. 2.4. The Applications Statistics Report

The Module Statistical Items report of the Switched Ethernet server room is shown in Figure 2.5.

| Name | Statistical Item | Value |
|--------------------------|-------------------------|-----------------------|
| DECswitch 400 LAN Switch | Current utilization | 0.596639 % |
| | Average utilization | 0.614243 % |
| | Average delay | 1.11672e-005 s |
| | Average workload | 1.13036e+006 byte/sec |
| | Current workload | 1.09797e+006 byte/sec |
| | Packets for last second | 2198 packets |
| SQL Server | Average workload | 162158 byte/sec |

Fig. 2.5. The Module Statistical Items Report

Compared to the Ethernet network, the total network load dropped from 100 % to 43 %; the response time decreased by almost 2 times.

Make appropriate conclusions. Enter the values of the main characteristics (the response time, the network load, the communication equipment load) obtained on the simulation model of the Switched Ethernet network in the final table.

Laboratory work № 3

CONSTRUCTION OF SIMULATION LOCAL NETWORK MODEL BY FAST ETHERNET TECHNOLOGY

- Objective:
1. Get acquainted with Fast Ethernet technology.
 2. Examine the limitations of the Fast Ethernet physical layer specifications.
 3. Master the method of estimating the configuration of the Fast Ethernet network.
 4. Acquire practical skills of physical structuring of the network.

1. Individual task

Problem statement: on the basis of the given infrastructure (according to the variant of the individual task) to design a network on the basis of Fast Ethernet technology, to estimate its loading, response time and cost.

2. The sequence of execution

1. Get acquainted with Fast Ethernet technology (general and distinctive properties of Fast Ethernet from Ethernet, the limitations of the standards of the physical level of Fast Ethernet).

2. Make the transition to Fast Ethernet technology: justify the choice of physical environment for horizontal, vertical and campus subsystems.

3. Perform an analysis of all limitations of the standards in accordance with the chosen physical environment; justify the choice of communication equipment for physical structuring of the Fast Ethernet network.

4. Check the correctness of the configuration of the received network.

5. On the simulation model to determine the "threshold" of the network.

6. Calculate the cost of the built Fast Ethernet network.

7. Run on the simulation model of the Fast Ethernet network. Analyze the average load of network equipment and data transmission medium, as well as the response time for the data flow.

8. Prepare a report on laboratory work:

– theme and purpose of laboratory work;

– initial and additional data;

– substantiation of the required amount of communication equipment and its brief characteristics;

– structure of the Fast Ethernet network (with indication of distances, locations of servers and communication equipment);

– calculation of the correctness of the configuration of the Fast Ethernet network;

– found the "threshold" of the Fast Ethernet network;

– calculation of the cost of the Fast Ethernet network;

– printout of the report with the definition of the average load of network equipment and data transmission medium, as well as the response time for the data flow;

– conclusions.

9. Prepare to defend the topic "Fast Ethernet Technology".

3. Example of laboratory work (option № 43)

The physical structuring of the Fast Ethernet network should be based on the "single repeater" rule (Figure 3.1) or the "two repeater" rule (Figure 3.2).

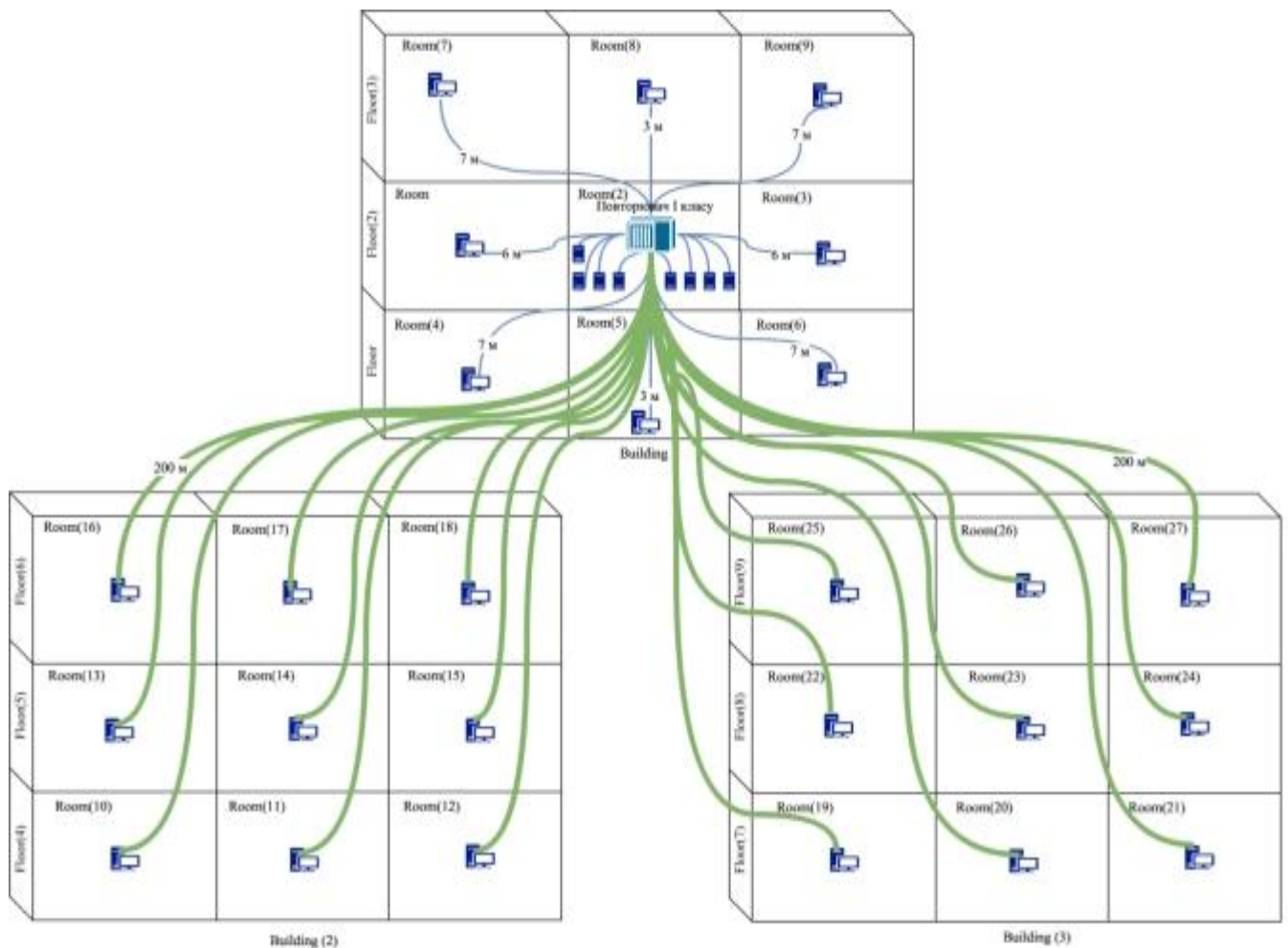


Fig. 3.1. Fast Ethernet network structure based on one repeater

Consider the first approach (Figure 3.1): when using a multiport repeater Fast Ethernet Class I, the size of the conflict zone is $200 + 200 = 400$ m (distance between buildings 200 m), and the maximum value of the conflict zone 260,8 m; this means that it is impossible to build a Fast Ethernet network.

Consider the second approach (Figure 3.2): when using two multiport Fast Ethernet Class II repeaters, the size of the conflict zone is $200 + 200 + 5 = 405$ m (distance between houses 200 m, distance between repeaters 5 m), and the maximum value of the conflict zone 216,2 m; this means that it is impossible to build a Fast Ethernet network.

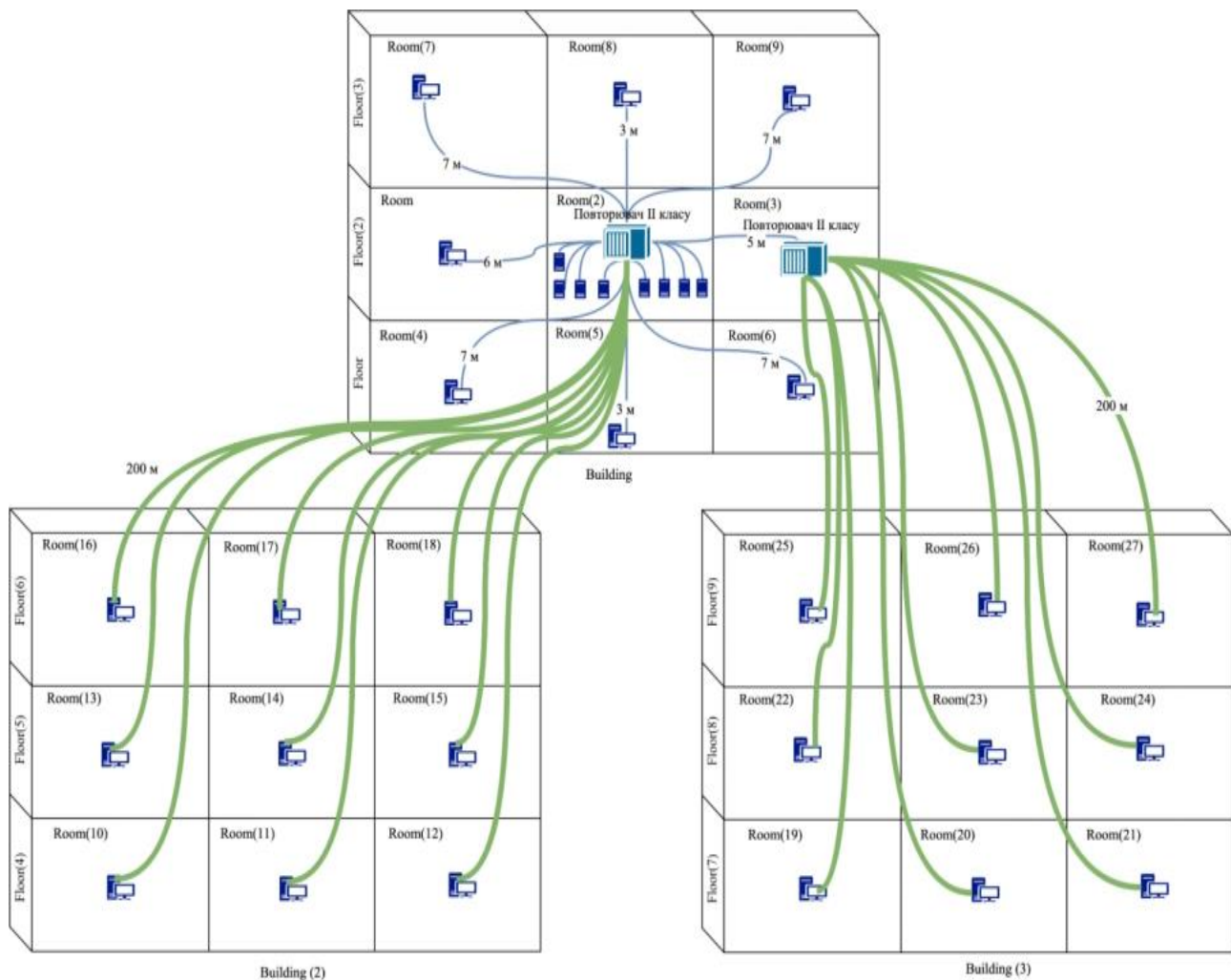


Fig. 3.2. The structure of the Fast Ethernet network based on two repeaters

Laboratory Work № 4

CONSTRUCTION OF SIMULATION LOCAL NETWORK MODEL BY SWITCHED FAST ETHERNET TECHNOLOGY

- Objective:
1. Get acquainted with the Switched Fast Ethernet technology.
 2. Study the general and distinctive properties of the I and II class repeaters.
 3. Acquire practical skills of logical structuring of the Fast Ethernet network.

1. Individual Task

Problem statement: on the basis of the given infrastructure (according to the variant of the individual task) design a network on the basis of Switched Fast Ethernet technology with the help of the NetCracker Pro program, estimate its loading, response time and cost.

2. The Sequence of Execution

1. Get acquainted with Fast Ethernet technology (class I and II repeaters, logical redundant codes).
2. Substantiate the need to solve the problem of logical structuring of the Fast Ethernet network (from the laboratory work № 3).
3. Analyze the location of the required number of communication equipment for logical structuring of the Fast Ethernet network.
4. Calculate the cost of the built network Switched Fast Ethernet.
5. Run on the simulation model of the Switched Fast Ethernet network. Analyze the average load of network equipment and data transmission environment as well as the response time for the data flow.
6. Compare the obtained characteristics (cost, response time and load) of Switched Ethernet and Fast Ethernet networks.
7. Compare the obtained characteristics (cost, response time and load) of the Fast Ethernet and Switched Fast Ethernet networks.
8. Prepare a report on the laboratory work:
 - the theme and the purpose of the laboratory work;
 - the substantiation of the required amount of the communication equipment and its brief characteristics;
 - the Switched Fast Ethernet network structure (with indication of the distances, the locations of the servers and the communication equipment);
 - the calculation of the cost of Switched Fast Ethernet;
 - the printout of the report with the definition of the average load of the network equipment and the data transmission medium as well as the response time for the data flow;
 - the conclusions.
9. Provide the teacher with computer simulation models built in the laboratory works № 1–3.
10. Prepare to defend the topic Fast Ethernet Technology.

3. Example of laboratory work (option № 43)

3.1. Development of the Switched Ethernet network structure. It is necessary to solve the problem of the logical structuring of the Fast Ethernet network using a switch. The structure of the corresponding network is presented in Figure 4.1.

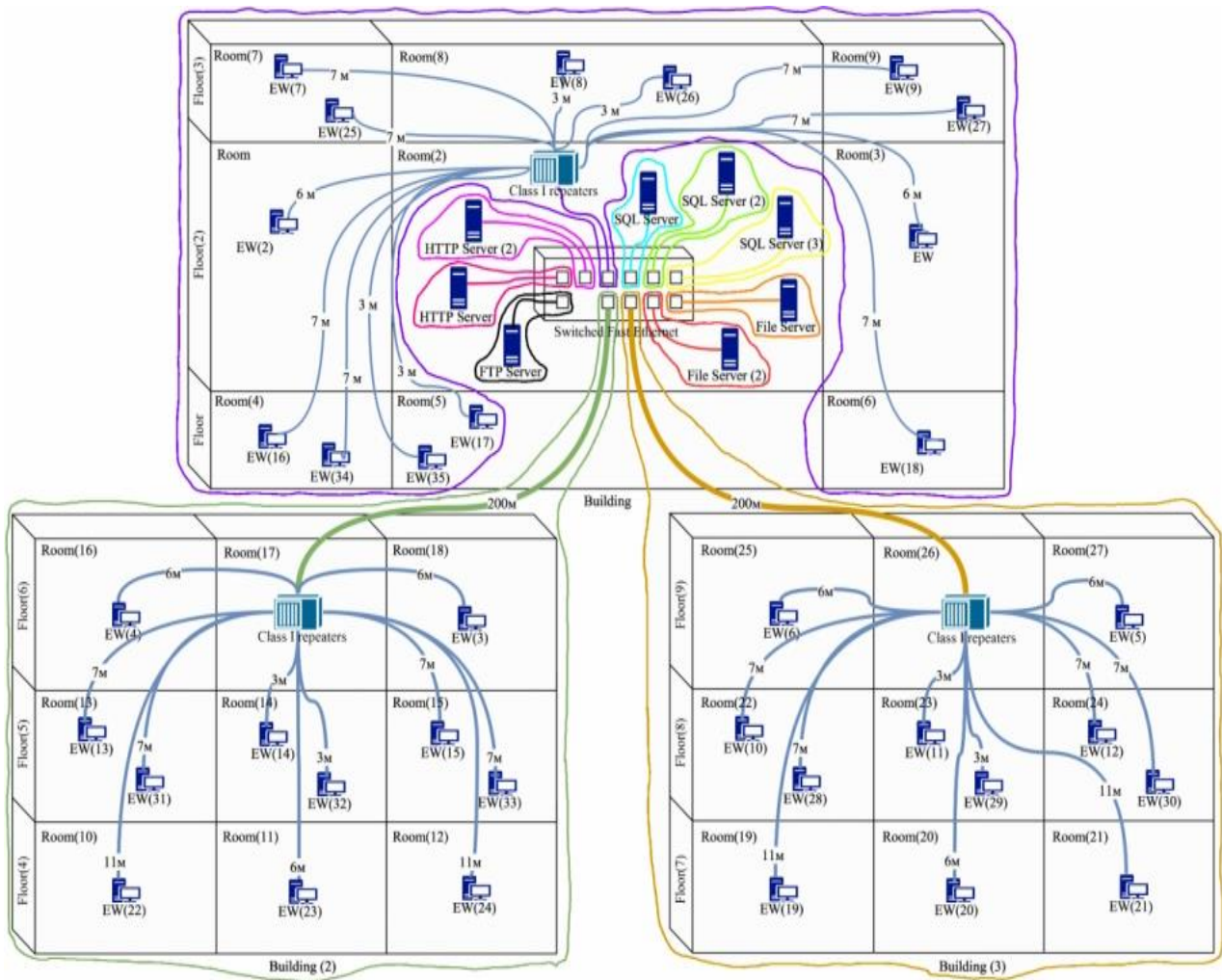


Fig. 4.1. The Switched Fast Ethernet network structure

With the introduction of the network switch, 11 conflict zones emerged: one conflict zone when connecting the hub to the Building; two identical zones of conflict when connecting hubs with Building 2 and Building 3; eight identical zones of conflict when connecting servers.

Estimation of the size of the conflict zone. For example, for a conflict zone based on Building 2, the following paths should be considered: the distance between the most remote workstations in the zone (Ethernet Workstation 22 and Ethernet Workstation 24); the path on which the repeaters are concentrated; the distance between the farthest station (Ethernet Workstation 22) and the switch.

Ethernet Workstation (22) → Ethernet Workstation (24) = 11+11=22 m;

Ethernet Workstation (22) → Switch Fast Ethernet = 211 m;

Ethernet Workstation (22) → Switch Fast Ethernet = 211 m;

$$\max\{22; 211; 211\} = 211 \text{ m} < 260,8 \text{ m.}$$

Estimation of the value of PDV. For example, for the conflict zone in Building 2:

$$PDV_1 = PDV_1 = 22 \cdot 1,112 + 100 + 140 = 264,464 \text{ bt;}$$

$$PDV_2 = 11 \cdot 1,112 + 200 \cdot 1 + 100 + 140 = 452,232 \text{ bt;}$$

$$PDV_3 = 11 \cdot 1,112 + 200 \cdot 1 + 100 + 140 = 452,232 \text{ bt} < 512 \text{ bt.}$$

The conflict zone in Building 3 coincides with the conflict zone in Building 2. For the conflict zone in the Building, the size of the conflict zone and the value of PDV must be determined separately.

Estimate the size of the Building conflict zone:

$$\text{Ethernet Workstation (16)} \rightarrow \text{Ethernet Workstation (18)} = 7+7=14 \text{ m};$$

$$\text{Ethernet Workstation (16)} \rightarrow \text{Switch Fast Ethernet} = 7 \text{ m};$$

$$\text{Ethernet Workstation (16)} \rightarrow \text{Switch Fast Ethernet} = 7 \text{ m};$$

$$\max\{14; 7; 7\} = 7 \text{ m} < 200 \text{ m.}$$

Estimation of the value of the PDV Building:

$$PDV_1 = 14 \cdot 1,112 + 100 + 140 = 255,568 \text{ bt}; \quad PDV_2 = 7 \cdot 1,112 + 100 + 140 = 247,784 \text{ bt};$$

$$PDV_3 = 7 \cdot 1,112 + 100 + 140 = 247,784 \text{ bt, отже } \max\{255,568; 247,784; 247,784\} = 255,568 \text{ bt} < 512 \text{ bt.}$$

The server conflict zones are completely the same, so the conflict zone definition and the PDV value are calculated once.

Estimation of the size of the server conflict zone: Ethernet Server \rightarrow Switch Fast Ethernet = 1 m; $\max\{1\} = 1 \text{ m} < 200 \text{ m.}$

3.2. Building a simulation model of the Switch Fast Ethernet network in NetCracker Pro. Copy the file in which the simulation model Switched Ethernet is located (Lab № 2).

All Ethernet hubs need to be replaced with Class I Ethernet Multiport Repeaters. For the Fast Ethernet specification on 100Base-TX twisted pair, 100Base-FX fiber optic cable.

Class I Ethernet Rackmount Hubs FEH-16s is used as a Class I repeater, which is located: Alloy Computer Products \rightarrow Fast Ethernet Rackmount Hubs FEH-16s; add the Fiber Optic Uplink Port module. The repeater has 16 100Base-TX ports and 1 100Base-FX port; the maximum delay is 1,4 μs .

Replace the Ethernet switch with a Fast Ethernet switch. As a switch we use BayStack 450-12-T, which is located: Switches \rightarrow Workgroup \rightarrow Ethernet \rightarrow Bay Network \rightarrow BayStack 450-12-T; add the BayStack 400-2FX 2-port 100Base-FX module. The switch has 12 ports for 100Base-TX and 2 ports for 100Base-FX.

When connecting workstations to the repeater, you need to make the settings shown in Figure 4.2.

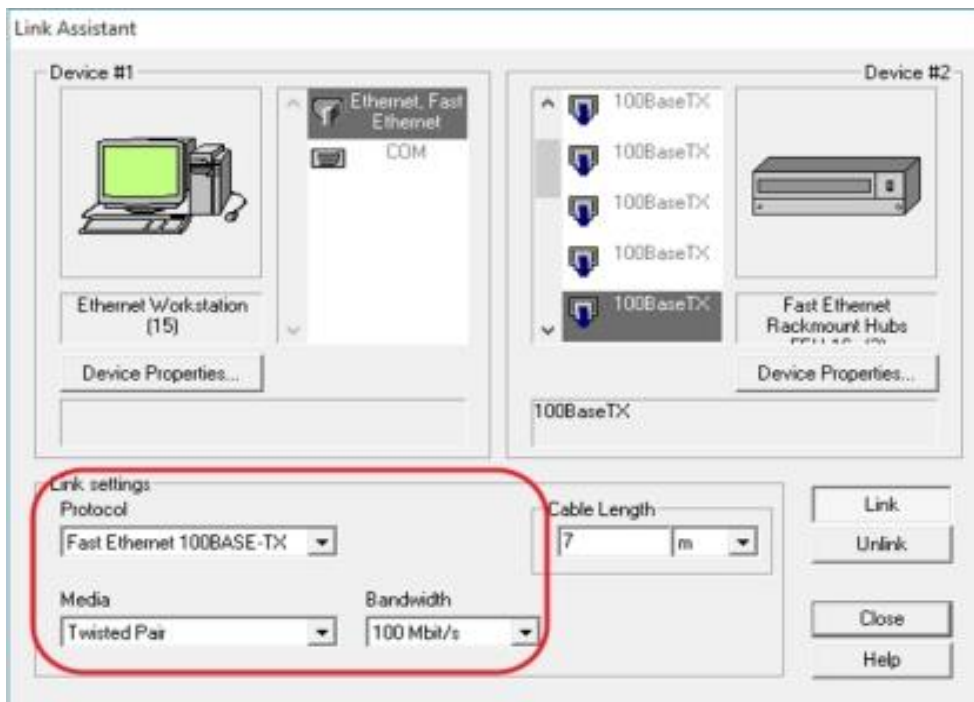


Fig. 4.2. Setting the parameters of the vertical subsystem

The same settings are used for connecting servers to the switch.

By connecting the repeaters (Building 2 and Building 3) with the switch (Building), the settings are performed as follows (Figure 4.3).

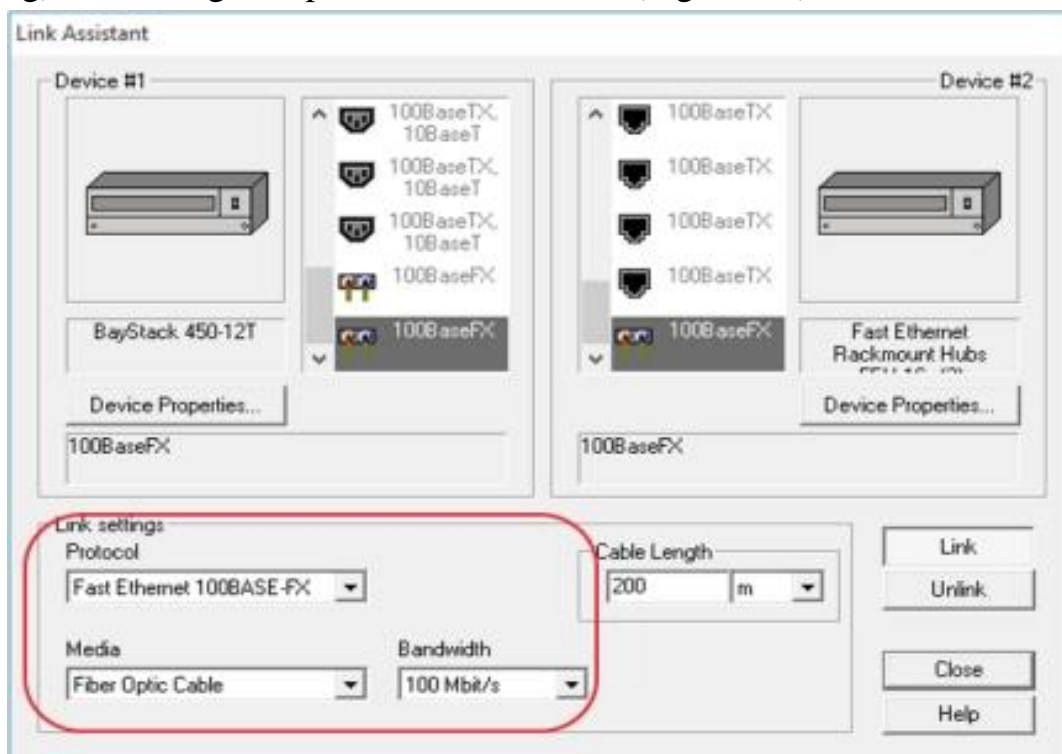


Fig. 4.3. Setting the Campus settings

Since the Class I repeater is selected, it is necessary to set the corresponding delay equal to 1,4 μ s (delay for the Class I repeater is 140 bt, 1 bt = 0,01 μ s, ie 140 bt

= 1,4 μ s). Do a click of the right button of the mouse on the repeater: Properties \rightarrow Telecom \rightarrow Latency. The result is shown in Figure 4.4.



Fig. 4.4. The Class I repeater delay task

We are launching a simulation model Switch Fast Ethernet. The model must work without failures.

3.3. Conducting experiments on the simulation model Switch Fast Ethernet. The start of the Switch Fast Ethernet simulation model is performed at a certain Ethernet performance threshold (35 workstations). The experiments are carried out under the same conditions as in previous simulation models (network uptime, packets size, packet sending interval).

The LAN Segments Statistics report obtained from the Switched Fast Ethernet simulation model is shown in Figure 4.5.

| Name | Vendor | Utilization | Workload | Packet delay |
|--|-------------------------|-------------|---------------|---------------|
| Fast Ethernet Rackmount Hubs FEH-16s | Alloy Computer Products | 4.0 % | 4 Mbit/sec | 57.00 μ s |
| Fast Ethernet Rackmount Hubs FEH-16s (2) | Alloy Computer Products | 1.0 % | 127 Kbyte/sec | 38.00 μ s |
| Fast Ethernet Rackmount Hubs FEH-16s (3) | Alloy Computer Products | 0.0 % | 97 Kbit/sec | 38.00 μ s |

Fig. 4.5. The LAN Segments Statistics Report

The figure shows that the load of the central hub in the Switch Fast Ethernet network compared to Ethernet (100 %) and Switched Ethernet (43 %) fell to 4 %.

The Applications Statistics report is shown in Figure 4.6.

| Name | Source | Destination | Travel time | Response time |
|------------------------------------|---------------------------|-----------------|---------------|---------------|
| Small office database server's cli | Ethernet Workstation | SQL Server (3) | 67.00 μ s | 5.00 min |
| Small office database server's cli | Ethernet Workstation (2) | SQL Server (3) | 67.00 μ s | 5.00 min |
| File server's client | Ethernet Workstation (3) | File Server (2) | 6.00 ms | 0.00 μ s |
| File server's client | Ethernet Workstation (4) | File Server | 6.00 ms | 0.00 μ s |
| HTTP client | Ethernet Workstation (5) | HTTP Server (2) | 55.00 μ s | 30.00 ms |
| HTTP client | Ethernet Workstation (6) | HTTP Server (2) | 61.00 μ s | 30.00 ms |
| FTP client | Ethernet Workstation (7) | FTP Server | 76.00 μ s | 29.00 ms |
| Small office database server's cli | Ethernet Workstation (8) | SQL Server (2) | 66.00 μ s | 7.00 min |
| Small office database server's cli | Ethernet Workstation (9) | SQL Server | 67.00 μ s | 5.00 min |
| HTTP client | Ethernet Workstation (10) | HTTP Server | 62.00 μ s | 30.00 ms |
| HTTP client | Ethernet Workstation (11) | HTTP Server | 53.00 μ s | 30.00 ms |
| HTTP client | Ethernet Workstation (12) | HTTP Server (2) | 56.00 μ s | 30.00 ms |
| File server's client | Ethernet Workstation (14) | File Server | 6.00 ms | 0.00 μ s |
| File server's client | Ethernet Workstation (15) | File Server (2) | 6.00 ms | 0.00 μ s |
| File server's client | Ethernet Workstation (13) | File Server (2) | 6.00 ms | 21.00 ms |
| Small office database server's cli | Ethernet Workstation (16) | SQL Server | 66.00 μ s | 5.00 min |
| Small office database server's cli | Ethernet Workstation (17) | SQL Server (2) | 66.00 μ s | 7.00 min |
| Small office database server's cli | Ethernet Workstation (18) | SQL Server (3) | 67.00 μ s | 5.00 min |
| HTTP client | Ethernet Workstation (19) | HTTP Server (2) | 59.00 μ s | 31.00 ms |
| HTTP client | Ethernet Workstation (20) | HTTP Server (2) | 59.00 μ s | 30.00 ms |
| HTTP client | Ethernet Workstation (21) | HTTP Server | 58.00 μ s | 30.00 ms |
| File server's client | Ethernet Workstation (22) | File Server | 6.00 ms | 0.00 μ s |
| File server's client | Ethernet Workstation (23) | File Server (2) | 6.00 ms | 0.00 μ s |
| File server's client | Ethernet Workstation (24) | File Server | 6.00 ms | 0.00 μ s |
| FTP client | Ethernet Workstation (25) | FTP Server | 59.00 μ s | 29.00 ms |
| Small office database server's cli | Ethernet Workstation (26) | SQL Server (2) | 67.00 μ s | 7.00 min |
| Small office database server's cli | Ethernet Workstation (27) | SQL Server | 66.00 μ s | 5.00 min |
| HTTP client | Ethernet Workstation (28) | HTTP Server (2) | 55.00 μ s | 31.00 ms |
| HTTP client | Ethernet Workstation (29) | HTTP Server | 51.00 μ s | 31.00 ms |
| HTTP client | Ethernet Workstation (30) | HTTP Server (2) | 59.00 μ s | 31.00 ms |
| File server's client | Ethernet Workstation (31) | File Server | 7.00 ms | 0.00 μ s |
| File server's client | Ethernet Workstation (32) | File Server (2) | 6.00 ms | 0.00 μ s |
| File server's client | Ethernet Workstation (33) | File Server | 6.00 ms | 0.00 μ s |
| Small office database server's cli | Ethernet Workstation (34) | SQL Server (2) | 67.00 μ s | 7.00 min |
| Small office database server's cli | Ethernet Workstation (35) | SQL Server (2) | 67.00 μ s | 7.00 min |

Fig. 4.6. Applications Statistics Report

The figure shows that the maximum response time in Switched Fast Ethernet is 7 minutes, which is 42 % less than that ones in Switched Ethernet (maximum response time is 12 minutes), and 3 times less than in Ethernet.

The Module Statistical Items report of the server room is shown in Figure 4.7.

| Name | Statistical Item | Value |
|--|---------------------------------|-----------------|
| BayStack 450-12T | Current utilization | 0 % |
| | Average utilization | 0 % |
| | Average delay | 1.00619e-005 s |
| | Average workload | 635262 byte/sec |
| | Current workload | 621096 byte/sec |
| | Packets for last second | 1751 packets |
| | Packets dropped for last second | 0 packets |
| BayStack 400-2FX 2-port 100BASE-FX MDA | Average workload | 0 byte/sec |
| | Current workload | 0 byte/sec |
| | Current utilization | 0 % |
| | Average utilization | 0 % |
| | Packets for last second | 0 packets |
| | Packets dropped for last second | 0 packets |
| | Average delay | 0 s |

Fig. 4.7. Module Statistical Items Report

Compared to Ethernet (100 %) and Switched Ethernet (43 %), the overall load of the Switch Fast Ethernet network dropped to 4 %.

Draw the appropriate conclusions. Enter the values of the main characteristics (response time, network congestion, communication equipment congestion) obtained on the simulation model of the Switched Fast Ethernet network in the final table.

Laboratory Work № 5

CONSTRUCTION OF SIMULATION MODEL OF LOCAL NETWORK USING TOKEN RING TECHNOLOGY

Objective: 1. Get acquainted with Token Ring technology.
2. Study the features of marker access methods.
3. Acquire practical skills in solving the problem of physical structuring of the Token Ring network.

1. Individual Task

Problem statement: on the basis of the given infrastructure (according to the variant of the individual task) with the help of NetCracker Pro, to design a network on the basis of Token Ring technology, to estimate its loading, response time, and cost.

2. The Sequence of Execution

1. Get acquainted with Token Ring technology (logical and physical topology of the network; the retention time and the maximum turnover of the marker; the diagram of the channel level states by the marker method of the access to the ring; the data frame formats and the marker).

2. Study the purpose of the communication equipment for physical structuring of the network.

3. Get from the teacher a variant of the individual task (Table 4-6).

4. Choose a physical environment for horizontal and vertical subsystems and campus subsystems; justify the choice.

5. Perform an analysis of all standards constraints according to the chosen physical environment; justify the choice of communication equipment for the physical structuring of the Token Ring network.

6. Determine the "threshold" of the Token Ring network on the simulation model: the number of workstations, the intensity of requests, the length of the frame.

7. Calculate the cost of the built network Token Ring.

8. Start the simulation model of the Token Ring network. Analyze the average load of the network equipment and data transmission environment as well as the

response time for the data flow. Specify areas of the network that are vulnerable to congestion.

9. Make a report on the laboratory work:

- topic and purpose of laboratory work;
 - initial and additional data;
 - substantiation of the required amount of the communication equipment and its brief characteristics;
 - structure of Token Ring network (with indication of distances, locations of servers and communication equipment);
 - found the threshold of the Token Ring network;
 - calculation of the cost of the Token Ring network;
 - printout of the report with the definition of all characteristics;
 - conclusions.
10. Prepare to defend the topic Marker Technologies.

3. Example of laboratory work (option № 43)

3.1. Development of the structure of the Token Ring network. For the Campus subsystem, the best type of cable is fiber optic; for vertical and horizontal subsystems, one of the possible options is using UTP Cat 3.

The first step is to determine if it is possible to build a computer network using Token Ring technology without hubs/concentrators. When directly connecting workstations to the ring, the length of the physical segment is $200 \text{ m} + 7 \text{ m} = 207 \text{ m}$ which exceeds the maximum length of the physical segment of the network that is 100 m. It is necessary to carry out the physical structuring of the Token Ring network, the structure of the corresponding network is presented in Figure 5.1.

Since the maximum cable length between the hubs concentrators is 45 m and the distance between the houses is 200 m, 3 hubs concentrators are connected to each other in a ring (the distance between them is 20 m), and the other three of them connect the houses to the logic ring. Therefore, 6 hubs concentrators (MSAUs) must be installed between the buildings, which are interconnected via Ring In / Ring Out (RI / RO) ports.

SuperStack LinkBuilder FMS TR 24 Stackable Hub and 16 Meg Token Ring Repeater Module are used to build a simulation network model. The main parameters of these hubs concentrators: bandwidth is 16 Mbps, the number of ports SuperStack LinkBuilder FMS TR 24 Stackable Hub is 27, of which 13 are used; number of ports 16 Meg Token Ring Repeater Module is 3 ports; filtering speed is 400,000 packets/s, data rates are 4 and 16 Mbps.

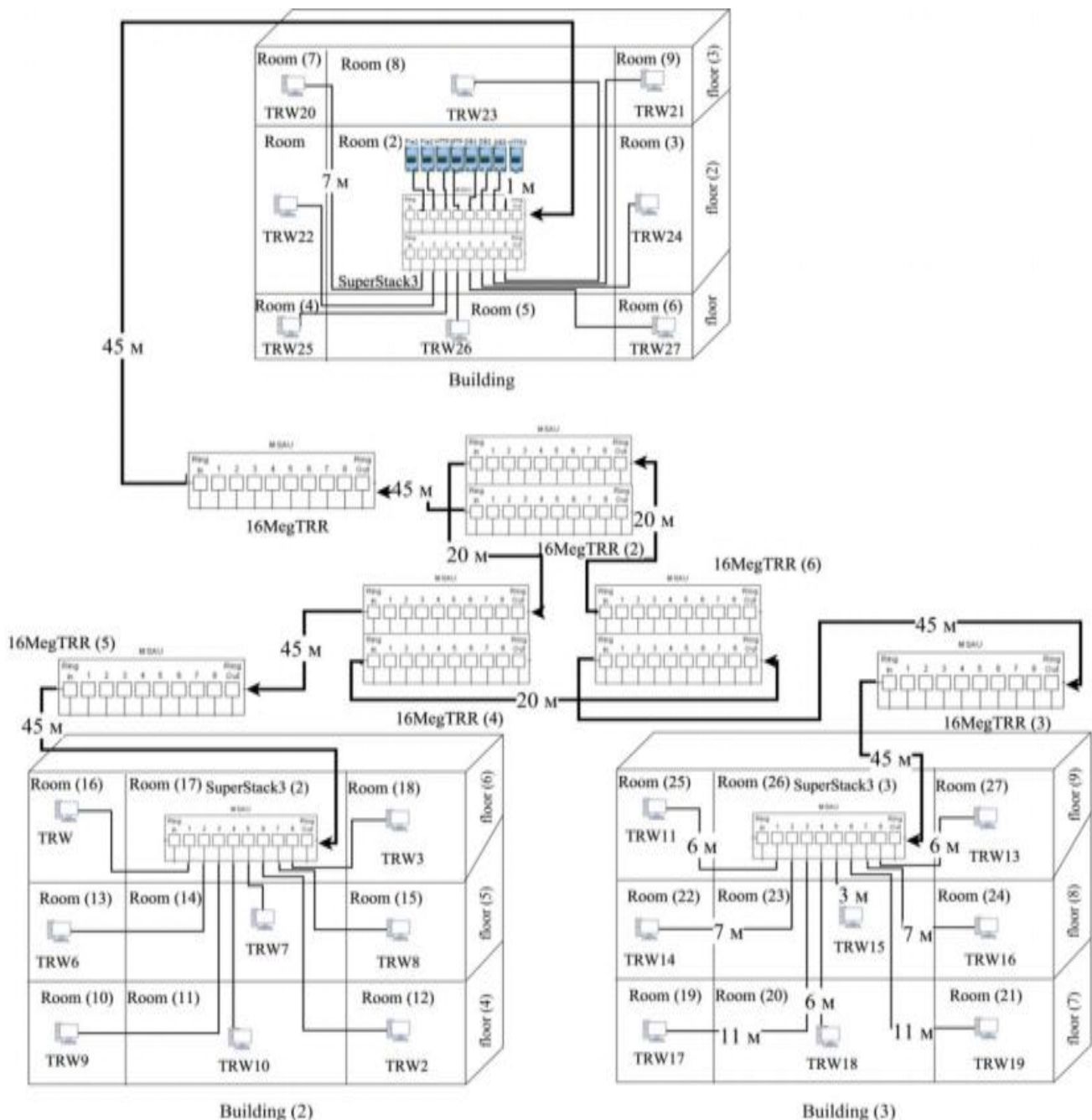





Fig. 5.1. Physical structuring of the Token Ring network

3.2. Construction of a simulation model of the Token Ring network. Start Net

Cracker Pro. Create a new project: File → New (). Save the project immediately:

File → Save (), select a folder to save and click OK. When creating a project, the *Top* window will open. In the Devices tab (on the left side of the panel), select Buildings, Campuses and LAN workgroups. From the bottom of the window, drag



the Campus () to the clear field of the *Top* window. To place houses on campus, right click on Campus and select Expand from the context menu. A new Campus




window will be opened. From the bottom panel (Devices tab), drag  to the clear field of the Campus window. Thus, the campus subsystem is created (Figure 5.2).



Fig. 5.2. Creating a Campus subsystem

It is necessary to make three floors in each house ( , Figure 5.3), with three rooms on each floor ( , Figure 5.4).

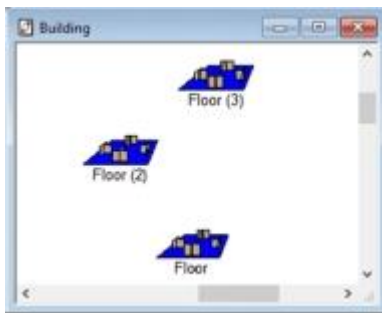


Fig. 5.3. Creating a vertical subsystem Fig. 5.4. Creating a horizontal subsystem

The structure of the network can be viewed on the Project Hierarchy tab in the left panel (Figure 5.5).

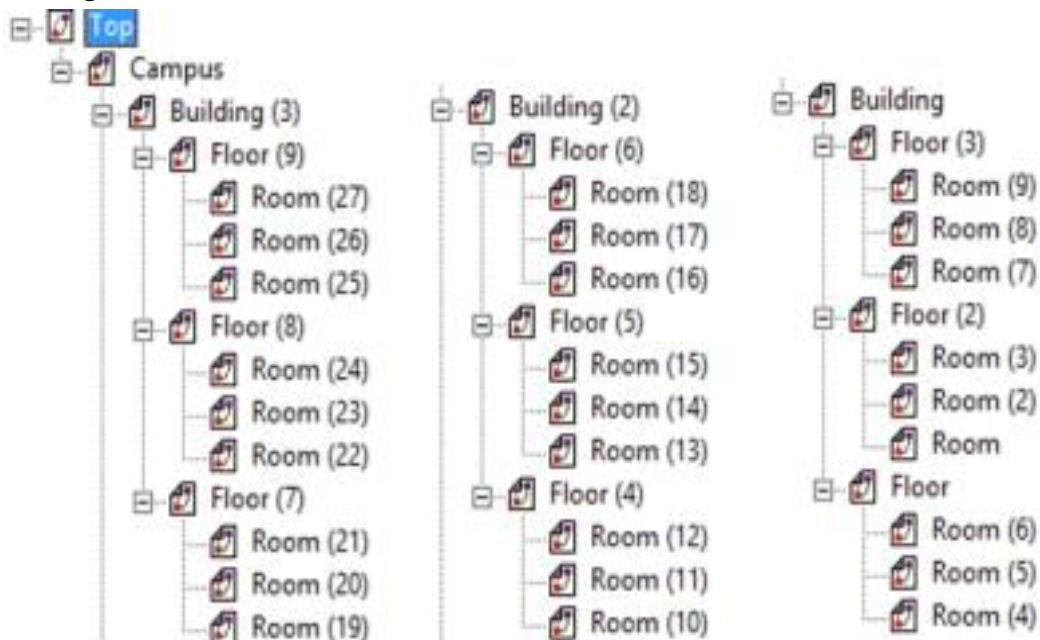




Fig. 5.5. Hierarchy of network simulation model

To build a simulation model of the Token Ring network, you must use Token

Ring Server servers which are located on the Devices → Lan Servers tab ();
 Token Ring Workstations which are also located on the Devices tab → Lan Workstations ().

Install the server software as follows: Devices → Network and Enterprise software → Server Software ().

Hubs located in vertical subsystems are as follows (Figure 5.6): Devices → Hubs → Shared Media → Token Ring → 3Com Corp. → SuperStack LinkBuilder FMS TR 24 Stackable Hub.

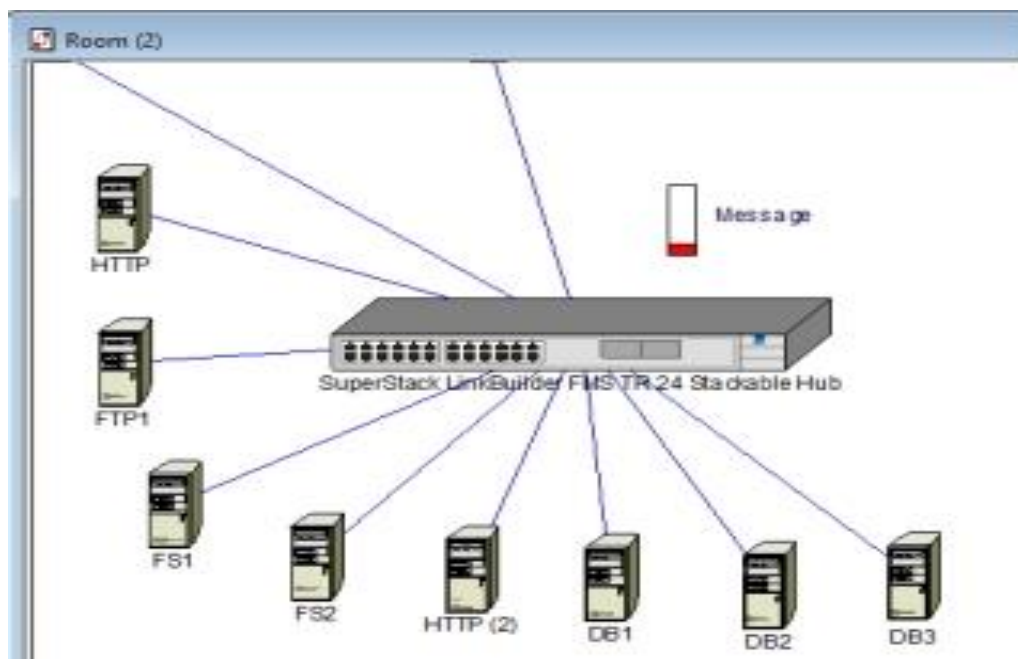


Fig. 5.6. Hub for the vertical subsystem

MSAU required in the campus subsystem is as follows (Figure 5.7): Devices → Hubs → Shared Media → Token Ring → Black Box Corp.

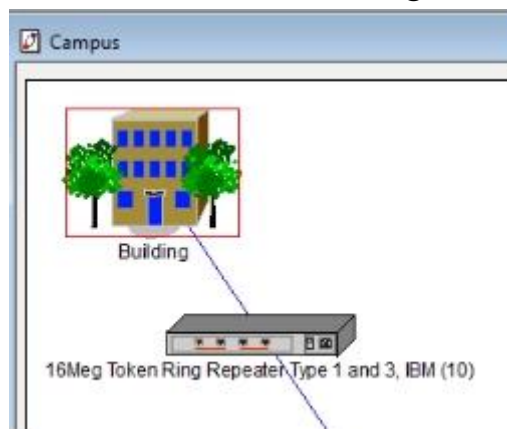




Fig. 5.7. Hub for campus subsystem

Set the logical ring that is located in the Devices tab → Generic LANs →



Token Ring ().

Connect the hubs, servers and workstations according to the network structure (see Figure 5.1). To do this, click  on the toolbar, then on the workstation, then on the hub; the Link Assistant window will be opened.

In the Link Assistant window (Figure 5.8) select the Token Ring ports for the workstation and the hub; set the cable length in the Length field (for example, 3 m to connect the workstation in Room 8 to the hub); data transfer rate from the list in the Bandwidth field (4 or 16 Mbps); Media → Twisted Pair; Protocol → Token Ring and click Link.

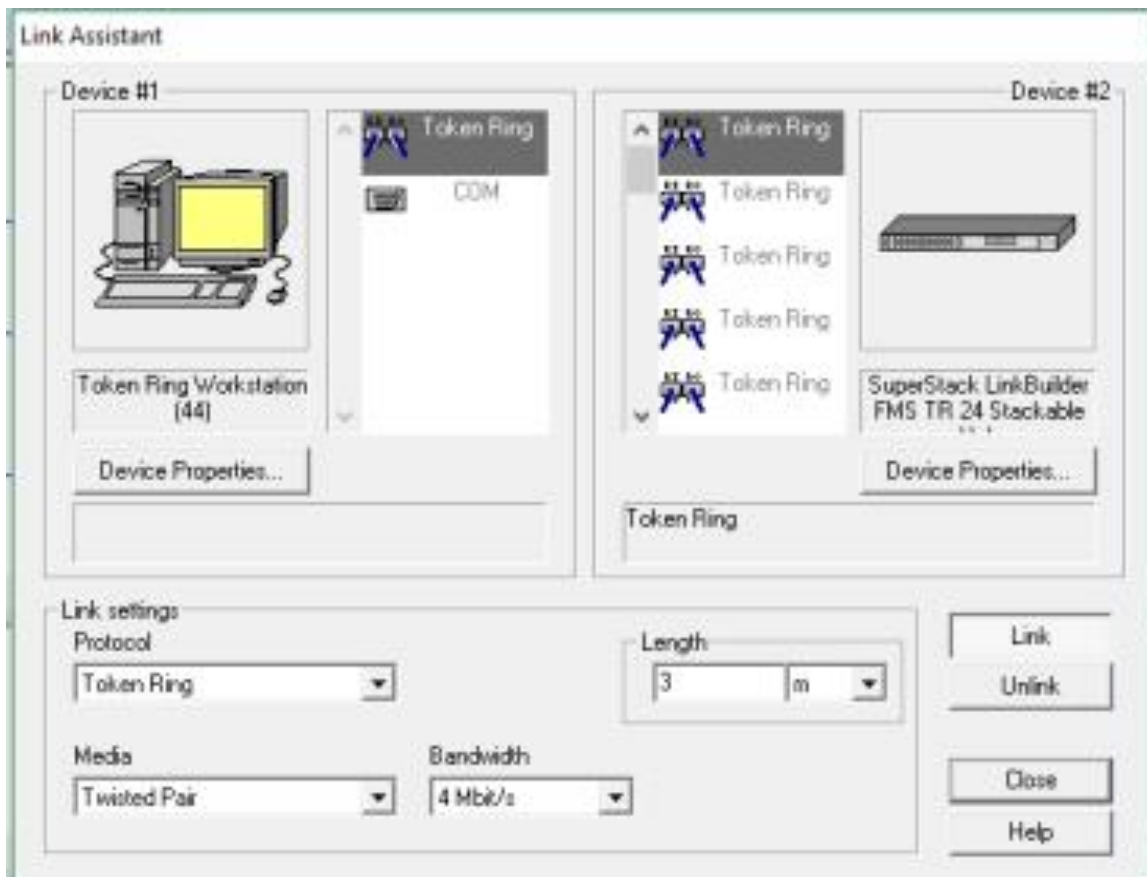


Fig. 5.8. Setting the parameters of the horizontal subsystem

Similarly, connect the server to the hub (Figure 5.9).

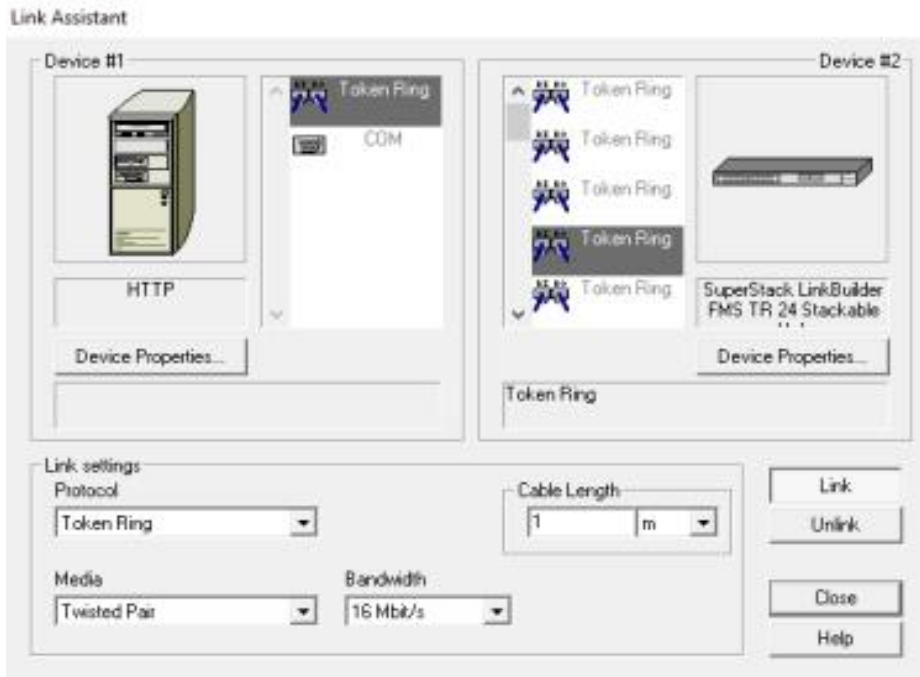


Fig. 5.9. Task parameters of the campus subsystem


3.3. Determining the threshold of the Token Ring network performance on the simulation model. To determine the performance threshold, you must add one workstation to the network and configure the data transfer to the servers for each workstation. To configure data transfer press  on the toolbar (above); on the workstation, and then on the server to which we send data; the Profiles window will be opened, which is shown in Figure 5.10.



Fig. 5.10. Working with the Profiles window

In the Profiles window, select the item whose name matches the server name, such as the FTP client, and click Assign.

Run the simulation model by clicking Start (). The movement of the packets is displayed on the model. If  appears somewhere in the network, the

network is congested (Figure 5.11), ie the threshold of the Token Ring network is 7 stations.

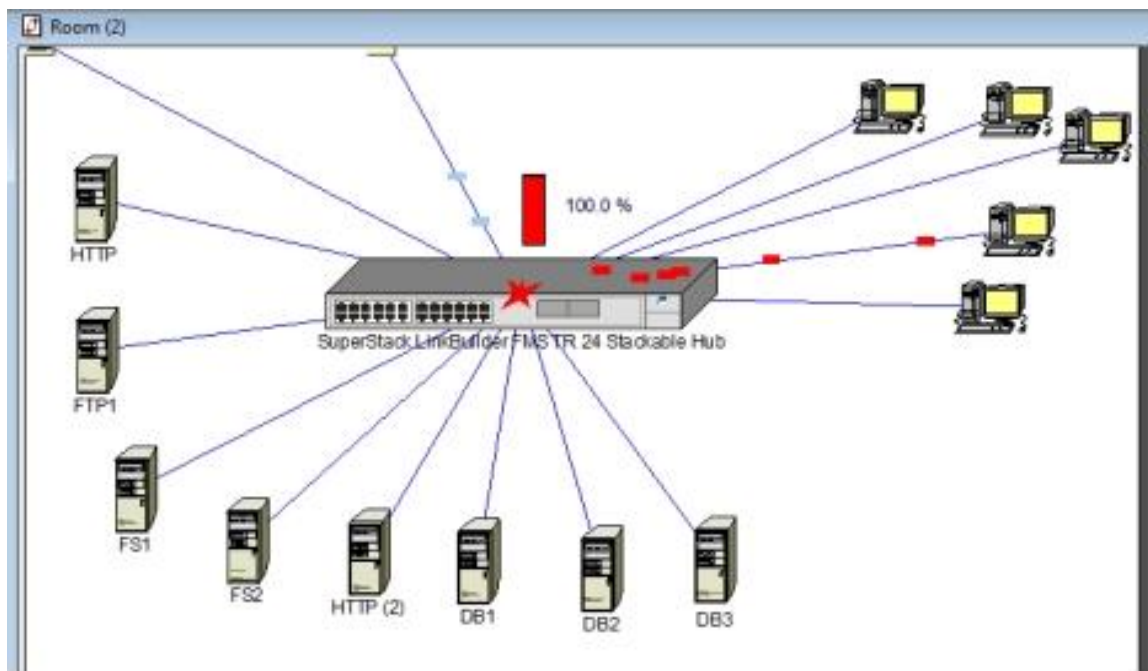


Fig. 5.11. The fall of the Token Ring network at 8 stations

Therefore, the Token Ring simulation model will not be able to work with 35 workstations (this is the Ethernet performance threshold found in Lab № 1).

3.4. Conducting experiments on the simulation model Token Ring. The conditions of the experiment on the simulation model Token Ring are the same as in the Laboratory Work № 1: the simulation model should work for 7 minutes; the packets from 500 to 1000 bytes are transmitted; every 0,02 s by exponential law.

To get network statistics, use the Report Wizard: Tools → Reports → Wizard. In the window Select a report (Figure 5.12) select LAN → LAN Segment Statistics.

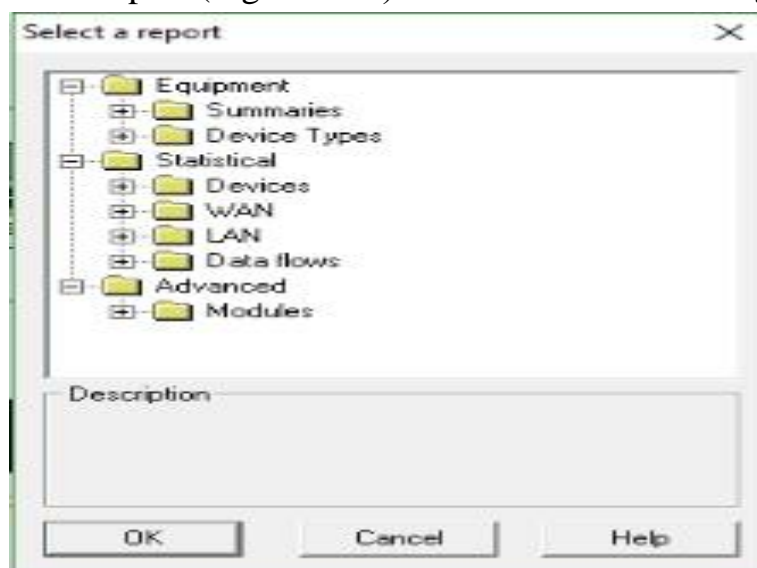


Fig. 5.12. Working with the Select a report window

As a result of the Master's work we get the report "LAN Segment Statistics", which is presented in Figure 5.13.

| Name | Vendor | Utilization | Workload | Packet delay |
|--|-----------------|-------------|------------|--------------|
| 16Meg Token Ring Repeater Type 1 and 3, IBM | Black Box Corp. | 19.0 % | 3 Mbit/sec | 253.00 μs |
| 16Meg Token Ring Repeater Type 1 and 3, IBM (10) | Black Box Corp. | 19.0 % | 3 Mbit/sec | 253.00 μs |
| 16Meg Token Ring Repeater Type 1 and 3, IBM (12) | Black Box Corp. | 19.0 % | 3 Mbit/sec | 253.00 μs |
| 16Meg Token Ring Repeater Type 1 and 3, IBM (3) | Black Box Corp. | 19.0 % | 3 Mbit/sec | 253.00 μs |
| 16Meg Token Ring Repeater Type 1 and 3, IBM (7) | Black Box Corp. | 19.0 % | 3 Mbit/sec | 253.00 μs |
| 16Meg Token Ring Repeater Type 1 and 3, IBM (9) | Black Box Corp. | 19.0 % | 3 Mbit/sec | 253.00 μs |
| SuperStack LinkBuilder FMS TR 24 Stackable Hub | 3Com Corp. | 19.0 % | 3 Mbit/sec | 253.00 μs |
| LinkBuilder FMS TR Copper RI/RO Module | 3Com Corp. | 0.0 % | 0 bit/sec | 0.00 μs |
| SuperStack LinkBuilder FMS TR 24 Stackable Hub (2) | 3Com Corp. | 19.0 % | 3 Mbit/sec | 253.00 μs |
| SuperStack LinkBuilder FMS TR 24 Stackable Hub (4) | 3Com Corp. | 19.0 % | 3 Mbit/sec | 253.00 μs |
| Token Ring | | 19.0 % | 3 Mbit/sec | 253.00 μs |

Fig. 5.13. LAN Segment Statistics Report

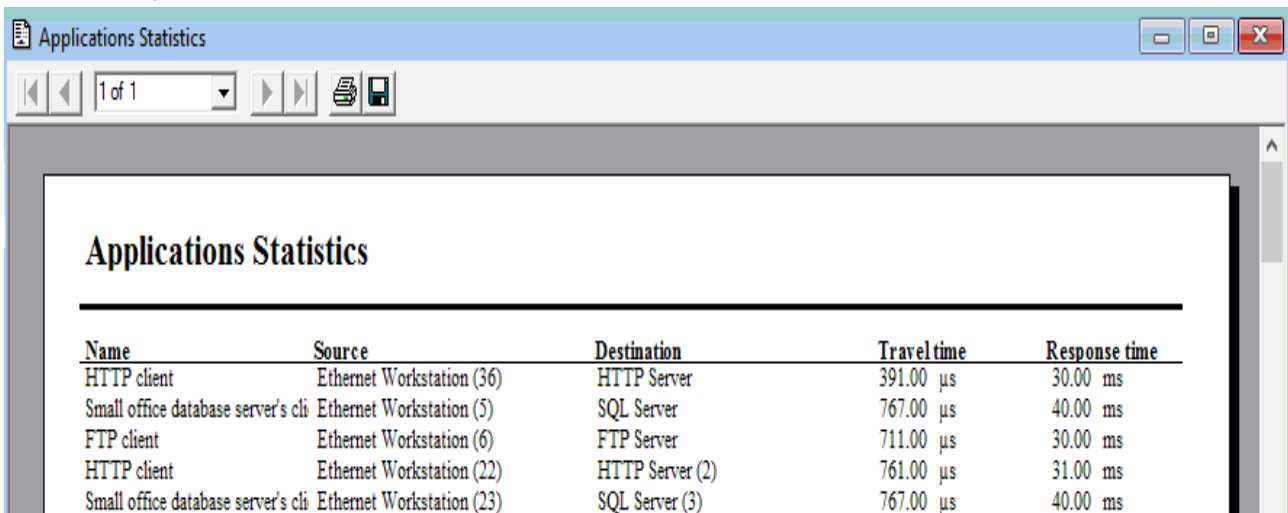
The figure shows that the occupancy of the Token Ring is 19 % which is approximately 1,8 times bigger than the occupancy of the Ethernet network.

To determine the maximum network response time for a data stream and to assign traffic in the Select a report window you should opt: Data Flows → Application Statistics. The resulting report is shown in Figure 5.14.

| Name | Source | Destination | Travel time | Response time |
|------------------------------------|-----------------------------|-------------|-------------|---------------|
| HTTP client | Token Ring Workstation | HTTP | 6.00 ms | 37.00 ms |
| Small office database server's cli | Token Ring Workstation (6) | DB1 | 40.00 ms | 86.00 ms |
| FTP client | Token Ring Workstation (18) | FTP1 | 39.00 ms | 69.00 ms |
| HTTP client | Token Ring Workstation (40) | HTTP | 6.00 ms | 37.00 ms |
| Small office database server's cli | Token Ring Workstation (43) | DB3 | 6.00 ms | 50.00 ms |

Fig. 5.14. Application Statistics report for Token Ring network

The figure shows that the maximum response time for the Token Ring network is 86 ms (with 7 workstations) which is approximately 2,15 times longer than on the Ethernet network: the response time of the Ethernet network with 7 workstations is 40 ms (Figure 5.15) .

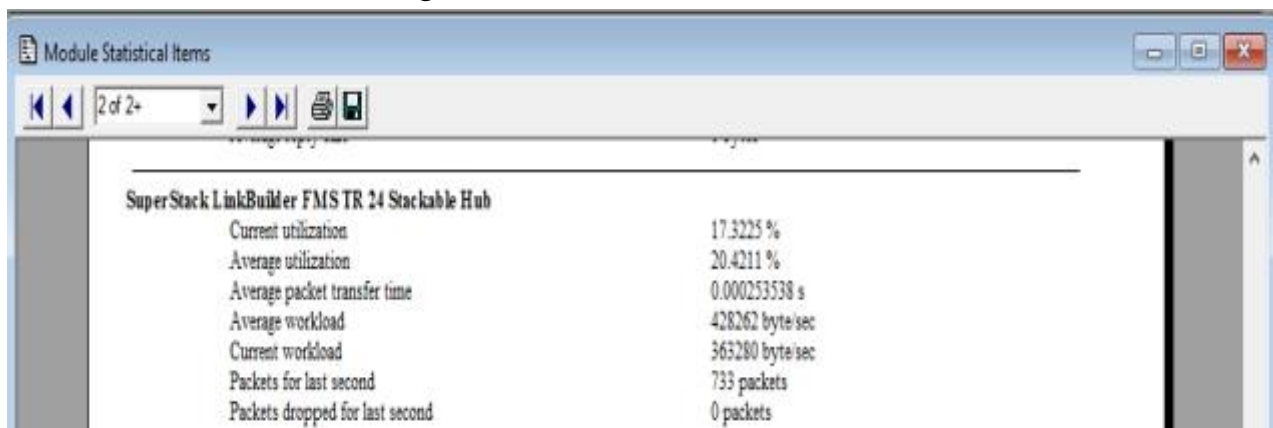


The screenshot shows a window titled 'Applications Statistics' with a table of application performance data. The table has five columns: Name, Source, Destination, Travel time, and Response time. The data is as follows:

| Name | Source | Destination | Travel time | Response time |
|------------------------------------|---------------------------|-----------------|-------------|---------------|
| HTTP client | Ethernet Workstation (36) | HTTP Server | 391.00 μs | 30.00 ms |
| Small office database server's cli | Ethernet Workstation (5) | SQL Server | 767.00 μs | 40.00 ms |
| FTP client | Ethernet Workstation (6) | FTP Server | 711.00 μs | 30.00 ms |
| HTTP client | Ethernet Workstation (22) | HTTP Server (2) | 761.00 μs | 31.00 ms |
| Small office database server's cli | Ethernet Workstation (23) | SQL Server (3) | 767.00 μs | 40.00 ms |

Fig. 5.15. Application Statistics Report for Ethernet

To obtain the network characteristics of a particular part of the network (for example, the server room), in the window Select a report you should opt: Modules → Module Statistical Items and select the desired room. As a result, the report "Module Statistical Items" is built (Figure 5.16).



The screenshot shows a window titled 'Module Statistical Items' displaying performance metrics for a 'SuperStack LinkBuilder FMSTR 24 Stackable Hub'. The data is as follows:

| | |
|---------------------------------|-----------------|
| Current utilization | 17.3225 % |
| Average utilization | 20.4211 % |
| Average packet transfer time | 0.000253538 s |
| Average workload | 428262 byte/sec |
| Current workload | 363280 byte/sec |
| Packets for last second | 733 packets |
| Packets dropped for last second | 0 packets |

Fig. 5.16. The report Module Statistical Items for the Token Ring network

The figure shows that the load of the hub from the server room is 17,3225 % which is approximately 2 times less than in the Ethernet network: the load of the hub from the server room for the Ethernet network is 35,2168 % (Figure 5.17).

| LinkBuilder ECS 4-slot | |
|---------------------------------|------------------|
| Current utilization | 35.2168 % |
| Average utilization | 35.2535 % |
| Average packet transfer time | 0.000383455 s |
| Average workload | 3.52535 Mbit/sec |
| Current workload | 461593 byte/sec |
| Packets for last second | 933 packets |
| Packets dropped for last second | 0 packets |

Fig. 5.17. Module Statistical Items report for Ethernet

Enter to the final table the values of the main characteristics (maximum response time, network load, equipment load) obtained on the simulation model of the Token Ring network; draw appropriate conclusions.

Laboratory Work № 6

CONSTRUCTION OF SIMULATION LOCAL NETWORK MODEL USING SWITCHED TOKEN RING TECHNOLOGY

- Objective:
1. To get acquainted with the performance characteristics of switches.
 2. To study the structural diagrams of networks on switches.
 3. Acquire practical skills of logical structuring of the Token Ring network.

1. Individual Task

Problem statement: on the basis of the given infrastructure (according to the variant of the individual task), to design with the help of the NetCracker Pro program a network on the basis of Switched Token Ring technology, to estimate its loading, response time and cost.

2. The Sequence of Execution

1. Get acquainted with Token Ring technology (the algorithm for an early release of the marker; the mechanism for setting the priorities and their processing; the control procedures).
2. Study the purpose of the communication equipment of the logical structuring of the network, the general and characteristic properties of the bridge and switch.
3. Substantiate the need to solve the problem of the logical structuring of the Token Ring network (from the Lab № 5).
4. Analyze the location of the required number of the communication equipment for the logical structuring of the Token Ring network.
5. Calculate the cost of the built network Switched Token Ring.

6. Run the simulation model of the Switched Token Ring network. Analyze the average load of the network equipment and the data transmission environment, as well as the response time for the data flow.

7. Compare the obtained characteristics (the cost, the response time and the load) of Token Ring and Switched Token Ring networks.

8. Make a report on laboratory work:

- topic and purpose of laboratory work;
- substantiation of the required amount of the communication equipment and its brief characteristics;
- structure of the Switched Token Ring network (with indication of the distances, the locations of the servers and the communication equipment);
- calculation of the cost of the Switched Token Ring network;
- printout of the report with the definition of the average load of the network equipment and the data transmission environment, as well as the response time for the data flow;
- make conclusions.

9. Provide the teacher with the computer simulation models built in the Laboratory Works № 5, 6.

10. Prepare to defend the topic Marker Technologies.

3. Example of laboratory work (variant № 43)

3.1. Development of Switched Token Ring network structure. For the campus subsystem, the best type of cable is fiber optic; for the vertical and horizontal subsystem one of the possible is UTPCat3.

To build the simulation network model Super Stack Link Builder FMS TR 24 Stack Able Hub, 16 Meg Token Ring Repeater Module and Link Switch 2000 TR Switch are used. The main parameters of these hubs: bandwidth is 16 Mbit/s, number of Super Stack Link Builder FMS TR 24 Stack Able Hub is 27 ports of which 13 are used; number of ports is 16 Meg Token Ring Repeater Module and 3 ports are used; filtering speed is 400,000 packets/s, data rates are 4 and 16 Mbps.

Switch parameters are as follows: number of ports is 12 (10 are used), delay is 10 μ s, frame rate is 14880 frames/s, MAC address table size is 2048, bandwidth is 3,2 Gbps. The structure of the Switched Token Ring network is presented in Figure 6.1.

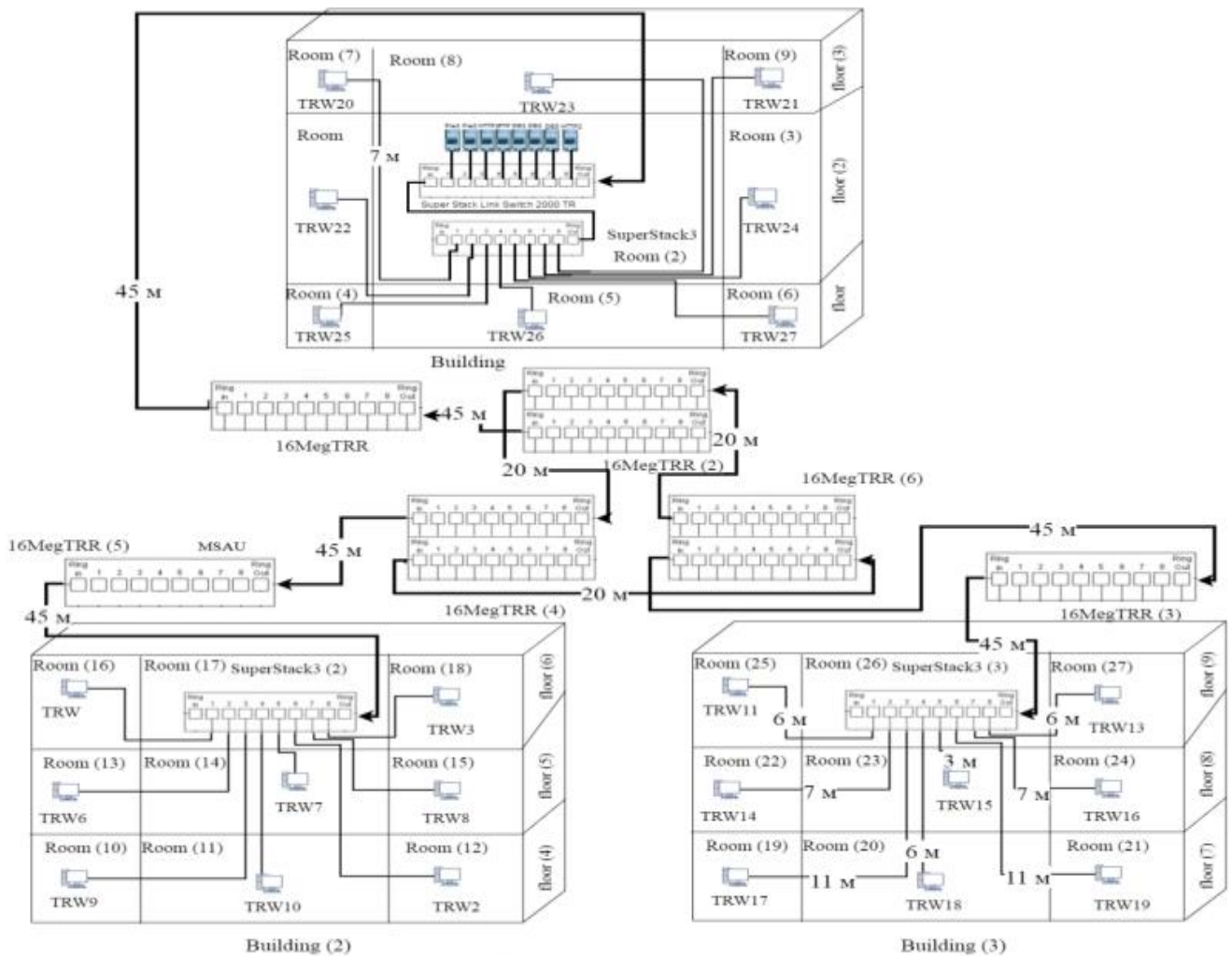


Fig. 6.1 Logical structuring of the Token Ring network

Symbols: — fiber optic cable; twisted steam; TRW – Token Ring Workstation

3.2. Construction of a simulation model of the Switched Token Ring network. We take as a basis the simulation model of Lab № 5 to which we need to add a switch.

Launch Net Cracker Pro. We open the project of Laboratory Work № 5. Next you need to install the switch: Switches → Workgroup → Token Ring → 3 Com Corp. → SuperStack LinkSwitch 2000 TR Switch. Select it in the panel and move it to the work area. Connect the switch to the hub "SuperStack II Hub TR 24" which is located in Building 2 (as shown in Figure 6.2.) and to the MSAU concentrator. Assign traffic as it is done in the Lab № 1.

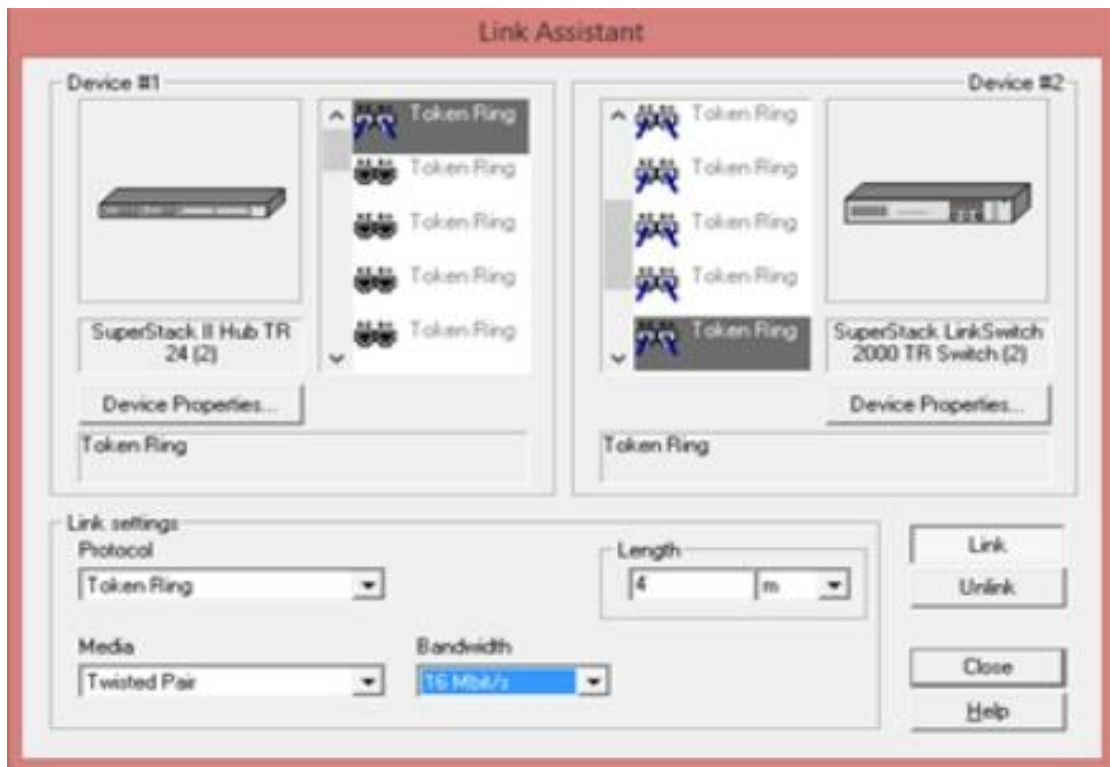


Fig. 6.2. Hub connection with switch

The conditions of the experiment are similar: the simulation model should work for 7 minutes; the packets from 500 to 1000 bytes are transmitted; every 0,02 s by exponential law. Number of stations in the Switched Token Ring network is 7 (found threshold of the Token Ring network, Lab № 5).

To obtain network statistics, use the Report Wizard: Tools → Reports → Wizard. In the Select a report window, select LAN → LAN Segment Statistics. As a result of the Master's work we get the report "LAN Segment Statistics" which is presented in Figure 6.3.

LAN Segments Statistics

| Name | Vendor | Utilization | Workload | Packet delay |
|-----------------------------|------------|-------------|--------------|--------------|
| SuperStack II Hub TR 24 (2) | 3Com Corp. | 4.0 % | 78 Kbyte/sec | 254.00 μs |
| SuperStack II Hub TR 24 (3) | 3Com Corp. | 20.0 % | 5 Mbit/sec | 314.00 μs |
| SuperStack II Hub TR 24 (4) | 3Com Corp. | 20.0 % | 5 Mbit/sec | 314.00 μs |
| SuperStack II Hub TR 24 (5) | 3Com Corp. | 20.0 % | 5 Mbit/sec | 314.00 μs |
| SuperStack II Hub TR 24 (6) | 3Com Corp. | 20.0 % | 5 Mbit/sec | 314.00 μs |
| SuperStack II Hub TR 24 (7) | 3Com Corp. | 20.0 % | 5 Mbit/sec | 314.00 μs |
| SuperStack II Hub TR 24 (8) | 3Com Corp. | 20.0 % | 5 Mbit/sec | 314.00 μs |
| Token Ring | | 20.0 % | 5 Mbit/sec | 314.00 μs |

Fig. 6.3. LAN Segment Statistics Report

The figure shows that the network load of the Switched Token Ring fell to 4 % compared to Switched Ethernet (35 %) and Token Ring (19 %).

To determine the maximum response time of the Switched Token Ring network for data flow and traffic assignment in the Select a Report window: Data Flows → Application Statistics. The result report is shown in Figure 6.4.

| Applications Statistics | | | | |
|--------------------------------|----------------------------|--------------------|--------------------|--------------------|
| Name | Source | Destination | Travel time | Response ti |
| HTTP client | Token Ring Workstation (3) | HTTP 1 | 229.00 μs | 31.00 ms |
| HTTP client | Token Ring Workstation (4) | HTTP 2 | 204.00 μs | 28.00 ms |
| File server's client | Token Ring Workstation (5) | FS 1 | 326.00 μs | 16.00 ms |
| SQL server's client | Token Ring Workstation | BD 3 | 282.00 μs | 15.00 ms |
| Database | Token Ring Workstation (2) | BD 2 | 262.00 μs | 13.00 s |
| File server's client | Token Ring Workstation (7) | FS 2 | 1.00 ms | 16.00 ms |
| Database | Token Ring Workstation (8) | BD 1 | 1.00 ms | 13.00 s |

Fig. 6.4. Application Statistics Report

The figure shows that the maximum response time for the Switched Token Ring is 31 ms which is 10 ms faster than the Switched Ethernet network (41 ms) and 55 ms faster than the Token Ring network (86 ms).

To obtain the network characteristics of a particular part of the network (for example, the server room), in the window "Select a report": Modules → Module Statistical Items and select the desired room. As a result, the report "Module Statistical Items" is built (Figure 6.5).

| | |
|---|-----------------|
| 16Meg Token Ring Repeater Type 1 and 3, IBM (12) - | |
| Current utilization | 11.792 % |
| Average utilization | 12.6073 % |
| Average packet transfer time | 0.000244968 s |
| Average workload | 264394 byte/sec |
| Current workload | 247297 byte/sec |
| Packets for last second | 504 packets |
| Packets dropped for last second | 0 packets |
| SuperStack LinkBuilder FMS TR 24 Stackable Hub (2) | |
| Current utilization | 11.792 % |
| Average utilization | 12.6073 % |
| Average packet transfer time | 0.000244968 s |
| Average workload | 264394 byte/sec |
| Current workload | 247297 byte/sec |
| SuperStack LinkSwitch 2000 TR Switch (2) | |
| Current utilization | 2.17825 % |
| Average utilization | 2.77253 % |
| Average delay | 1.08417e-005 s |
| Average workload | 348864 byte/sec |
| Current workload | 274087 byte/sec |
| Packets for last second | 743 packets |
| Packets dropped for last second | 0 packets |

Fig. 6.5. Module Statistical Items Report

The figure shows that the hub load from the server room is 11,792 % which is 5,6 % less than in the Token Ring network (17,322 %), and 23,2 % less than in the Switched Ethernet network (35 %).

The values of the main characteristics obtained on the simulation model of the Switched Token Ring network should be entered in the final table.

Laboratory Work № 7

CONSTRUCTION OF SIMULATION NETWORK MODEL USING FDDI TECHNOLOGY

- Objective:
1. To get acquainted with the technology of the marker method of access to the FDDI ring.
 2. Learn the types of node connections and FDDI port types.
 3. Acquire practical skills in building a simulation model of the FDDI network.

1. Individual Task

Problem statement: on the basis of the given infrastructure (according to the variant of the individual task) to design a network on the basis of FDDI technology, to estimate its loading, response time and cost.

2. The Sequence of Execution

1. Get acquainted with FDDI technology (general and characteristic features of FDDI from Token Ring, types of node connections and types of FDDI ports).
2. Make a partial transition to FDDI technology: justify the choice of physical environment for horizontal, vertical, and campus subsystems.
3. Perform an analysis of all limitations of the standards in accordance with the chosen physical environment; justify the choice of the communication equipment of the FDDI network.
4. Determine the threshold of the network on the simulation model.
5. Calculate the cost of the built network.
6. Run a simulation network model. Analyze the average load of the network equipment and the data transmission environment as well as the response time for the data flow.
7. Compare the obtained characteristics (cost, response time and load) of the Switched Fast Ethernet network and the FDDI network.
8. Prepare a report on laboratory work:
 - topic and purpose of laboratory work;
 - initial and additional data;
 - structure of FDDI network (with indication of distances, locations of servers and communication equipment);
 - found the threshold of the FDDI network;
 - calculation of the cost of the FDDI network;
 - printout of the report with the definition of the average load of network equipment and data transmission environment as well as the response time for the data flow;

– conclusions.

9. Present to the teacher the simulation models built in Lab № 6-7 on the computer.

3. Example of Laboratory Work (variant № 43)

3.1. Development of the FDDI network structure. The fiber cable is the selected for horizontal, vertical, and campus subsystems. The FDDI network includes a double ring one of which is primary and the other is secondary. In the FDDI network, a single connection (Single Attachment, SA) or a dual connection (Dual Attachment, DA) to the ring is possible. With a single connection, the stations are connected only to the primary ring, with a double connection – to the primary and secondary rings. Depending on whether the node is a hub or end station, you can select the following designations depending on the type of connection: end station with a single connection Single Attachment Station (SAS); Dual Attachment Station (DAS); Single Attachment Concentrator (SAC); Dual Attachment Concentrator (DAC). In the designed network we use only DAC and SAC. The structure of the corresponding network is presented in Figure 7.1.

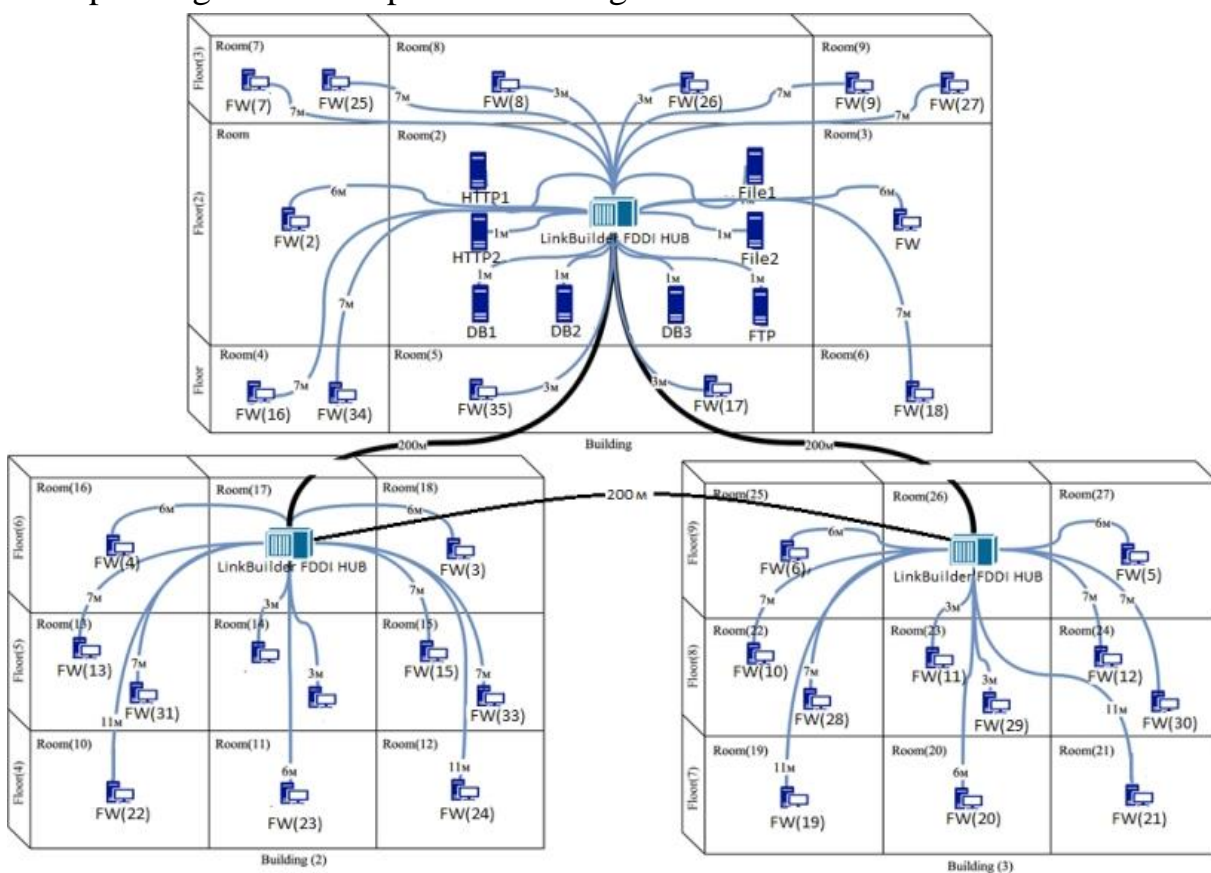


Fig. 7.1. The structure of the projected FDDI network

The use of FDDI ports of different types is shown in Figure 7.2.

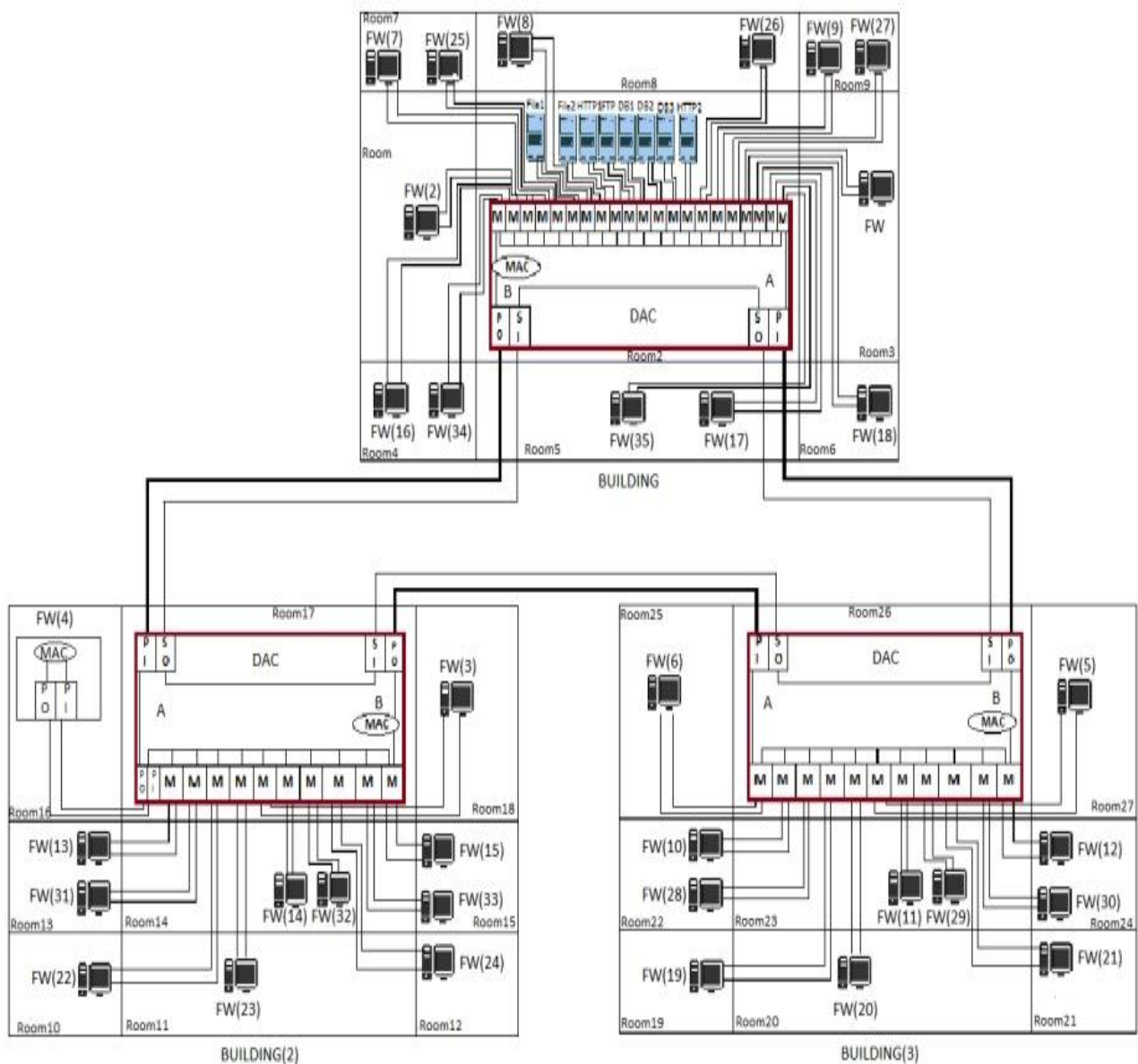


Fig. 7.2. Using different types of FDDI ports

The network uses a LinkBuilder FDDI Hub (16-ports). It is advisable to place all servers in one room (server room); it is located in Building (floor 2, room 2); see Lab № 1).

3.2. Building a simulation model of the FDDI network in NetCrackerPro.

Start the program: Create a new project: File → New (📄). Save the project immediately: File → Save (💾), select a folder to save and click OK. When creating a project, the Top window will open. In the Devices tab (on the left panel), select:



Buildings, campuses and LAN workgroups. Drag the campus (Campus) from the bottom of the window to the clear field of the Top window.

To place houses on campus, you need to right-click on Campus and select Expand from the context menu. A new Campus window will be opened. From the



bottom panel (Devices tab), drag **Building** to a clear field of the Campus window. Thus, the result of the action is presented in Figure 7.3.

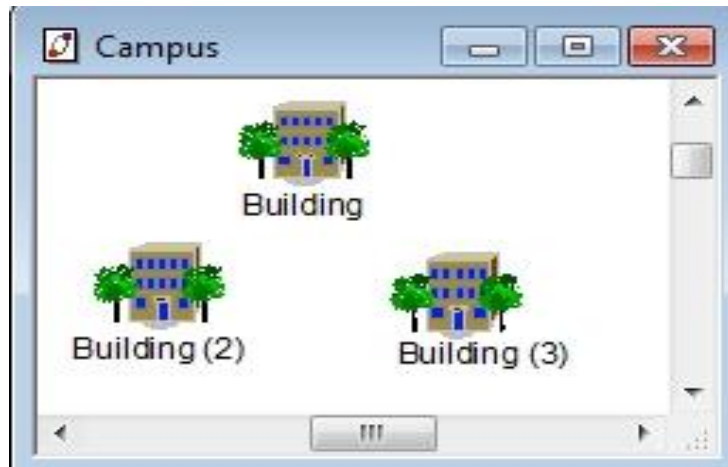


Fig. 7.3. Creating a Campus subsystem



By analogy, you need to make three floors in each house (**Floor** , Figure 7.4)



with three rooms on each floor (**Room** , Figure 7.5).

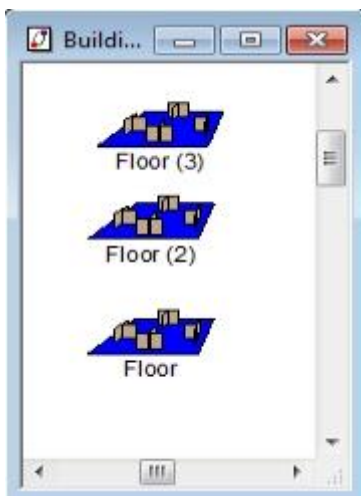


Fig. 7.4. Creating a vertical subsystem

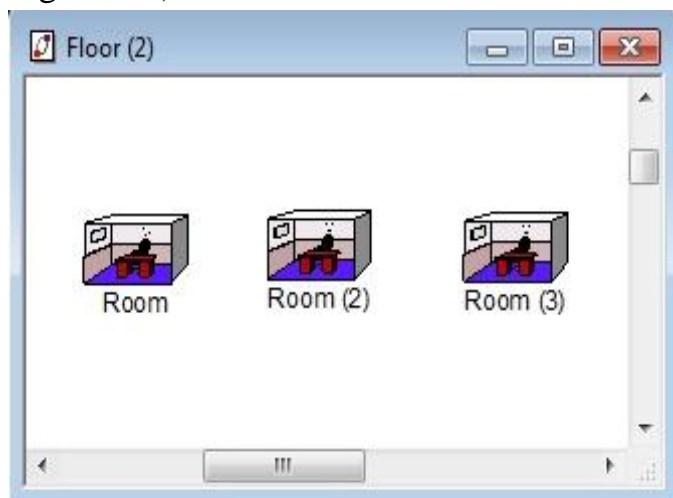


Fig. 7.5. Creating a horizontal subsystem

To install a double ring in the FDDI simulation model opt the follows: Devices



→ Generic LANs → FDDI (**FDDI**).

The structure of the FDDI network can be viewed on the Project Hierarchy tab (left panel) as shown in Figure 7.6.

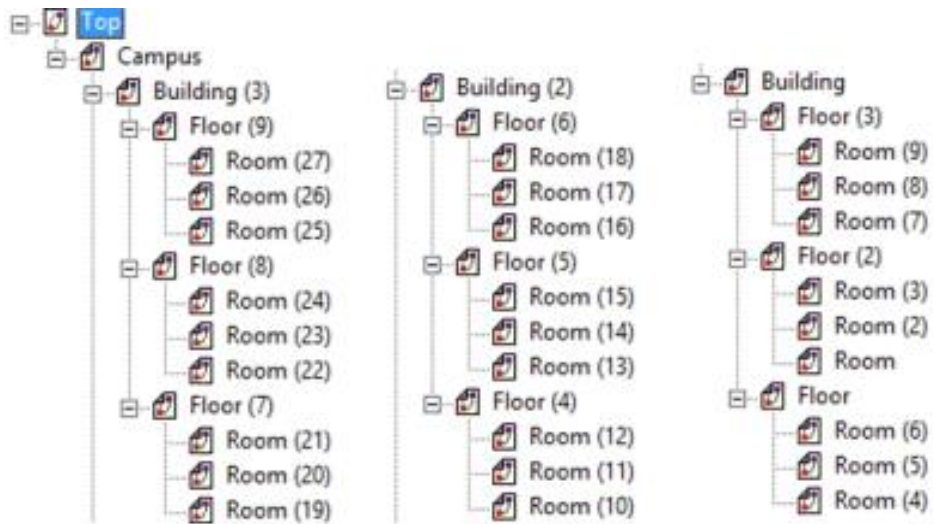


Fig. 7.6. The structure of the network

Eight FDDI-Servers (according to the variant) from the LAN servers panel (on the left) must be placed in the server room.

Click once on LAN servers; drag the FDDI-Server from the bottom into the room eight times. Now you need to make servers for a specific purpose. To do this, insert a specific disk into the server: Network and enterprise software → Server software. Left-click once on the Server software, several disks will appear at the bottom, from which we need: two File servers, one FTP server, two HTTP servers and three Small office database servers.

Add one disk to each server and rename the server accordingly (to rename, double-click on the name with the left mouse button, the Text Editor window will appear, rename, click OK). The set of received servers is presented in Figure 7.7.

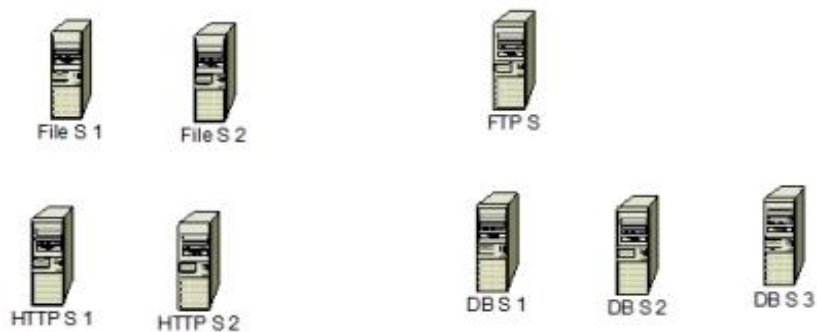


Fig. 7.7. The composition of the server room

In the server room (with the Expand command), put the hub LinkBuilder FDDI



Hub (left panel: Devices → Hubs → Shared Media → FDDI → 3ComCorp.); click once on the title and drag the bottom of the hub into the room.

You need to add modules with slots to the hub: three LinkBuilder FDDI Fiber Optic Modules. To add a module to the hub, you need to drag the module to the hub from the bottom panel. To view, double-click the hub with the mouse or right-click using the Configuration command. Place the hub in the server room. As a result, the LinkBuilder FDDI Hub has three modules, as shown in Figure 7.8.

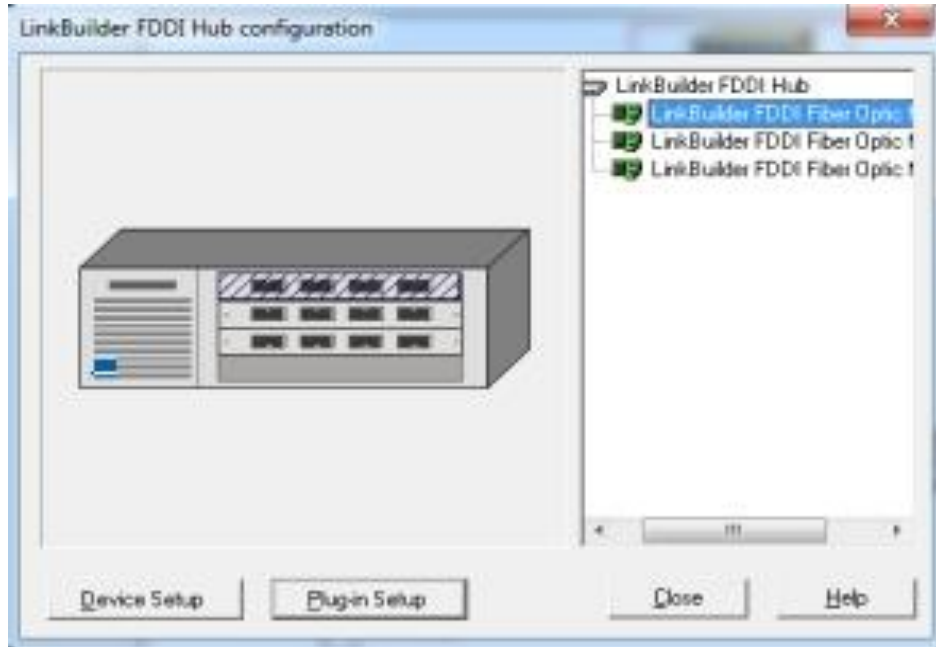


Fig. 7.8. LinkBuilder FDDI Hub structure

Let's connect hubs and servers. According to the structure of the network (see Figure 7.2) we place all hubs. The physical topology of the FDDI network is a double ring of trees, so each hub is connected to a ring, as shown in Figure 7.2. To do this, open the rooms in which they are situated (Figure 7.9).

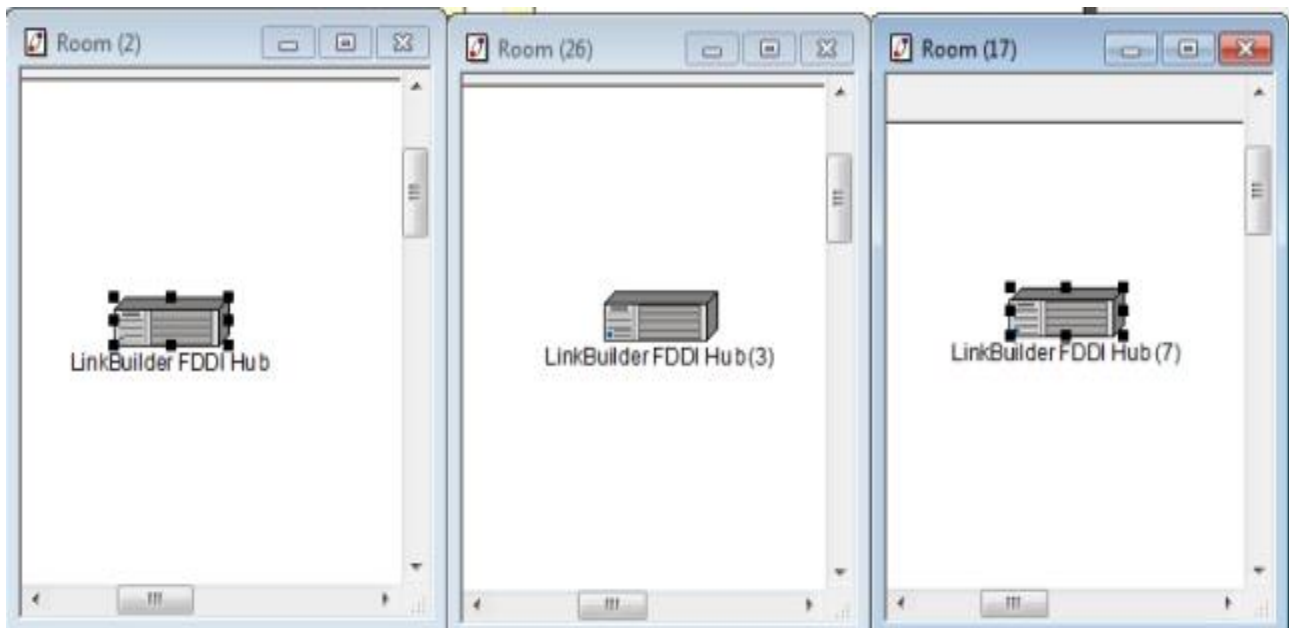



Fig. 7.9. Rooms with hubs

On the toolbar (at the top) click on , then click on one hub and then on the other; the LinkAssistant window will be opened (Figure 7.10).

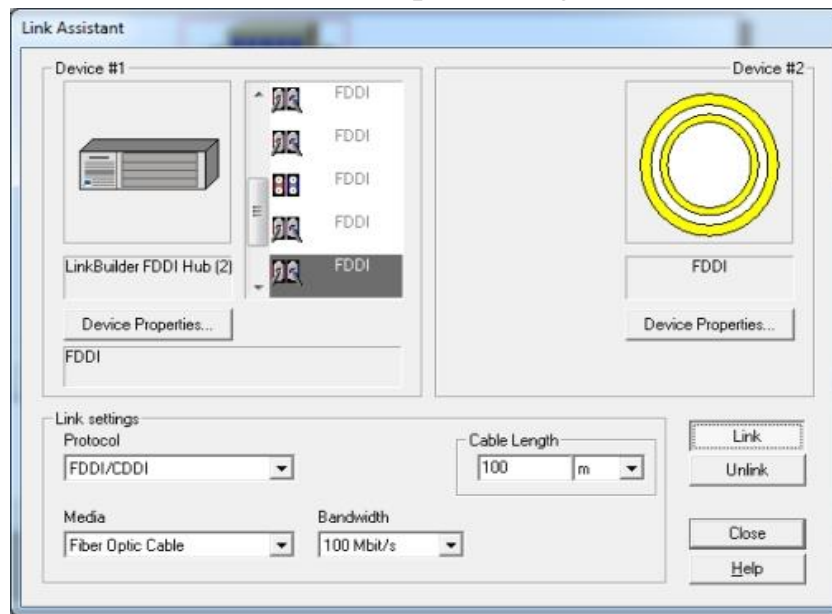


Fig. 7.10. Working with the LinkAssistant window

The FDDI port is selected in the LinkAssistant window (default); click the Link button. The value of Length is set to 100 m (distance between houses is 200 m); Protocol is FDDI / CDDI; Media is Fiber Optic Cable; Bandwidth is 100Mbit/s; click the Close button.


3.3. Determining the network performance threshold on the FDDI simulation model. To determine the performance threshold, you must add one workstation to the FDDI simulation model and configure data transfer to the servers for each workstation.

To add a workstation, you need to go to a room, for example in Room 3 in the panel Devices (on the left), and opt: LAN workstation, press once with the left mouse



FDDI Workstation

button; from the Devices panel (at the bottom) drag the workstation into the room. Connect the workstation to the hub located in this building (similar to connecting the server to the hub). Considering the width and height of the floor, set the Length (according to the variant of 3 m).

To configure the data transfer on the toolbar (above), press ; then press the workstation, and then the server to which we send data; the Profiles window will be opened which is shown in Figure 7.11.

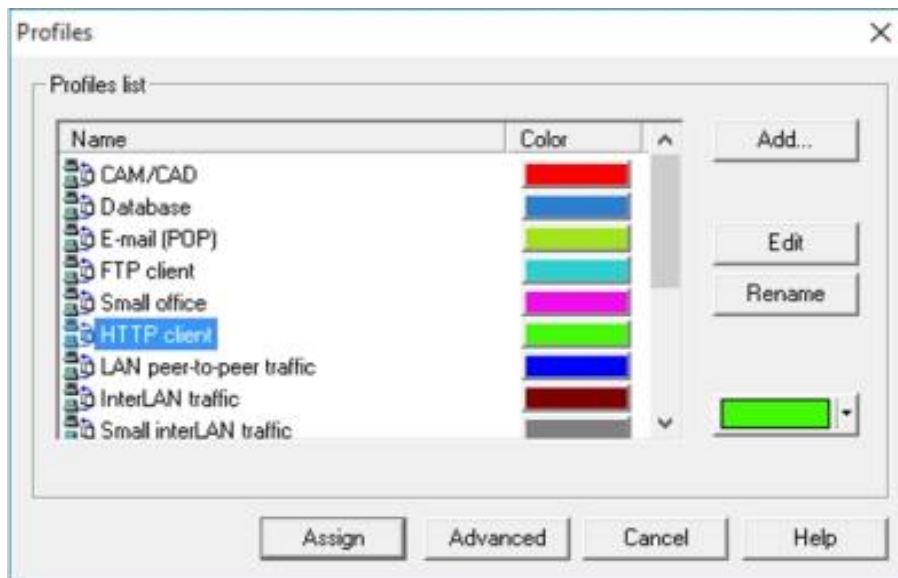




Fig. 7.11. Working with the Profiles window

In the Profiles window, select the item whose name matches the server name, for example, HTTP client, then click Assign. To start the simulation model, press the button . The movement of packets will be displayed on the model. If the button  appears anywhere in the network, it means that the network has crashed. In our case, the network fell with the number of stations 264 (Figure 7.12), i.e. the threshold of the network is 409 workstations.

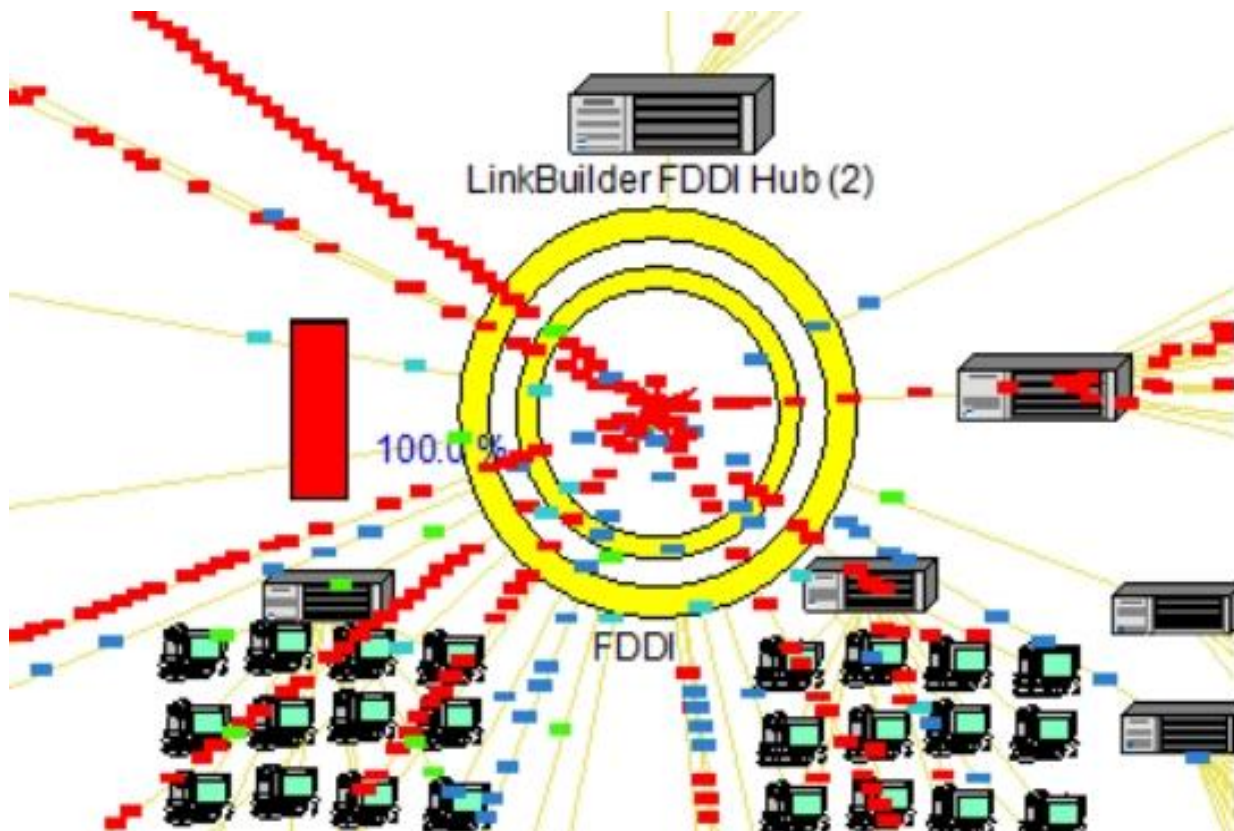


Fig. 7.12. The fall of the network on the simulation model

3.4. Conducting experiments on a simulation model. The following conditions must be met during the experiment: the simulation model must work for 7 minutes; packets from 500 to 1000 bytes are transmitted; every 0,02 s by exponential law. To adjust the packet size and sending interval you should opt: Global (in the main menu) → DataFlow; select the workstation, click Edit, the Profile window will be opened in which you need to select the type of server (e.g. Small office database server's client) to which the traffic is assigned; click Edit, the window Small office database server's client will be opened, where you need to set the appropriate parameters, this is shown in Figure 7.13.

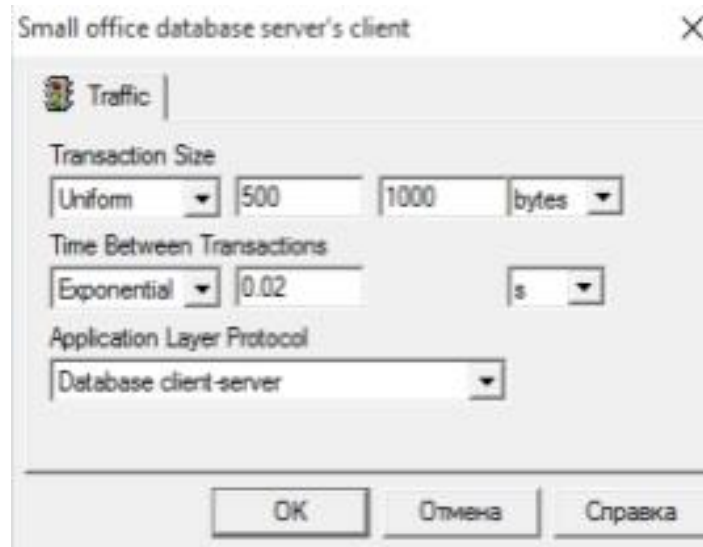


Fig. 7.13. Working with the window Small office database server's client

After all the settings, you need to obtain the statistics on the FDDI simulation model. For this aim, do the follows in the main menu: Tools → Reports → Wizard; the window Select a report will be opened in which to obtain statistics of the average load of the network equipment, select LAN Segments Statistics; the corresponding window will be opened, in which without changing anything click Next three times, then click Done (Figure 7.14).

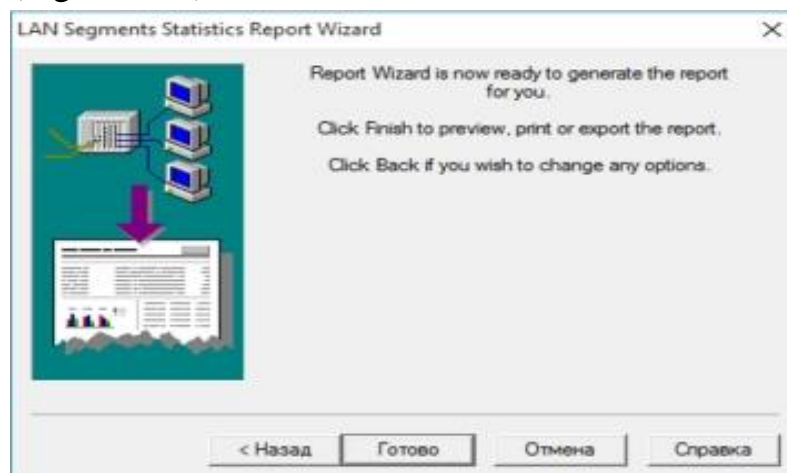


Fig. 7.14. Working with the LAN Segments Statistics Report Wizard

As a result, we obtain the report LAN Segments Statistics, which is presented in Figure 7.15.

| Name | Vendor | Utilization | Workload | Packet delay |
|--------------------------|------------|-------------|-------------|---------------|
| FDDI | | 11.0 % | 1 Mbyte/sec | 76.00 μ s |
| LinkBuilder FDDI Hub | 3Com Corp. | 11.0 % | 1 Mbyte/sec | 76.00 μ s |
| LinkBuilder FDDI Hub (2) | 3Com Corp. | 11.0 % | 1 Mbyte/sec | 76.00 μ s |
| LinkBuilder FDDI Hub (3) | 3Com Corp. | 11.0 % | 1 Mbyte/sec | 76.00 μ s |

Fig. 7.15. LAN Segments Statistics Report

At the threshold found on the Ethernet simulation model (35 workstations; see Lab № 1), the network load is 11 % as shown in Figure 7.16; this is almost 3 times more than the load of the Switched Fast Ethernet network (4 %).

The response time for the data flow and the traffic assignment is determined using the Applications Statistics item; the obtained report on the FDDI simulation model is shown in Figure 7.16.

| Name | Source | Destination | Travel time | Response time |
|----------------------|-----------------------|-------------|----------------|---------------|
| File server's client | FDDI Workstation (20) | File S 1 | 146.00 μ s | 1.00 min |
| File server's client | FDDI Workstation (21) | File S 2 | 145.00 μ s | 0.00 μ s |
| FTP client | FDDI Workstation (22) | FTP S | 144.00 μ s | 0.00 μ s |
| HTTP client | FDDI Workstation (23) | HTTP S 1 | 139.00 μ s | 24.00 ms |
| HTTP client | FDDI Workstation (24) | HTTP S 2 | 125.00 μ s | 0.00 μ s |
| Database | FDDI Workstation (25) | DB S 1 | 146.00 μ s | 2.00 min |
| Database | FDDI Workstation (26) | DB S 2 | 146.00 μ s | 2.00 min |
| Database | FDDI Workstation (27) | DB S 3 | 145.00 μ s | 2.00 min |
| File server's client | FDDI Workstation (28) | File S 1 | 145.00 μ s | 1.00 min |
| File server's client | FDDI Workstation (10) | File S 2 | 146.00 μ s | 0.00 μ s |
| FTP client | FDDI Workstation (11) | FTP S | 294.00 μ s | 0.00 μ s |
| HTTP client | FDDI Workstation (12) | HTTP S 1 | 123.00 μ s | 0.00 μ s |
| HTTP client | FDDI Workstation (14) | HTTP S 2 | 137.00 μ s | 0.00 μ s |
| Database | FDDI Workstation (15) | DB S 1 | 146.00 μ s | 2.00 min |
| Database | FDDI Workstation (16) | DB S 2 | 145.00 μ s | 2.00 min |
| Database | FDDI Workstation (17) | DB S 3 | 146.00 μ s | 2.00 min |
| File server's client | FDDI Workstation (18) | File S 1 | 146.00 μ s | 1.00 min |
| File server's client | FDDI Workstation (19) | File S 2 | 144.00 μ s | 0.00 μ s |
| FTP client | FDDI Workstation (9) | FTP S | 150.00 μ s | 0.00 μ s |

Fig. 7.16. Applications Statistics Report

The figure shows that the maximum response time is 2 minutes which is almost 4 times less than the maximum response time of the Switched Fast Ethernet network (7 minutes).

To remove the network characteristics of a particular part of the network (e.g. server room), select Module Statistical Items; the corresponding window will be opened (Figure 7.17).



Fig. 7.17. Working with the Module Statistical Items Report Wizard

Select the server room Room 2, and then opt Devices. As a result, the report Module Statistical Items is built which is shown in Figure 7.18.

| Name | Statistical Item | Value |
|-------|-----------------------------------|------------------|
| DB S3 | Average workload | 99758.3 byte/sec |
| | Current workload | 100858 byte/sec |
| | Packets for last second | 598 packets |
| | Packets dropped for last second | 0 packets |
| | Calls received | 0 |
| | Calls blocked | 0 |
| | Packets received | 634364 packets |
| | Transactions received | 634364 |
| | Responses received | 0 |
| | Transactions sent | 84588 |
| | Completely discarded | 0 bytes |
| | Average response time | 0 s |
| | Average transaction length, bytes | 750.566 bytes |
| | Calls established | 0 |
| | Calls requested | 0 |

Fig. 7.18. Module Statistical Items Report

The following statistics were obtained on the simulation model of the designed computer network FDDI (Figure 7.19).

| | |
|---------------------------------|----------------|
| Current utilization | 10.344 % |
| Average utilization | 10.3628 % |
| Packets for last second | 5116 packets |
| Packets dropped for last second | 0 packets |
| Average packet transfer time | 7.74162e-005 s |

Fig. 7.19. The FDDI network statistics for 35 workstations

Compared to the Switched Fast Ethernet network, the total network load increased from 4 % to 11 %; the response time decreased by almost 4 times.

Record the results obtained on the FDDI and Switched Ethernet simulation models in the final table; draw appropriate conclusions.

Conclusions

On the created simulation models of a local area network on various technologies at identical initial parameters and identical conditions of carrying out experiments the network characteristics which analysis allows to argue a choice of network technology are received.

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LOCAL NETWORKS

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