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Ternopil Ivan Puluj National Technical University

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Ternopil, 2022

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Faculty Computer Information Systems and Software Engineering
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ASSIGNMENT
for QUALIFYING PAPER

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ABSTRACT

Design of computer network for enterprise "Warmish" // Qualification work of the educational level "Bachelor" // Kollie Moselyn Korto / Ternopil National Technical University named after Ivan Pulyuy, Faculty of Computer Information Systems and Software Engineering, Department of Computer Systems and networks, group ISN-42 // Ternopil, 2022 // p. – , Fig. -, table. -, chair. -, added. -, bibliogr. -.

Keywords: SWITCH, CONNECTOR, LOGICAL TOPOLOGY, WORKSTATION, SERVER, PHYSICAL TOPOLOGY.

The object of development is the computer network of the "Warmish" enterprise. The purpose of the work is to design a computer network of the limited liability company "Warmish", Ternopil to improve the exchange of information between workstations, which will allow more efficient use of hardware resources and increase productivity.

In the process of work the design of logical and physical network topologies was performed, the selection of network equipment and hardware was carried out, the method of laying, installation and management of the network was described, the choice of security means and connection of network resources was substantiated, the network was tested.

LIST OF SYMBOLS, SYMBOLS, UNITS, ABBREVIATIONS AND TERMS

CFS – medium wave

DC – remote control

PC is a personal computer

ASK – acknowledgment packet

DCF – distributed coordination function

RTS – request to send

CTS – clear to send, transfer permission

PCF – point coordination function

NAT – network address translation, network address translation

Software – software

DTIM – delivery traffic indication message

CONTENT

INTRODUCTION ... 8
SECTION 1. ANALYSIS AND PURPOSE OF DEVELOPMENT ... 10
1.1 Analysis of the technical task ... 10
1.1.1 Name and scope ... 10
1.1.2 Purpose of development ... 10
1.1.3 Hardware and software requirements ... 12
1.1.4 Documentation requirements ... 13
1.1.5 Technical and economic indicators ... 13
1.1.6 Stages and stages of development ... 14
1.1.7 Procedure for control and reception ... 14
1.2 Initial data ... 15
SECTION 2. COMPUTER NETWORK DESIGN ... 17
2.1 Technical premises ... 17
2.1.1 Cable channels for various purposes ... 19
2.1.2 Location of equipment ... 20
2.2 Telecommunication design phase ... 22
2.2.1 Workplace subsystem ... 23
2.2.2 Design of the horizontal subsystem ... 24
2.3.3 Designing the subsystem of internal highways ... 26
2.2.4 Designing the subsystem of external highways ... 29
2.2.5 Designing the administrative subsystem ... 31
2.2.6 Selection of the type and calculation of the number of organizers 34
2.2.7 Calculation of the number and determination of the lengths of terminal, crossover and switching cables in technical premises ... 35
2.3 Calculation of additional elements of the SCS ... 38
2.3.1 Calculation of decorative boxes and their accessories ... 38
2.3.2 Other types of cable channels ... 41

2.4 Calculation of auxiliary elements of the SCS 45
2.4.1 Selection of type and calculation of volumes of supply of fastening elements 45
2.4.2 Calculation of the number of marking elements 46
2.4.3 Technological and measuring equipment 47
2.4.4 Selection of switches 49
2.4.5 Choosing a router 53
SECTION 3 LIFE SAFETY, BASICS OF LABOR PROTECTION 58
3.1 Hygienic requirements for the organization of equipment of workplaces with VDT 58
3.2 The effect of electric current on the human body, types of electrical injuries 59
CONCLUSION 64
REFERENCES 65

INTRODUCTION

The concept of computer systems is the logical result of the evolution of computer technology. The first computers of the 1950s were designed for a small number of users, and were also bulky and expensive. They were not intended for interactive work of the user, and were used in the mode of batch processing.

Batch processing systems are usually based on the mainframe – a powerful and reliable universal computer. Users could receive the results of calculations only the day after the issuance of the task on punch cards. At that time, the interactive interaction, during which the user could adjust the results of calculations had to be sacrificed, because the batch mode allowed the most efficient use of computing power of the machine.

As processors became less expensive in the early 1960s, new ways of organizing the computing process began to appear, including multi-terminal time allocation systems. Each of the several users received a terminal through which he could communicate with the computer; in addition, the response time of the computer system was short enough not to notice the parallel operation of several users. The user could access shared files and peripherals, while maintaining the illusion of complete sole ownership of the computer. Such multi-terminal systems have become the first step towards the creation of local computer networks. Their main drawback was that they still retained the centralized nature of data processing.

The first networks were created as a result of solving a fairly simple task – to organize access to a computer from a terminal hundreds and thousands of kilometers away. The terminals were connected to computers via telephone networks via modems. Then came systems with remote ones

Terminal-computer connections have also implemented remote computer-to-computer connections. Computers have the ability to exchange data automatically, which is the basic mechanism of a computer network. It was during the construction of the first global networks that most of the basic ideas and concepts of modern computer networks were proposed and tested.

With the advent of large integrated circuits in the early 1970s, it became possible to create mini-computers that became real competitors to mainframes. Even small businesses have been able to buy computers, which has led to the concept of allocating computer resources across the enterprise. To connect such computers to a network, we first used a variety of non-standard coupling devices with their own ways of presenting data on communication lines, their own types of cables, etc.

In the mid-80's, the first standard technologies for connecting computers to a network were approved – Ethernet, Token Ring. A significant stimulus for their creation was the emergence of the PC. These mass-produced products have become an ideal material for building networks – they are powerful enough to run network software, and on the other hand, they need to combine their computing power to solve complex problems.

At the moment, the networks continue to develop. There are more and more high-speed communication channels, highly intelligent switching equipment allows you to build large distributed corporate networks.

SECTION 1. ANALYSIS AND PURPOSE OF DEVELOPMENT

1.1 Analysis of the technical task

1.1.1 Name and scope

The purpose of this Bachelor's degree is to design a local area network for Warmish.

1.1.2 Purpose of development

Warmish was founded in 1995. Taking into account its own experience and the wishes of its clients, it performs a wide range of work related to:

– Design of heat and gas supply systems and water supply, gasification, heating, water supply;

– Installation: heating, water supply, sewerage, gasification;

– Acquisition of objects with state-of-the-art equipment of this profile.

Warmish is engaged in the following types of work:

1. Design works:

– preparation of design and estimate documentation for gas and heat supply of individual houses, apartments, communal – domestic and industrial facilities, fuel.

2. Gasification:

– performance of the whole complex of works on gasification of objects of communal and household purpose, houses, etc .;

– laying of street gas pipelines, gas inlets made of steel and polypropylene pipes.

3. Water supply:

– performance of works on laying of water supply systems both street, and internal from polypropylene and metal pipes.

– installation of submersible pumps and pumps for raising water pressure.

4. Water treatment:

– drinking water filters, reverse osmosis systems, industrial filters.

– water softening stations.

5. Windows, doors, gates:

– garage doors;

– metal-plastic windows and doors.

6. Heating:

– performance of works on the arrangement of autonomous heating of residential buildings, apartments, objects of communal and industrial purpose, schools, kindergartens, etc .;

– installation of different types of boilers: gas, electric, liquid and solid fuel boilers;

– replacement of the heating main.

7. Ventilation and air conditioning:

– industrial – production facilities;

– private homes.

8. Electrical work:

– switchboard, power lines;

– video surveillance security alarm system;

– intercoms;

– property safety from: gas leaks, flooding, smoke and fire.

9. Implementation:

– gas boilers: Viessmann, Vaillant, Sime.
– Electric: Kospel.
– Solid fuels: ORLAN, Sime Solida, Krzaczek, VIADRUS, Logica, Kriger.
– Boilers, heaters, pumps, convectors, steel and aluminum radiators;
– Burners for boilers;
– Polypropylene pipes and fittings.

1.1.3 Hardware and software requirements

The hardware of this network should provide fast and high-quality access to the database of the enterprise. The network should be built on the basis of plans of the premises of the enterprise (premises in which PCs are installed); provide security measures for unauthorized connection to this network. There should also be ways to expand and upgrade this network by connecting additional equipment and upgrading existing ones.

Accidental failure of one of the network devices should not lead to network failure.

Server and workstation software must meet the following requirements:
– functional completeness – a variety of supported services;
– productivity;
– scalability;
– ability to work on a powerful platform;
– provide reliable protection of information from unauthorized access;
– ensure the reliability of information storage;
– ensure the delimitation of access rights to resources;
– support "Client-Server" technology.

1.1.4 Documentation requirements

To build and maintain the proper functioning of the network, you need to provide appropriate documentation, which should include the following:

– The general structure of the network.

– Plan for the placement of network elements.

a) The principle of laying the cable system.

b) Symbols.

c) Plan of the premises and location of network switching elements.

– Technical description of network fragments.

a) The principle of marking cable segments.

b) Routes for laying cable segments.

c) Active network components.

– Concentrators.

– Switches.

Cable subsystem testing for compliance Sat.5.

Measurement results of cable segments.

Report on the cost of materials and components.

Current status of active equipment ports.

1.1.5 Technical and economic indicators

Funds should be allocated for the development of the network for the purchase of:

– personal computers;

– active equipment (switches, hubs, modems);

– passive equipment (cables and sockets);

– boxes for laying network cables.

Remuneration should also be provided for the installation of boxes, connection of network cables and placement of appropriate equipment in accordance with existing regulations.

1.1.6 Stages and stages of development

The project implementation should include the following stages:

– needs analysis and review of existing project solutions;

– development of a logical scheme of the project;

– technical and economic analysis and selection of network equipment;

– taking into account the technical features of the premises (plan of premises, power lines, lighting devices, wall thickness, etc.);

– development of a physical scheme of cable laying and equipment placement;

– features of mounting network nodes;

– hardware and software settings;

– network testing.

1.1.7 Procedure for control and reception

The following measures should be taken to check the readiness of the network:

– control of physical connections by means of the test equipment (tester) for check of correctness of crimping of sockets of cables;

– checking the correct power supply of network devices;

– check the correctness of the software settings for network equipment (service commands of operating systems);

– checking the correctness of recording information in the database of the organization (by entering it from several workstations);

– check the correctness of the software settings for delimitation of access rights to the organization's database and automated connection to the global network.

1.2 Initial data

The structured cabling system is installed in a two story office building, the individual floors of which have an identical layout. The height of the floor between the floors is 3.5 meters, the total thickness of the floors is 50 cm.

The created SCS must ensure the operation of the LAN equipment. SCS is designed to create a normal communication network and it provides for the transfer of information that does not belong to the category of confidential.

From the structure of the organization that will operate the cable system immediately after its completion and technical requirements, it follows that the operation of the customer's LAN is associated with the processing and transmission of large enough amounts of information. After analyzing the specifics of the organization, it turns out that the amount of data that will be transmitted to the LAN requires a large bandwidth of network channels. SCS is designed to create a data network for the ability to access the Internet, and data transmission within the organization.

In the corridors and working premises, the construction project envisages a suspended ceiling with a free space height of 50 cm. Behind the false ceiling, there is enough free space to accommodate cable trays and cable systems for various purposes. The external and internal walls separating the premises are made of brick, which greatly simplifies the laying of the cable system through the walls. As there are no special rooms and cable channels between the floors in the building, the connection of the two subsystems (floors) will be made by creating holes in the floor for laying the main box. Cable entries in technical and working premises for users, realized on sonic metal pipes with a diameter of 30 mm.

Cable entries in technical and working premises for users are realized on the basis of several metal pipes with a diameter of 32 mm.

In addition to information sockets, two power sockets connected to the guaranteed power supply network and one power socket connected to the household power supply network are provided for servicing each workplace. Laying of power cables, and also their connection to power sockets and a power switchboard is carried out by the adjacent subcontracting organization.

On each floor of the building according to the plan there are 5 working rooms designed to accommodate users. Data on the area of these premises are summarized in table. 1.1. In accordance with the provisions of SNiP 2.09.04-87, paragraph 3.2 for office buildings, we assume the installation of one block of sockets, mainly for every 6 m2 of working area. Additionally, to increase the ease of maintenance and operational flexibility of the information and computer system as a whole, we provide three blocks of sockets in each technical room on the floors of the building, ie on each floor it is necessary to install a total of 70 blocks of sockets, and a total of 140 blocks of sockets.

SECTION 2. COMPUTER NETWORK DESIGN

2.1 Technical premises

Workspaces on each floor are designed to accommodate user workstations, according to table. 2.1 is 345 m2. According to the norms, the area of the hardware serving the workplaces of the building should be 9.6 m2. There is also a restriction on the minimum hardware area of 14 m2. To accommodate the hardware in accordance with the recommendations, it seems most appropriate to allocate room 103, because they are not passable, have no windows and do not adjoin and are not located near the elevators, and so on. Room 103 has an area of 33.6 m2, which satisfies the recommended area of hardware, obtained on the basis of a specific norm – 0.7% of the working area (Table 2. 2).

Table 2.1 – Technical premises of the design system

Room number	Premises area m2	Number of mounted sockets
101	52	6
102	27	4
103	33.6	1
104	22.2	1
105	17.4	4
201	52	3
202	27	3
203	63.18	2
208	17.4	2

Table 2.2 – Technical premises of the design system

Cabinet number	Appointment	Area actual	Normally
103	Hardware	33	33

When choosing the final decision in favor of a room, the following considerations were additionally involved. According to the first option the location of the hardware in room 103. the standard area for the cross-country room based on the number of serviced IP according to should be 6.2 m2, which slightly exceeds the minimum allowable value of 6 m2. Rooms 103, which is twice the norm, are allocated for cross-country on different floors. The location of these technical rooms directly next to the hardware significantly simplifies the design of interfloor transitions and allows you to do with one riser without horizontal sections of the main cable. In addition, the availability of reserves by area and the installation of IP allows in the future to place in these premises additional network equipment for collective use in the event of significant modernization of the enterprise network. According to the plan, the distance from these technical rooms to the farthest socket is approximately 25 m, ie the diameter of the serviced working area will not exceed 70 m on the floors is implemented single-level (centralized) structure of the SCS.

On the ground floor of the building, a separate room for KP will not be allocated, and the switching equipment required for servicing the cables of the horizontal SCS subsystem of this floor is installed in the hardware room. Additionally, the possibility of providing environmental conditions in the selected technical premises is controlled. If necessary, private subcontractors should be given private terms of reference for the completion of these rooms to meet the requirements for the technical premises of the SCS.

In all technical rooms, in accordance with the requirements, the doors are hung, which must open to the outside. PBX, servers and central equipment LAN will be located in the hardware room, ie SCS is built on a two-tier scheme using the principle of multipoint administration.

2.1.1 Cable channels for various purposes

We use the following types of channels for laying horizontal and trunk cables of the subsystem of internal trunks of the designed SCS:

– closed metal trays behind the false ceiling, designed for laying cables of the horizontal subsystem in the corridors;

– decorative cable boxes (due to the lack of channels in the walls and floor of users' work rooms), made of non-combustible plastic and used for laying horizontal subsystem cables and power cables;

– mortgage pipes of the type of sleeves with a diameter of 32 mm, through which the introduction of horizontal cables, removed from the tray in the corridor, is carried out behind the false ceiling of the working premises of users;

– vertical tubular elements such as sleeves with a diameter of 80 mm, located along the right wall of the technical room at a distance of approximately 80 cm from its rear wall and performing the functions of riser channels and used for laying cables of the internal trunk subsystem. All these elements, except for the riser channels.

The trays are located behind the false ceiling, fastened at least 1.5 m and grounded according to the rules of PUE. The height of installation of the case of a tray is chosen equal 3 m from floor level that provides observance of norms. relative to the height of the free space between the upper edge of the channel and the capital ceiling. To reduce the cost of a decorative box and thus minimize the cost of the project and some reduction in the duration of its implementation, horizontal box laying is used in rooms to accommodate users at the height of sockets and one vertical descent due to false ceiling for laying cables. Under the sleeves on each floor are provided for the attachment of vertical sections of trunk cables located on distance not more than 1 m from each other. The calculation of dimensions, as well as the cost of these elements and their accessories is performed further in the sections.

Table 2.3 – Determination of the maximum and minimum length of the horizontal cable

Area cable rout	Maximum length m	Minimum length m
left B Assembly cabinet Ta stock no	3	2.5
Obpoblenia section Cabinet wall equipment	1	1
Distance To Input B Cabinet	48.5	2.7
The magnitude of the descent in the office	0.8	0.3
The magnitude of the descent in the office	2.2	2
horizontal section of the route in	12.5	2
Together	68	10.5
Average Value	39.25	

2.1.2 Location of equipment

In the designed system taking into account the total number of serviced workplaces on the basis of data we will accept the following scheme of placement of the equipment:

– cabinets with folding front doors are installed in cross-country rooms;

– in the hardware room a mixed version of the installation is used with the placement of part of the equipment on the wall.

The latter solution is largely due to the fact that in the hardware room are also installed panels serving the cables of the horizontal subsystem. Switchboards for various purposes, mounted in each cross-floor, support the operation of active network equipment connected to 90 IP. In this type of technical room, taking into account the provisions, we use the installation of equipment in a closed mounting structure such as cabinets with glass front doors. Based on the provisions, regardless of the type of organization of the switching field for the installation of switching equipment and equipment LAN in the manual will need one cabinet. Determination of specific dimensions of the mounting structure is performed further in the section.

The hardware room to save space is combined with a cross-country ground floor. Therefore, taking into account the placement of additional network equipment for collective use in this technical room, we install two mounting structures. The central location of the cabinet with a circular approach to it is used in the premises of the CP. In the hardware cabinet are installed in a row and fastened to each other on the basis of the requirements for the installation of equipment. The relatively small width of the technical room (2640 mm) does not allow to provide circular access to the mounting structure in the hardware with the width of the passage according to BICSI rules. Therefore, a number of cabinets in the hardware is installed close to the right of the entrance wall of the room. The shift of cabinets to the right relative to the longitudinal axis of the hardware room is due to the passage of the riser channels along this wall. In this case, the passage has a width: 264 – 2 x 80 = 104 cm, which exceeds the minimum allowable value of 76 cm. The distance from the wall to the rear wall of the cabinet is chosen equal to 1 m, which allows you to get:

– free access to the rear door of the cabinet;
– ease of insertion of main cables into the riser channels.

To ensure the ease of operation of the cable system and network equipment installed in the hardware, the door of the cabinet, standing near the wall, is made so that it opens from left to right. SCS cross equipment, which ensures the operation of the telephone exchange, is made in the form of cross towers, which together with the organizers are installed on the wall of the room. The capacity of these towers, as shown later in the section, is 400 pairs. The height of the tower installation to ensure ease of maintenance and switching is selected so that in accordance with the provisions of which the upper edge of the base was at a height of 1.7 m from the floor level. The extreme organizer of the tower is located at a distance of approximately 900 mm from the cabinet, which ensures full opening of the door and free access to the equipment. The PBX is located on the short end wall of the hardware room opposite the cabinets. Placing a wall cross between the mounting structure and the telephone exchange reduces the total cable consumption and simplifies the installation of equipment.

2.2 Telecommunication design phase

At the time of design work, the main standard for building LAN is Ethernet in various versions. The use of category 5e element base base for the implementation of the horizontal subsystem provides transmission of signals of all widely used in practice variants of this LAN LAN interface, up to its ultra-high-speed version of Gigabit Ethernet 802.3ab. Thus, the proposed solution provides a reserve of capacity of the horizontal paths of the SCS, sufficient to support the operation of all known at the time of design and promising types of applications, ie reliable protection of the customer's investment in the SCS.

According to the initial data, the created information and computer system of the enterprise is not intended for the transfer of confidential information. Therefore, a structured cable system is based on a cheaper and less complex in practice unshielded element base.

2.2.1 Workplace subsystem

The composition of sockets at each workplace is determined by the customer in the technical requirements and is given in the initial data, which provides for one IP with two socket modules, creating subscriber ports SCS, and three power sockets for different purposes. To meet the requirements for installation height and distance between power and information sockets, we use their design in the form of a single unit, mounted on the wall next to the box at a height of about 80 cm. The type of socket modules is determined by location and selected mounting method. In this particular case, for the construction of information sockets, we use single modules of category 5e of the MAX series type MX-C5-02-IT, installed in pairs in its seat in the Mosaic 45 socket using the adapter MX-45-82-IT. The use of two category 5e socket modules is determined by considerations of universality and fully meets the requirements of the standard.

Information about the number of information and power outlets in each room is entered in table 1. 1. The total number of SCS socket modules, just like the number of electrical power sockets, is the final values in columns 4-8 of table 2.4.

Table 2.4 – Distribution of jobs

No P/P	Cabinet No	IP Number	Category 5e	Power Sockets	Fastening Method
1	101	6	30.4	9	-
2	102	4	23.2	7	-
3	103	1	12.3	6	-
4	104	1	10.6	4	-
5	105	4	24.5	4	-
6	201	3	15.1	10	11
…….					
16	208	4	47.5	4	-
Together		26	274.6	34	11

According to the initial data, the customer did not set any special requirements for the number of terminal cables supplied to connect LOM workstations in user premises and did not provide information about the type and number of active LOM network devices used in the information and computing system. Therefore, to specify this parameter, we use a statistical approach, that is, we will enter into the specification of the installed equipment 70% of the cables from the total number of IR plus 10% – as part of the ZIP, that is, only 64 cords per floor.

Cable lengths are selected taking into account the provisions as follows: 58 cables with a length of 2 m and 6 cables with a length of 3 m. The last size is selected in order to increase the functional flexibility of the designed cable system. These cables are designed to connect workstations on each floor. In connection with the uniformity of the layout of the floors of the building, the total volume of supply of cables of the indicated lengths is set by a fourfold increase. To obtain the parameters of the horizontal subsystem paths, which provide the possibility of transmitting Gigabit Ethernet signals, the cables have the characteristics of category 5e. Edge cables for connecting telephone sets, produced by well-known manufacturers of this type equipment, are usually included in their delivery and, on the basis of this, are not included in the final specification.

2.2.2 Design of the horizontal subsystem

In this building there are no large halls and compact isolated user groups. On the basis of this, it will not apply the laying of cables under the carpet and the impractical implementation of individual sections and some tracts of the horizontal subsystem based on a multi-pair cable. In turn, this means that transition points and consolidation points are not needed in SCS. Thus, the design process of the horizontal subsystem in this case will be reduced to the calculation of the supply volume of the horizontal cable and the determination of its design.

The SCS horizontal subsystem is built on the basis of unshielded 4-pair category 5e cables, laid two to each block of sockets. The required amount of cable is calculated using a statistical method based on the data of the unit. The basis for its use is the fact that there are more than 42 information sockets on each floor and the requirement of an even distribution of sockets over the serviced area has been met1. 12 IRs are installed on each floor. To place SCS switching equipment and active LOM network equipment in crossovers, we use floor mounting cabinets. The minimum height of these structures will be approximately 35 U. As the IR, which has the minimum distance from the technical room, according to the plan, we will accept the socket block number 3 in room 103. The IR with the maximum length of the cable throw is the socket block number 4 in room 101. Calculations of the maximum and the minimum length of cable throws are given in the table. 1.3 and indicate that the maximum value of this parameter does not exceed 70 m. Therefore, based on the provisions, the statistical method is applicable to all IRs served by the switching equipment in this technical room. The length of the cable spent on the implementation of an average throw, taking into account a 10 percent technological margin, will be 1.1×33.3 = 36.6 m. One standard 1000-foot cable box will be enough to implement an average of 305/36.6= 8 throws. The total number of throws on one floor is equal to 2×90 = 180, and for their implementation, 23 boxes of 4-pair horizontal cable will be required. The total volume of cable supply will be equal to 187 m per floor. The layout of each floor of the building and the layout of IRs on them coincide. Based on this, the same amount of 4-pair cable will be needed to create horizontal cabling on each floor. The laying of cables of the horizontal subsystem of any route, i.e. in the corridors, technical and working rooms of the building in accordance with the provisions of section 2.2, is carried out in closed channels made of non-combustible materials. This makes it possible to apply a cheaper construction of these products with a polyvinyl chloride sheath.

2.3.3 Designing the subsystem of internal highways

Cables of the subsystem of internal trunks connect the switching equipment installed in the rooms of the cross and hardware. According to the initial data, these cables mainly transmit information flows created by LOM network equipment and PBX telephone signals. The designed system adopts the principle of using 2-port information sockets at workplaces. There are no outlets and PBX hubs on the floors. Based on these two factors, one should expect the transmission of signals of a significant number of telephone conversations over trunk cables. Based on this circumstance, taking into account the adopted principle of multi-point administration, the following ideology of building a subsystem of internal highways is adopted:

– the part of the subsystem of internal trunks, intended for the maintenance of the telephone network, is built on a multi-pair cable made of twisted pairs of category 3;

– fiber-optic cable is used to organize a part of the subsystem of internal highways serving the operation of LOM;

– to increase the operational flexibility and survivability of the created system, duplication of each pair of fibers with a 4-pair cable made of twisted pairs of category 5e is used. According to the initial data, the total height of the building is 16 m. Riser channels pass through the technical premises. Taking into account these circumstances, the maximum length of the trunk cable will be approximately 25 m.

Let's calculate the required total capacity of cables in pairs/fibers. The designed cable system has a high degree of integration. At the same time, the subsystem of the internal highway is built with the aim of ensuring the functioning of the IR with two socket modules for each workplace. Based on the selected configuration, we assume that 2 pairs of category 3, 0.4 pairs of category 5e and 0.2 fibers should be provided for each workplace in the internal trunk of the building, and accordingly for each floor: 180 pairs of category 3, 36 pairs of category 5e and 18 optical fibers. This information allows you to determine the capacity of trunk cables and, if necessary, specify their design.

The industry serially produces category 3 twisted pair cables with a capacity of 25, 50 and 100 pairs. Therefore, it is advisable to use two 100-pair cables when implementing trunk paths for PBX signal transmission. Let's determine the capacity and number of optical cables of the internal trunk. The calculation established that 18 fibers are needed in general for the organization of the LOM main tracts in the "KP – hardware" section. Due to the peculiarities of their design, cables of internal laying of similar capacity have unsatisfactory weight-dimensional characteristics, poor flexibility and increased cost. Therefore, in this particular project, we will use twice as many 12-fiber cables. Based on the provisions, as the basis of the backbone for the transmission of LOM signals, a multimode fiber-optic cable of internal laying with fibers of a traditional design of type 62.5/125 should be used, which provide somewhat lower insertion loss and are not so demanding on the quality of the installation of the optical connectors.

All the necessary data for calculating the length of different types of trunk cable with its breakdown into separate segments are presented in table 2.5. The lengths of individual trunk cables with the indication of their identifiers, obtained as a result of the calculation, are given in the table. 1.6. The total cable consumption is a summation of the corresponding values in column 8 of this table.

Record in line 10 of the table. 1.5 describes the "degeneracy", that is, the lines that do not go beyond the boundaries of the hardware trunk, which represent part of the cross ports of the PBX on the type 110 panel in the mounting structure of this technical room. This part of the wiring appeared because there is no dedicated room for cross-country skiing on the first floor, and its equipment is located in the hardware room.

Table 2.5 – To calculate the length of trunk cables

No	Name	Unit Ex.	Length,(m)	Stock,(m)
1	2	3	4	5
1	Cable twisted pair 5K(RJ45) 1.2920BIT 5K (RJ45)	M	30.4	2.48
2	Cable 2x1.5 (220V)1.3039K. 220V 2x1.5	M	23.2	1.98
3	Cable Twisted pair 5K(RJ45) 1.3044BII 5K (RJ45)	M	12.3	1.28
4	Cable 2x1.5 (220V) 1.3033K 220v 2x1.5 220V 2x1.5	M	10.6	1.29
5	Cable twisted pair 5K (RJ45) 1.2878BII 5K (RJ45)	M	24.6	2
6	Cable 2x 1.5 (220V) 1.3028K. 220V 2x 1.5	M	15.1	1.33
……………………				
25	Cable Twisted pair 5K(RJ45) 1.3029BII 5K (RJ45)	M	47.5	4.66
Total length of cables: 274.6m				
Total length of stocks: 11.7m				

Summarizing the obtained values, the necessary amount of cable for the implementation of the subsystem of the internal trunk of the designed cable wiring:

– 280 m of 4-pair cable of category 5e – for the implementation of backup paths of LOM equipment (according to the calculation, 266.6 m is needed, but in the specification, due to the peculiarities of the factory supply, the total length is indicated in multiples of the whole standard package of 305 m);

– 111m of 100-pair category 3 cable – for the transmission of telephone signals;

– 121 m of 12-fiber optical cable.

There is only one riser in the building. Therefore, measures to reserve information transmission paths are reduced to the laying of 4-pair category 5e cables, which reserve optical cables of the subsystem of internal highways. According to fire safety regulations, all cable products must meet a class not lower than Riser. Fulfillment of the last requirement ensures the laying of cables in riser channels without the use of additional protection means.

2.2.4 Designing the subsystem of external highways

According to the initial data, two 100-megabit information streams should be transmitted over the cable tracts of the subsystem of external highways. In the case of using the currently most common Ethernet technology, an optical cable containing at least four fibers will be required to organize such paths. In order to increase the operational flexibility of the design network, we use an 8-fiber cable with twice the capacity. The cable laying of the subsystem of external highways is carried out along the sewer channel with a total length of 1,850 m according to the plan. Based on this, in accordance with the provisions for the organization of this line, we choose a single-mode cable of the external laying. This product has a protective coating of corrugated steel tape and hydrophobic filling of the inner voids of the core to protect against moisture. According to the factory technical specifications, the cable can be operated without any restrictions in the channels of cable drainage and has a maximum permissible tensile force of 3 kN.

The industry produces similar cables in accordance with technical specifications with a maximum construction length of 4 km, that is, it would be advisable to build the linear part of the subsystem of external highways without installing an intermediate coupling. To choose a laying method, determine the expected traction force in accordance with the recommendations of the International Telecommunication Union. We will calculate according to the formula in tabular form.

When performing the calculations, it is assumed that there is no jamming effect (k zk l = 1), since the laying, according to the initial data, is led into the free channel of the cable sewer. The results of the calculations are summarized in the table. 1.6 and testify to the need to use one or more methods to reduce gravity forces to an acceptable value.

To achieve the goal, we will carry out a stretch from the intermediate point E, which allows us to reduce the maximum length of the laying route by 500 m and reduce the number of turning points in the laying process to one in each section.

The results of the calculations (Table 2.6) indicate that in this case the expected tensile force does not exceed 1720 N, which is more than 1.5 times lower than the allowable according to the technical specifications for this type of cable. The cable entrance to the building is located in such a way that the distance from it to the hardware room is about 8 m, that is, even taking into account the rise from the basement, the length of the subsystem of internal mains laid inside the cable does not exceed 15 m. This allows the use of a cheaper structure with a polyethylene sheath without switching to cables with external non-flammable protective coatings.

Table 2.6 – Calculation of the tensile forces of the cable of the outer lining when pulling from the end point A

Beginning	End	Plot Type	Length M	Tilt in	Turn B”	Gravity
A	B	Straight	35	0	0	260
B	B	Turn	0	0	90	420
B	C	Straight	24	3	0	630
C	D	Straight	25	0	0	940
D	L		15	-5	0	1190
L	L	Turn	0	0	90	1900
L	r	Straight	15	0	0	2000
r	r	Turn	0	0	90	3300
F	G	Direct	35	4	0	35000
G	H	Straight	25	0	0	37000

Pipe wiring is used to organize the laying route inside the building from the point of cable entry to the hardware, which ensures compliance with fire safety standards and reliable protection of the cable against mechanical damage during operation. The total length of the cable, taking into account the amount of technological reserves on the unevenness of laying and the installation of final switching and processing devices, is defined as 1850 × 1.057+ 2×5 +2x5=1995 m≈2000 m.

2.2.5 Designing the administrative subsystem

As switching equipment in technical premises, we will use:

– 19-inch panels with modular connectors in a fixed configuration – for connecting cables of the horizontal subsystem;

– 19-inch panels of type 110 – for connecting multi-pair trunk cables of category 3 in floor crossovers and crossover towers of type 110 in the hardware room;

– set-up panels with modular connectors – for the organization of reserve trunk lines of category 5e;

– switching shelves with duplex sockets of the SC type multimode connector – for connecting optical cables of the subsystem of internal highways;

– switching shelf with single-mode sockets of the FC type – for connecting the optical cable of the subsystem of external trunks.

In all technical premises of the lower level of this specific project, that is, in the control room, as well as in the hardware room in that part of it that serves the workplaces of the first floor, the method of switching connection (interconnect) will be used to connect high-speed network equipment to the horizontal subsystem.

Each technical room of the designed system serves 90 2-port IRs at workplaces. To connect horizontal cables, you will need 2×90/24 =8 panels with a height of 1 U with 24 socket parts of connectors. The choice of this type of panels is justified by the slightly lower installation time compared to double-height panels. For connecting multi-pair cables of category 3 of the internal trunk subsystem based on the data in the table. 9.6 one 200-pair type 110 panel will be required in each installation cabinet installed in the KP. Spare cables of category 5e are wound on the collection panels. According to the data in the table. 1.3 there are 9 such cables in each KP. Accordingly, 27 category 5e cables are laid in the hardware room through the channels of the riser. Therefore, the design system will require 5 dial panels: one in each of the KPs and two in the hardware room. We mount the socket modules in the dial panels installed in the KP in their right part under the up-link ports of the switches of the working group level. Part of the installed sockets for the socket modules of these panels remains free. Cabinets with glass front doors were chosen as the assembly structure. Therefore, to improve the aesthetic indicators of the switching field, the free holes are closed with plugs. The dial panel has holes, each of which is designed to install two modules. Then 12-9/2 = 7 holes remain unused in the KP in the dial panels, and 2x12-27/2 = 10 holes in the hardware, and all you need is 3x7 + 10 = 31 plugs.

Two 12-fiber optical cables of internal laying are wound into each KP. A 1 U high optical shelf for their connection has 2 cable inputs and 12 duplex SS sockets, that is, both cables can be placed in one such shelf.

The standard splice plate is equipped with the following elements: a case with a built-in organizer of the technological supply of fibers, two removable holders of KDZS sleeves for 6 seats and a protective cover. Two splice plates can be installed in each shelf. In order to increase the functional flexibility of the network being created, we will terminate all the fibers of the cables inserted into the shelf, for which 24 mounting cords with a plug of a multimode SS connector will be required. In the hardware room, we will install 3 similar optical shelves with the same set of accessories.

The cable of the subsystem of external mains is additionally introduced into the hardware room. For its connection, a 1 U shelf with 8 single-mode FS sockets is ordered. In the connection process, 8 single-mode installation cables with FS connector plugs, 8 KDZS protective sleeves, one splice plate with the same set of components as used in shelves with multimode connectors are used.

A communication scheme between crosses is used to connect the PBX to the SCS. From the SCS side, 2×400=800 pairs are suitable for cross country. For wiring these pairs, we use two 400-pair wall cross towers. We will choose similar equipment as an intermediate cross of the UATS of the cross. At the same time, of the eight 100-pair blocks of these towers, seven are intended for connecting internal telephones, and the eighth – for connecting direct city numbers. This option is possible because, according to the initial data, at the first stage of operation of the information and computing system of the enterprise, the bulk of the telephone sets will be operated according to the single-pair scheme. In the case of a complete transition to a 2-pair scheme, a wall-mounted 100-pair panel can be installed next to the panels, for which there is enough free space in the hardware room.

The results of the calculations of the switching equipment installed in the technical premises of different levels are entered in the table.

2.2.6 Selection of the type and calculation of the number of organizers

The following types of organizers are used in the designed cable system:

– horizontal organizers installed in mounting structures;
– vertical organizers installed in cabinets;
– vertical organizers installed next to cross ones;
– towers in the hardware room.

According to the scheme, 9 horizontal organizers will be needed in each of the KPs. In this case, SCS switching equipment and LOM network devices are placed in one installation cabinet. Therefore, on the basis of the provisions, we choose the height of the organizer 1 U. In the hardware room in that part of the switching field that performs the functions of the KP equipment, the required number of organizers coincides with the similar parameter of the KP (that is, 9 pieces). Set-up panels of category 5e reserve line in the amount of 2 pieces require one organizer, 3 optical shelves – three. In addition, 2 organizers are provided, mounted above and below the central switch. Thus, a total of 15 organizers will be needed in the hardware room. Summing up the specified values, we get the number of products of this variety that are included in the specification: 9×3+15 = 42.

Vertical cable organizers (holders) of cables of cords of various purposes in the cabinets are installed on mounting rails next to the panels and equipment of individual functional sections of the switching field on two sides of each functionally completed block, i.e. in pairs – for each horizontal organizer and in pairs – for each 200- a paired panel of type 110. Thus, 22 holders of this type will be required in each crossover. In the hardware, the functional section of the horizontal subsystem and the network equipment of the LOM working group are served by 16 holders, the UATS port display panel – by two, optical shelves – by six, and the category 5e reserve trunk panel – by two. Next to the central switch, due to its high height, we install two holders on each side. Thus, a total of 30 holders will be needed in the hardware room

Summing up the specified values, we get the number of holders included in the specification: 22×3+30 =96. The dimensions of the holder based on the data are chosen equal to 93x80 mm. Vertical organizers for cross towers in connection with the customer's requirement to use switching cables in this part of the administrative subsystem are installed:

– on both sides of the cross towers;

– according to the rules set out in – between the second and third cross towers.

Thus, the total number of vertical organizers is equal to 3. The height of the installation of the bases of the cross towers is chosen equal to the height of the organizers.

2.2.7 Calculation of the number and determination of the lengths of terminal, crossover and switching cables in technical premises

The following types of corded products are provided for cross-country shoes:

– single-pair combined cords with modular plugs and type 110 plugs at different ends, intended for connecting the panels of the horizontal subsystem and the main line of category 3;

– 4-pair cords with plugs of modular connectors – for connecting horizontal lines to the ports of floor switches of LOM working groups;

– optical cords – for connecting optical up-link ports of floor switches of working groups to fiber-optic lines of the internal trunk subsystem;

– spare 4-pair cords with plugs of modular connectors – for connecting the electrical ports of floor concentrators to the trunk cable of category 5e.

To calculate the total number of cables of a certain variety, by analogy with the provisions, we use a statistical approach. We assume that the supplied cords provide service for 70% of workplaces, and we assume 10% of this number as part of the PPE. This means that the specification of the supplied equipment includes a total of 77 cables of the first two types and 8 cables for connection to the up-link ports of floor switches.

According to the initial data, single-pair combination cords will be used to connect to the trunk of category 3. Determination of the volume of supply of cables of a certain length of the first two varieties is carried out according to the method given in the literature.

With the placement of LOM and SCS equipment accepted in the project, the maximum distance between the switches and the panel of the reserve line of category 5e will not exceed 65 cm. Taking into account the fact that the sockets of the dial panel of the reserve line are located under the sockets of the up-link ports of the floor switches, this allows the use of cables 1 m long. To connect the optical modules of the up-link ports of the floor switches, we use cables of a standard length of 3 m.

The following types of cord products are provided in the hardware store:

– single-pair combined cables with modular plugs and type 110 plugs at different ends, intended for connecting the socket parts of the connectors of the horizontal subsystem panels and the "degenerate" main line of category 3 connecting the mounting structure and wall cross racks;

– 4-pair cords with plugs of modular connectors – for connecting horizontal lines to the ports of floor switches of LOM working groups;

– optical cables – for connecting the optical ports of the central switch of the network to the fiber-optic lines of the internal trunk subsystem;

– optical cables – for connecting the optical ports of the central network switch to the fiber-optic lines of the subsystem of the external trunk;

– 4-pair cables with plugs of modular connectors – for connecting the up-link ports of the floor switches of the working groups to the ports of the central LOM switch;

– spare 4-pair cables with plugs of modular connectors – for connecting the electrical ports of the floor hubs to the trunk cable of category 5e;

– single-pair cables of type 110 – for switching socket parts of connectors of cross racks;

– 25-pair Te1so mounting cords on one end – for connecting the installed telephone station to the dedicated 100-pair cross rack panel.

Accordingly, in order to improve the technical and economic indicators of the designed system, the hardware room additionally performs the functions of the KP of the first floor. Therefore, the number and distribution of cables of the first two varieties in the hardware coincide with similar parameters in any floor crossover. The central LOM switch is connected to the up-link ports of the work group switches as follows:

– 4-pair cords of category 5e with plugs of modular connectors – to switches in room 128;

– multimode optical cords with plugs of SS connectors through optical cables of the subsystem of the internal main line – to the switches of the rest of the crossovers;

– by single-mode optical cords through optical cables of the subsystem of external highways – to a previously constructed network in another building. Let's estimate the length of cables from twisted pairs of the last variety. In section 4.3, the rationale for the use of structures with a width of 800 mm in the hardware is made.

It is advisable to place the central switch and switches of the LOM working group of the information and computing system in different mounting structures. In the case of their installation at the same height, to simplify the convenience of maintenance, the distance between the connected ports of these devices can only reach 1.5 m horizontally. Because of this, it is advisable to use cables with a length of 2 m. The total number of these cables can be found at based on the expected number of switches of workgroups in the hardware and taking into account the 10 percent reserve will be 8 pieces.

A total of 3×8=24 multimode optical cords, 2+1=3 single-mode optical cords will be required to connect the central switch via optical channels.

To connect the PBX, mounting cords in the form of 25-pair cables with Te1so connectors installed on one end are used. Cords up to 30 m long can be ordered. The distance between the cross racks and the PBX system unit on the wall of the room is approximately 1 m. In this case, taking into account rises and turns, as well as reserves for the non-linearity of laying and processing, we will take the average length of the installation cord equal to 5 m In the process of designing the administrative subsystem for the cross PBX, seven 100-pair blocks were allocated, which will allow in the future to switch to the connection of 2-pair phones without any problems. Therefore, the total number of installation cables of the specified type will be:

$$700 / 25 = 28.$$

A total of 77 × 4 = 308 single-pair cables with type 110 connectors will be required to perform switching on cross towers. We use standard cords 1 m long to perform this operation.

2.3 Calculation of additional elements of the SCS

2.3.1 Calculation of decorative boxes and their accessories

The calculation is performed in accordance with the regulations. In the workplaces, the cable is laid in decorative boxes in accordance with the customer's requirements. According to the plan, the scheme for laying decorative boxes is chosen in such a way that individual segments of cable channels of this type are mainly used for laying cables to two information sockets. Three IRs serve segments in rooms 22, 24, 27 and 36, four – in rooms 14, 15 and 24, five – in rooms 22 and

24. The dimensions of the decorative box are calculated as follows. We take the diameter of a category 5e horizontal cable as 5.2 mm, which corresponds to a cross-sectional area of 21.2 mm2. We take the coefficient of use of the area equal to ki = 0.5, and the coefficient of filling – the average according to the TIA/ EIA-569-A standard and equal to kz = 0.45. With such a degree of filling, the operation of the cable system is significantly simplified and it becomes possible, if necessary, to install additional IRs with the laying of new cables in the existing boxes. In case of urgent need, it is sometimes allowed to increase this parameter, but not higher than the maximum value established by the standard.

According to the initial data, in addition to the information network, a power supply network should be created. In order to comply with fire safety standards, a separate section of the decorative box must be allocated for the laying of power cables. With a relatively small number of IRs served by one segment of decorative boxes, the use of these large-sized products with removable partitions is impractical. Thus, we get that in order to minimize the dimensions, it is necessary to use 3-section wall cable channels, i.e. boxes with a size of 60x16 mm or more.

The results of the calculations of the dimensions of the box are shown in Table 2.7 and indicate that the project will use boxes of two standard sizes: 60x16 mm and 75x20 mm, which allow the installation of information and power socket housings next to the box on the surface of the wall. Two sections of these products will be used for laying horizontal information cables, and one for two power cables (one for the guaranteed power supply system for computer equipment, the other for connecting household power outlets). At the same time, it is assumed that power sockets of various purposes are connected by a power cable "in a loop", i.e. in series.

Table 2.7 – To calculate the dimensions of decorative boxes in rooms for accommodating users

The number of serviced IP	2	3	4	5	6
Number of horizontal cables	4	6	8	10	12
Required cables area, mm2	276	848	1130	1413	1413
Overall dimensions of the box		60*175*2 6	0	75.2 0	75.2 0

Due to the diversity of working premises, the use of the statistical calculation method proposed in the subsection to calculate the number of boxes can lead to a significant error. Therefore, due to the relatively small number of premises, we use a more accurate tabular method of calculation. We believe that the box contains only one vertical descent and a horizontal section, the length of which is determined by the dimensions of the room and the topology of the IR placement.

With a floor height of 3.5 m, a false ceiling height of 80 cm, a vertical section can be covered by one two-meter section of this box. The results of the calculations are summarized in the table. 2.7. In the list of supplied equipment, we indicate the number of the linear part of the cable channel with a margin of 6.3%, calculated to compensate for inevitable waste during the installation process, and with rounding to the large side with an accuracy of 2 m. The latter is determined by the standard length of delivery of this type of products from manufacturing plant. The cost of connecting parts at this stage of the design will be estimated by a value numerically equal to half the length of the box.

Premises of cross-training and hardware according to the scheme and the data of the table. 1.2 are located directly above each other, and the hardware is located on the first floor. According to the initial data, the functions of the riser channels are performed by three pipes with a nominal internal diameter of 80 mm. The busiest part of the channels is the section at the transition between the first and second floors, where, according to the scheme, six optical cables of the internal laying, six 100-pair trunk cables of category 3 and 27 reserve trunk 4-pair cables of category 5 pass.

According to the data, a vertical channel with a minimum area of 6470 mm2 is required for the laying of these cables (at 100 percent filling and utilization factor ki =0.4). The cross-sectional area of one pipe of the riser channel is 5000 mm2, therefore, the SCS cables will be laid along two pipes.

2.3.2 Other types of cable channels

Table 2.8 – Calculation of the number of boxes and accessories

No	Name	Unit Measurements	% Filling	Length (M)	Stock (M)
1	2	3	4	5	
1	Box 40x40 K40 225	M	16.98	2.09	0.19
2	Box 40x40 K40 226	M	16.98	4.40	0.40
Okay 3	Box 40x40 K40 227	M	16.98	0.99	0.09
4	Box 40x40 K40 228	M	16.98	2.86	0.26
5	Box 40x40 K40 229	M	16.98	2.75	0.25
6	Box 40x40 K40 230	M	16.98	10.45	0.95
7	Box 40x40 K40 231	M	16.98	0.88	0.08
113	Kopob 40x40 K40 337	M	48.61	2.53	0.23
…					

114	Kopob 40x40 K40 338	M	48.61	0.33	0.03
103	Kopob 40x40 K40 339	M	5.40	0.44	0.04
	Together			336,050	30.44

According to the plan, two cable entrances are provided in the technical room, implemented on the basis of tube blocks with an internal diameter of 32 mm. The first of them leads to the elevator hall (room 2 according to the plan), the second connects the technical room with room 29. Entrance number 1 serves horizontal cables that are laid to the information sockets in rooms 23, 24, 25 and 26. Cables are passed through entrance number 2 , which are connected to IR in the rest of the premises for users, with the exception of premises 27, 28, 29 and 30. According to the data of table 2.8, 44 cables pass through the first entrance, 104 through the second.

Let's apply the calculation method, as a result of which we get that through one tube with a diameter of 32 mm it is possible to enter 9 horizontal 4-pair cables with a single filling factor. Hence, the minimum allowable number of tubular elements at inlet number 1 is five, and at inlet number 2 – twelve. Thus, the cable entries provided for in the construction project of the building can be used to build structured cabling with sufficient margin.

For the introduction of cables from the trays into the working premises, holes are formed in the corresponding places of the walls of the corridor behind the false ceiling, in which the installation pipes are installed along the entire thickness of the wall for the laying of SKS cables. The number of IRs to which horizontal cables passing through one input are connected does not exceed six. Taking into account the fact that no more than 9 cables can be inserted through one tube, we get that no more than two tubes are needed for laying.

The ends of input pipe blanks are processed in accordance with the rules before installation. They are cleaned of burrs, and chamfers are removed from them to remove sharp edges that can damage the cable sheaths during routing.

To lay the cables of the horizontal subsystem in accordance with the decisions made in the architectural design phase, trays are installed on the floors along the corridor behind the suspended ceiling. In the process of calculating the cable entries in the technical premises of the designed cable wiring, it was established that cables pass through them, which are then laid on trays. With a horizontal cable area of 21.2 mm2 and a 10 percent utilization factor according to this table. 1.8 we get that the area of the trays should be 933 and 2200 mm2. Trays with a nominal cross section of 50x200 mm and 100x300 mm have the corresponding area. Trays of smaller cross-section can be used as they are removed from the technical room. In this case, due to the uniformity of the element base in the entire project, we use trays of the second type. According to the plan, 49 m of trays will be required on each floor, and a total of 200 m of trays with appropriate accessories and fastening components must be provided to implement the cable system. The distance from the floor to the lower edge of the tray according to the data of subsection 1.2 is 3 m. If the height of the side wall of the tray is 10 cm and the total height of the room to the capital ceiling is 350 cm, the distance between the upper edge of the tray and the ceiling will be 40 cm, which exceeds the minimum value of 25 cm and enough for normal work.

In subsection 2.1, it was justified that SCS equipment and active LOM devices are placed in closed mounting cabinets with glass front doors. According to the formulas, taking into account the principle of organization of the switching field according to the switching connection scheme (interconnect) and the number of serviced workplaces N=24, we get that the total height of the assembly structure of the warehouse is approximately $H = 9/32 \times N + 7 \approx 33U$, which practically coincides with the value. In order to obtain the necessary supplies for the development of the information and computing system of the enterprise, the same cabinets with a height of 42 U are applicable in the cross room and the hardware room. As it was established above, in the assembly structure of the hardware room, in addition to the network equipment for collective use, the SCS switching equipment serving the IR workplaces of the first floor is installed. Based on this, one cabinet will be installed in the control room, and two in the hardware room. At the same time, there is free space for installing servers, a central switch, a disk array, modem pool frames, and other active network devices: 2×42 – 33 = 51 U. Accordingly, in this project, we will use mounting cabinets with a width of 800 mm. From the initial data concerning the principles of construction and the nature of the operation of the customer's LOM, it follows that the probability of installing specialized servers in the KP is quite high. Therefore, on the basis of the regulations, we will choose the nominal depth of the mounting cabinets equal to 800 mm (the actual value is 875 mm). Minimization of costs of the main cable and simplification of the elements of its supply to the mounting structures is provided by the installation of cabinets next to the risers. In order to obtain the necessary stiffness of the structure and in accordance with the requirements, the cabinets in the hardware room are connected to each other, for which standard sets of fasteners are used.

Cabinets are additionally equipped with the following equipment:

– a set of legs (set for a structure);

– a fan module, which is installed to save installation height in the cover of the cabinet, – alone on the structure;

– with a grounding kit – alone per structure;

– vertical power supply distributor – in pairs per structure;

– shelves with a depth of 454 mm for installation of equipment that does not have fastening elements on 19-inch rails, – one per structure.

2.4 Calculation of auxiliary elements of the SCS

2.4.1 Selection of type and calculation of volumes of supply of fastening elements

According to the subsection, the parameters and volume of supply of cable ties, decorative box fasteners, and equipment fasteners in the 19-inch structure are subject to calculations.

Cable ties are used to form cable bundles in 19-inch structures and on trays. If the number of serviced workplaces is N = 90, we use a 380-mm-long fastening. According to the formula, we get the total costs of charges of this type in the cabinets installed in the KP, equal to 101 pcs.

In subsection 1.2, it was justified that on each floor of the building under the sleeves there are three points of attachment of cables of the subsystem of internal highways. To fasten these cables outside the mounting cabinets, another 4×3 = 12 ties will be required.

In addition, let's take into account the fact that in accordance with the provisions of section 4.3, structures with a margin of height are used in the control room, and two mounting cabinets are installed in the hardware room. Taking into account these circumstances, five packages of 100 pcs. in every.

Tightening with a length of 550 mm is used for fastening cable bundles on trays. The total length of the trays serving one floor in this system is 49 m. Thus, two packages of these 100 pcs. in every.

As a fastening element of boxes and socket modules, taking into account the material of the walls of the building, determined in the initial data, and the information presented in the table, you can use a nylon dowel. In this particular project, we use a more affordable nylon dowel (screw dowel).

According to the results obtained in subsection 1.4.2, an average of (202+66)/90 =3 m of boxes with dimensions of no more than 75×20 mm is brought to one workplace in this project. For installation of power and information sockets, the method of mounting on the surface next to the box in the frame is used. At the same time, a total of four frames are attached: one – for IR, two – for power outlets of "clean" power supply and one – for an electric outlet of the household network. For boxes up to 75×20 mm in size according to subsection 1.5.4.1, the average distance between the attachment points is approximately 40 cm. Thus, the total consumption of dowels-screws will be equal to 4×90×[3/0.4 + (1 + 2 +1)×3] = 7020 pcs. The supply of these components is carried out in packages of 100 pcs. in each, i.e. 71 packages will be needed in total.

To determine the amount of consumption of this type of components, we will use the provisions of the subsection. The switching field in the KP is formed according to the interconnect scheme, the number of serviced workplaces is N=90. According to the formulas given in the table. 1.10, we get that for the installation of the equipment in one KP cabinet requires 105 sets of "M6 screw – square nut", and a total of 420 sets in all technical rooms. Delivery of this type of fastening elements is carried out in packages of 50 pcs. We include 10 such packages in the list of supplied equipment. The resulting stock is used for the installation of active network equipment in the hardware room, and is also left in the spare parts for use in the process of the current operation of the company's information and computing system.

2.4.2 Calculation of the number of marking elements

Determination of the types and quantity of finishing and technological marking is carried out in accordance with the provisions of the subdivision.

It is believed that the panels for various purposes, which are installed in the technical rooms of the cross floors and the hardware room, have standard marking elements. Marking of individual cables, cables and sockets is done with self-adhesive markers. At the same time, both ends of corded products are marked in accordance with the applicable rules. According to this rule, four markers are used for each cable (2 for technological and 2 for finishing marking) and two for each cord. IR socket modules are marked once. The results of the calculations are summarized in the table. 1.7.

2.4.3 Technological and measuring equipment

Technological and measuring devices are included in the specification of the delivered equipment. This equipment is handed over to the customer after the installation is completed and is used by him during current operation for various checks, during minor repairs, when organizing new cable lines and in other similar situations. During the installation process, they often perform the functions of visual assistance and are used to train the customer's personnel who will operate the SCS in the future (if such training is stipulated by the contract).

Single-wire and 5-pair percussion instruments are used when connecting cables to socket modules of information sockets and switchboards.

Note. 1. Markers for reserve lines of category 5e subsystem of internal highways are taken into account when calculating the number of horizontal cable markings. 2. The number of marking cables is determined in accordance with the data of subsection 2.1.7.

The Omniscanner 2 and Simplifiber devices are designed, respectively, for testing cable lines and tracts of twisted pairs and optical cables.

In addition, in this subsection, you need to describe the specifications provided by the instructions. A set of tools and consumables that allow pre-trained operating personnel to perform work on the installation of optical connectors. Its presence provides the possibility of development of the cable system and its repair in case of accidents and malfunctions of low and medium severity.

Table 2.9 – Excerpt from the equipment specification

No	Name	Article number of the manufacturer	Article number of distributor	Manufacturer	Unit measurement	How many Name
1	Cable optical 9/125		IK-OKS M4P-4A-1.5	Intercross	M	28.82
2	Automaton			Another	Piece	3.00
3	Outside boxing Dual port 23.1xx82.6 (connects LD 5)	CBX2AW-A	CBX2AW A	Panduit	Pcs	77.00
4	Jack RJ11			Another	Piece	64.00
5	Jack RJ45			Another	Piece	78.00
6	Cable 2x1.5 (220v)				M	262.30
7	Cable twisted pair 5k(RJ45)				M	4369.61
8	Switch 24x 10/100+2x1000 Fast ethernet			Another	Piece	3.00
9	BOX 40x40			Panduit	M	336.05
10	Mini. ACT Panasonie kx TD816BX			Panasonic	Piece	2.00
11	Module RJ11 unshielded cat3	CJ66AW	CJ66AW	Panduit	Piece	77.00
12	Module RJ 45 blue ,cat 5th	CJ588BU	CJ588BU	Panduit	ulT	77.00
13	Closet			Another	Piece	2.00
14	Screw				Pcs	1510.00
15	What			Another	Piece	1.00
16	Electric meter			Another	Piece	1.00

The full version of the exposure from the specification in columns 2, 6 and 7. The filling of the last columns depends to a large extent on the specific manufacturer of the SCS and therefore is not given here, in accordance with the general structure of the designed network scheme. For ease of understanding, part of the switching cables is not shown in the drawing.

2.4.4 Selection of switches

When the first devices appeared, allowing to disconnect the network into several collision domains (essentially fragments of local networks built on hubs), they were two-port and were called bridges. As this type of equipment developed, they became multi-port and received the name switches (switch-her). For some time, both concepts existed simultaneously, and later instead of the term "bridge" they began to use "switch".

As a rule, when designing a network, several collision domains of the local network are connected with each other with the help of switches. In real life, as a rule, the floors of the building in which the network is being created act as domains of collisions. there are usually more than 2 of them, and as a result, traffic management is much more effective than that of the forefather of the bridge switch. At the very least, it can support redundant connections between network nodes.

Due to the fact that switches can manage traffic based on the link layer protocol (Layer 2) of the OSI model, it is able to control the MAC addresses of devices connected to it and even provide translation of packets from standard to standard (for example, Ethernet to FDDI and back). The results of this capability are particularly successfully presented in Level 3 switches, that is, devices whose capabilities are close to those of routers.

A switch allows packets to be forwarded between several network segments. It is a learning device and operates on similar technology. Unlike bridges, some switches do not buffer all received packets. This happens only when transmission rates need to be negotiated, or the destination address is not in the address table, or when the port to which the packet should be directed is busy and is switching packets on the fly.

The switch only analyzes the destination addresses in the packet header and, after checking the address table, immediately (with a delay of about 30-40 microseconds) sends this packet to the appropriate port. Thus, when the packet has not yet completely passed through the input port, its header is already transmitted through the output port. Unfortunately, typical switches work according to the "address aging" algorithm. This means that if, after the specified time period, there were no calls to this address, it is deleted from the address table. Switches support full duplex mode when connected to each other. In this mode, data is transmitted and received at the same time, which is impossible in ordinary Ethernet networks. At the same time, the speed of data transfer is increased by two times, and when several switches are connected, it is possible to achieve higher peak performance.

The hub transmits (rebroadcasts) the data packets that come to it in all directions, except for the one by which they came. And the bandwidth of the network is limited, and with a heavy load, it decreases due to frequencies conflicts during simultaneous attempts to transfer data to the network. To increase network throughput, instead of a hub, you can use a switch (or a switching hub). It performs the functions of a hub, but transmits incoming messages only in the direction in which the recipient of the message is located. In this way, the switch divides the network into several segments, not allowing unnecessary messages into each segment. This significantly reduces the load on the network (network traffic).

In our case, we will use the switches in the premises and in the accounting department, since the majority of network traffic is concentrated here. Based on the above considerations, one 16-port switch will be installed in the premises. We present a comparative table with several devices of this type in table 2.10.

The new EZ Switch™ 10/100 switches, EZ-108DT, EZ-1016DT and EZ-1024, have 8, 16 and 24 10BACE-T/100BACE-X ports (in Fig. 1.2), respectively, their high performance and reliability make these "plug&play" devices are the ideal choice for integrating Fast Ethernet technology and expanding the bandwidth of a local network for small and medium-sized workgroups. All EZ Switch 10/100 switches are fully compatible with existing standards of Ethernet and Fast Ethernet networks, so you will not have to rebuild the network, which will save capital investment in the infrastructure. Each port of the switch (and, accordingly, the connected network segment) is able to function at a speed of 10 or 100 Mbrs, the selection of the optimal mode and speed is carried out using the autoload function. The system of indicators provides the possibility of monitoring network segments and helps to find malfunctions in the network.

Figure 2.1 – EZ-108DT and EZ-1016DT switches

These devices have sufficient power, reliability and performance to be used as departmental switches (collapsed backbone), supporting Fast Ethernet hubs, servers and dedicated users along with the existing segments of the Internet. Moreover, the "store and forward" switching method used prevents false packets from spreading over the network. Support for flow control in full-duplex mode (as well as half-duplex) ensures maximum data preservation even at high network load.

Table 2.10 – Comparative characteristics of switches

	Elect switchboard	Analog 1	Analog 2
Producer	SMC	Allied teiesyn	3com
Model	EZ-1016DT	AT-PS716	OC switch OC (3c
Quantity Port	16*10 base T/100 base TX	16*10 base T/100base TX	
Speed Mbits/s	10/100	10/100	10/100
Support network standards	• IEEE802.3 10BASE-T Ethernet (copper twisted pair) IEEE802.3u 10BASE-TX Fast Ethernet (copper twisted pair) IEEE802.3x Flow control	IEEE802.3 10BASE-T twisted pair) IEEE802.3u 10BASE-TX Fast Ethernet bridge function (copper) twisted pair) IEEE802.3x Flow control	IEEE802.3 (Ethernet) IEEE802.3u (Fast Ethernet) • IEEE 802.1d IEEE 802.3x (flow
Price uah	1615	1626	1711.55

High performance:

– Bandwidth of 0.8, 1.6 or 2.4 Gbps.

– Filtering and retransmission of frames takes place at the maximum possible speed in the cable (full wire speed).

– Automatic memory of addresses 1000 MAC addresses (8 and 1b-port models) 12000 MAC addresses (24-port model).

– Store and forward switching architecture prevents the propagation of erroneous packets.

– Full-duplex (as well as half-duplex) flow control support prevents data loss even under high network load.

– Ease of installation and use:

– Plug & Play.

– Auto-negotiation for automatic selection of the optimal data transfer rate and operating mode.

– A system of indicators for visual monitoring of traffic in network segments.

– Cascade port.

– Can be installed in a 19" rack.

– Reliability.

– Three-year warranty.

– Free technical support.

We will choose a switch of the same manufacturer, only with 8 ports, for connecting personal computers. Thus, here we will use the switch SMC-EZ108DT (8x10/100Vase-TX).

2.4.5 Choosing a router

Hubs that organize a work group, bridges that connect two network segments and localize traffic within each of them, as well as switches that allow connecting several segments of a local computer network are all devices that designed to work in IEEE 802.3 or Ethernet networks. However, there is a special type of equipment called routers, which is used in networks with a complex configuration to connect its sections with various network protocols (including access to global (WA) networks), as well as for more effective division of the schedule and the use of alternative paths between network nodes. The main purpose of using routers is the unification of disparate networks and maintenance of alternative paths.

Different types of routers differ in the number and types of their ports, which actually determines where they are used. Routers, for example, can be used in a local Ethernet network to effectively manage traffic when there are a large number of network segments, to connect an Ethernet-type network to networks of another type, such as Token Ring, FDDI, and also to provide exits of local networks to the global network . Routers not only connect different types of networks and provide access to the global network, but can also manage traffic based on the network layer protocol (the third in the OSI model), that is, at a higher level compared to switches. The need for such control arises when the topology of the network becomes more complicated and the number of its nodes increases, if redundant paths appear in the network (supported by the IEEE 802.1 Spanning Tgee protocol), when it is necessary to solve the problem of the most efficient and fast delivery of the sent packet to its destination. At the same time, there are two main algorithms for determining the most profitable path and method of data delivery: RIP and OSRF. When using the RIP routing protocol, the main criterion for choosing the most efficient path is the minimum number of "hops", that is, network devices between nodes. This protocol minimally loads the router's processor and greatly simplifies the configuration process, but it does not rationally manage traffic. When using OSRF, the best path is selected not only from the point of view of minimizing the number of hops, but also taking into account other criteria: network performance, packet transmission delay, etc. Large networks that are sensitive to traffic congestion and rely on complex routing hardware require the use of the OSP protocol. Implementation of this protocol is possible only on routers with a sufficiently powerful processor, because its implementation requires significant processing costs. Routing in networks, as a rule, will be carried out using five popular network protocols – TSR/IR, Novell IPX, Appletalk II, Decnet Phase IV and Herokh XNS. If the router receives a packet of unknown format, it starts working with it as a self-learning bridge. In addition, a router provides a higher level of traffic localization than a bridge, providing the ability to filter broadcast packets as well as packets with unknown destination addresses because it can process network addresses. Modern routers have the following properties:

– support level 3 switching, high-speed level 3 routing and level 4 switching;

– support advanced data transmission technologies, such as Fast Ethernet, Gigabit Ethernet and ATM;

– support ATM technologies using speeds up to 622 Mbit/s;

– simultaneously support different types of cable connections (copper, optical and their varieties);

– support WAN connections, including support for PPP, Frame Relay, NSSI, SONET, etc.;

– support layer 4 switching technology (Layer 4 Switching), which uses not only information about the addresses of the sender and recipient, but also information about the types of programs that network users work with;

– provide the possibility of using the mechanism "service on request" (Quality of Service) – Qos, which allows assigning

– priorities for certain resources in the network and ensure traffic transmission in accordance with the priority scheme;

– allow you to manage bandwidth for each type of traffic;

– support the main routing protocols, such as IP RIP1, IP RIP2, OSPF, VGR-4, IP RIP/SAR, as well as IGMP, DVMPR, PIM-DM, РИМ-SM, RSVP protocols;

– support several IR networks at the same time;

– support SNMP, RMON and RMON 2 protocols, which makes it possible to control the operation of devices, their configuration from the network management station, as well as to collect and further analyze statistics about the operation of the device as a whole and its interface modules;

– support both unicast and multicast traffic.

In this case, it is necessary to choose a router that has the ability to connect 4 Fast Ethernet ports for connecting and managing traffic between the main nodes of the network, and one port for connecting the local network to the global network.

Thus, taking into account the presence of a built-in modem and the cost of the corresponding equipment, we choose the SMC7404BPA router to connect the local network to the global network. ADSL Varricade is an excellent all-in-one solution for organizing a broadband ADSL connection in an office or home. This multifunctional router has 4 RJ-45 10/100Mbps ports, a DB-25 port for connecting a printer and an RJ11 port for connecting to an ADSL line. A network switch or hub can be connected to the RJ-45 10/100Mbps ports to increase the number of users who can use the Internet at the same time. SMC7404BPA also has a built-in DHCP server that can assign IP addresses to network computers and a print server that can be accessed by all network users. Vaggisasie ADSL supports Full-rate G.dmt (G.992.1), G.Lite ADSL(G.992.2) and access to the external network.

Figure 2.2 – Router SMC7404BPA

High efficiency and functionality.

– 4 10/100 Mbps ports with automatic connection speed detection.

– Support for full-rate G.dmt (8Mbrs downstream, 640Kbrs upstream) and economic G.lite connection (1.5Mbrs downstream and 512Kbrs upstream).

– Built-in firewall (packet filtering, NAT, NAPT) to ensure data and access security.

– Support for remote management and recovery of micrococo.

– Functions as a bridge and/or router.

– Built-in print server.

– Compatibility.

– Compatible with all major manufacturers of DSLAMs.

– Annexe A support.

– RFC1483 Encapsulation (IR, Bridging & Encapsulated Routing).

– PPP over ATM (LLC & VS multiplexing) RFC2364.

– Support for up to 8 RVS.

– Traffic shaping (UBR, VBP, CBP).

– OAM support (1.610).

– PPP over Ethernet (RFC2516).

– Support for DSL handshaking, G.994.1.

SECTION 3 LIFE SAFETY, BASICS OF LABOR PROTECTION

3.1 Hygienic requirements for the organization of equipment of workplaces with VDT

The equipment and organization of the workplace with VDT must ensure the compliance of the design of all elements of the workplace and their mutual location with ergonomic requirements, taking into account the nature and features of work (GOST 12.2.032-78, GOST 22.269-76, GOST 21.889-76).

The design of the workplace of the VDT user must ensure the maintenance of an optimal working posture.

Workplaces with VDT should be located in relation to the light openings in such a way that natural light falls from the side, preferably from the left.

The following distances should be observed when placing work tables with VDT: between the side surfaces of the VDT - 1.2 m; from the back surface of one VDT to the screen of another - 2.5 m.

The VDT screen should be located at the optimal distance from the user's eyes, which is 600...700 mm, but not closer than 600 mm, taking into account the size of alphanumeric signs and symbols.

The location of the VDT screen should ensure the convenience of visual observation in the vertical plane at an angle of +30° to the normal line of sight of the worker.

The keyboard should be placed on the surface of the table at a distance of 100...300 mm from the edge facing the worker. The design of the keyboard should include a support device (made of a material with a high coefficient of friction that prevents it from involuntarily shifting), which allows change the angle of inclination of the keyboard surface within 5...15°.

To ensure protection and achieve standardized levels of computer radiation, it is necessary to use near-screen filters, local light filters (means of individual eye protection) and other means of protection that have been tested in accredited laboratories and have an annual hygiene certificate.

When equipping a workplace with a VDT laser printer, the parameters of laser radiation must meet the requirements of DSanPiN 3.3.2.007-98.

In the organization of work related to the use of VDT computers and personal computers, in order to preserve the health of workers, prevent occupational diseases and maintain working capacity, intra-shift regulated rest breaks are provided.

Internally variable regimes of work and rest contain additional short breaks in the periods preceding the appearance of objective and subjective signs of fatigue and reduced work capacity.

When performing work that belongs to different types of work, the main work with VDT should be considered to be that which takes at least 50% of the working time. During the work shift, the following should be provided:

– breaks for rest and eating (lunch breaks);
– breaks for rest and personal needs (according to labor standards);
– additional breaks introduced for individual professions taking into account the specifics of labor activity.

3.2 The effect of electric current on the human body, types of electrical injuries

The most important issues of labor protection are electrical safety, which is a system of organizational, technical measures and means that ensure protection of people from harmful and dangerous effects of electric current, electric arc, electromagnetic field and static electricity.

Dangerous and harmful production factors include an increased value of the voltage in the electrical circuit, the closure of which can occur through the human body, an increased level of static electricity, electromagnetic radiation, and increased intensity of electric and magnetic fields.

Electrical equipment poses a great potential danger to humans, especially due to the fact that the senses do not perceive electrical voltage at a distance, unlike heat, light, moving elements, odors and other harmful and dangerous production factors. Therefore, when the current affects a person, his oxidative reaction is manifested only after direct contact with parts of equipment that are under voltage.

The effect of electric current on living tissue, unlike other physical factors, has a peculiar and versatile character.

The mechanism of injury to a person by electric current is extremely complex and is accompanied by thermite, electrolytic and biological effects. At the same time, irreversible violations of the functional activity of vital human organs are possible.

The thermal effect is characterized by heating of body tissues, blood vessels, nerves, heart and other organs that are in the path of the current.

Electrolytic effect decomposes blood, lymph and plasma, disrupts their physical and chemical composition. The biological impact is manifested in the violation of biological processes that occur in the body, accompanied by irritation or destruction of nervous and other tissues and burns, up to the complete cessation of the activity of the respiratory organs and blood circulation. According to the consequences, electric injuries are divided into local, accompanied by clearly defined local injuries of the body, and general, or electric shocks, which lead to damage to the entire body due to disruption of vital functions of the most important organs and systems. Most electrocutions (-55%) are a combination of local electrocutions and electric shocks.

The danger of local electric injuries and the complexity of their treatment depends on the nature and damage of the tissue, the reaction of the body to this damage. As a rule, local electrical injuries are cured and the victim's ability to work is fully or partially restored. Sometimes (more often with severe burns) a person dies. In this case, the direct cause of death is not electric current (or arc), but local damage to the body caused by current (or electric arc). Characteristic types of local electric injuries: electric burns, electric signs, metallization of the skin, electroophthalmia and mechanical damage.

Electric burn is the most common electrical injury that occurs in 60...65% of victims of electric current, most of whom are operational personnel servicing operating electrical installations.

Electric burns occur in places of contact of the surface of the human body with an electrode (contact or current burn) or under the influence of an electric arc (arc burn).

When a large amount of heat is released, burns can affect not only the skin, but also the subcutaneous fat layer, muscles, nerves and bones. Such burns are called deep and heal for a long time.

Electric signs, or electric marks, appear on the human skin in places of its close contact with current-conducting parts. These are hardened spots of gray or pale yellow color, usually round or oval in shape. Unlike burns, marks do not cause pain and their treatment ends well.

Metallization of the skin - the penetration of the smallest metal particles into the surface layers of the skin, which is melted and sprayed under the action of an electric arc. This can happen during short circuits, tripping of disconnectors and circuit breakers under voltage, etc. This type of electrocution occurs in -10% of victims. Metallization of the skin can be avoided by using overalls and protective glasses,

Electroophthalmia is an inflammation of the cornea of the outer membranes of the eyes, which occurs as a result of exposure to a powerful flow of ultraviolet rays, which are immediately absorbed by the cells of the body and cause chemical changes in them. Such exposure is possible in the presence of an electric blow (which occurs, for example, in the event of a short circuit), which is a source of intense radiation of not only visible electric light, but also ultraviolet and infrared rays. The use of protective glasses with colorless glass, which almost does not pass ultraviolet radiation, helps to prevent eye diseases.

Mechanical damage occurs as a result of sudden involuntary convulsive contractions of muscles under the action of current passing through a person. As a result, ruptures of the skin, blood vessels and nervous tissue, as well as joint dislocations and even bone fractures can occur. Mechanical injuries, as a rule, are significant injuries that require long-term treatment, they are very rare. Mechanical damage caused, for example, by the fact that a person falls from a height due to the action of current, does not belong to electric injuries.

Electric shock is the most dangerous type of electric injury, which is accompanied by damage to the body, in which there is paralysis of the muscles of the musculoskeletal system, the muscles of the chest (respiratory), and the muscles of the ventricles of the heart. In the first case, convulsive muscle contractions do not allow a person to free himself from contact with an electrical installation. With respiratory paralysis, gas exchange and the supply of oxygen to the body stop, as a result of which suffocation occurs. With paralysis of the heart muscles, its work either stops completely, or is accompanied by tremors (fibrillation) for some time.

Fibrillation is a chaotic, fast and different time contractions of heart muscle fibers (fibrils), in which the heart stops working as a pump, that is, it is unable to ensure the movement of blood through the vessels. As a result, blood circulation stops, the supply of oxygen to tissues and organs stops, which causes the death of the organism.

Medical practice has established that after the cessation of heart and breathing as a result of oxygen starvation, the cells of the central nervous system die after 5...6 minutes, resulting in loss of consciousness and cessation of control of the functions of all body organs. This condition is called "clinical (apparent) death" because the cells of other body organs are still alive. But with a long-term absence of breathing and blood circulation, the vital activity of the remaining cells and organs ceases, and irreversible biological death occurs. Therefore, it is necessary immediately after releasing a person from the effect of electric current, no later than the first 5...6 minutes, to provide pre-medical assistance through artificial respiration and indirect heart massage, which will make it possible to prevent a fatality.

CONCLUSION

The computer network of the "Warmish" enterprise was designed in the qualifying work of the "Bachelor" educational level.

In the design process, the topology of the computer network was created, the network equipment was connected, and the address space was divided.

Building a network with the installation of virtual networks provided a convenient mechanism for combating unauthorized access to service information and increasing network performance. Combining users on the basis of network addresses into virtual networks turned out to be a convenient device for small networks, which ensures free movement of the user within the network.

In the main part of the explanatory note, an analysis and overview of the technologies required for the development of the network was carried out. Also, this section describes the design of the cable infrastructure, the key principles of building a logical topology and creating virtual subnets.

Server and workstation software meets the following requirements:

– functional completeness – a variety of supported services;

– productivity;

– scalability;

– the ability to work on a powerful platform;

– ensures reliable protection of information from unauthorized access;

– ensures reliability of information storage;

– ensures delimitation of access rights to resources.

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