THE REPUBLIC OF MONTENEGRO
THE MINISTRY OF EDUCATION AND SCIENCE

MEIS
(Montenegrin Educational Information System)

MAIN PROJECT ON EDUCATION INFORMATION SYSTEM OF MONTENEGRO


Project team
<table>
<thead>
<tr>
<th>Name</th>
<th>Employer</th>
<th>Role in the Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radovan Rutešić</td>
<td>Faculty of Mathematics and Computer Science</td>
<td>Project leader</td>
</tr>
<tr>
<td>Goran Šuković, MS</td>
<td>Faculty of Mathematics and Computer Science</td>
<td>Team member</td>
</tr>
<tr>
<td>Biljana Stamatović, DS</td>
<td>Faculty of Mathematics and Computer Science</td>
<td>Team member</td>
</tr>
<tr>
<td>Verica Sekulić</td>
<td>Faculty of Mathematics and Computer Science</td>
<td>Team member</td>
</tr>
<tr>
<td>Predrag Stanišić, DS</td>
<td>Faculty of Mathematics and Computer Science</td>
<td>Team member</td>
</tr>
<tr>
<td>Srđan Kadić, MS</td>
<td>Faculty of Mathematics and Computer Science</td>
<td>Team member</td>
</tr>
<tr>
<td>Milenko Mosurović, DS</td>
<td>Faculty of Mathematics and Computer Science</td>
<td>Team member</td>
</tr>
<tr>
<td>Stevan Šćepanović, DS</td>
<td>Faculty of Mathematics and Computer Science</td>
<td>CEFT sub-project leader</td>
</tr>
<tr>
<td>Igor S. Ivanović</td>
<td>Faculty of Mathematics and Computer Science</td>
<td>Team member</td>
</tr>
<tr>
<td>Igor B. Ivanović</td>
<td>Faculty of Mathematics and Computer Science</td>
<td>Team member</td>
</tr>
<tr>
<td>Slavoljub Popadić</td>
<td>Internet CG</td>
<td>MEN sub-project leader</td>
</tr>
<tr>
<td>Saša Leković</td>
<td>Telekom CG</td>
<td>Team member</td>
</tr>
<tr>
<td>Zoran Peković</td>
<td>Ministry of Education and Science</td>
<td>Team member</td>
</tr>
<tr>
<td>Dušica Slović</td>
<td>Faculty of Mathematics and Computer Science</td>
<td>Team member</td>
</tr>
</tbody>
</table>
## CONTENTS

1. **MEIS MAIN PROJECT TASKS AND OBJECTIVES** .............................................1  
2. **LOGICAL ARCHITECTURE OF MEIS PROJECT (LA-MEIS)** ......................3  
   2.1. **INTRODUCTION TO MEIS SUB-PROJECT** ..........................................3  
   2.2. **MEIS THREE-TIER ARCHITECTURE** ....................................................4  
      2.2.1. Advantages of J2EE Platform .........................................................8  
   2.3. **MEIS PROCESS DESCRIPTION** ...............................................................12  
      2.3.1. Main Processes in Education ..........................................................12  
      2.3.2. Monitoring of Resources ...............................................................20  
      2.3.3. Administrative Operations .............................................................27  
      2.3.4. Management Support ..................................................................27  
      2.3.5. IS Administration .........................................................................28  
   2.4. **PROVISION OF QUALITY IN IMPLEMENTATION OF LA-MEIS PROJECT** ..........................................................30  
      2.4.1. Standardization .............................................................................30  
      2.4.2. Quality .........................................................................................30  
   2.5. **IMPLEMENTATION PLAN (APPLICATION SPECIFICATION)** ..................31  
      2.5.1. Implementation Phases .................................................................31  
      2.5.2. Cost of Implementation (I-MEIS) and Application Maintenance .........33  
      2.5.3. Implementation Time Schedule (I-MEIS) ...........................................33  
   2.6. **DESCRIPTION OF MEIS LOGICAL ARCHITECTURE DEVELOPMENT** ....35  
      2.6.1. Contents of LA-MEIS .....................................................................35  
   3. **PHYSICAL ARCHITECTURE OF MEIS PROJECT (PA-MEIS)** .................38  
   3.1. **MONTENEGRIN EDUCATIONAL NETWORK (MEN) SUB-PROJECT** .......38  
      3.1.1. Introduction to MEN Sub-project ....................................................38  
      3.1.2. Key Factors Determining the Network Concept at LAN and WAN Level ..................................................................................38  
      3.1.3. LAN Level .....................................................................................39  
      3.1.4. WAN level .....................................................................................44  
      3.1.5. Connection via the MIPNET.............................................................54  
      3.1.6. Conclusion of the subproject MEN .......................................................66  
   3.2. **DEFINITION OF REQUIRED HARDWARE AND SOFTWARE** ...............68  
      3.2.1. Server and Client Architecture, System Software and Related Equipment ..........................................................68  
      3.2.2. Workstation Architecture ...............................................................69  
      3.2.3. Printers .........................................................................................71  
      3.2.4. Software Specification (System and DB Software) .......................75  
   3.3. **MAINTENANCE OF MEIS** ..................................................................78  
      3.3.1. Introduction to IS Maintenance Sub-project ......................................78  
      3.3.2. Organizational Scheme of IT Services within Institutions of the Ministry of Education and Science ...........................................79  
      3.3.3. Maintenance Organization .............................................................80  
      3.3.4. Failure Reporting and Intervention Procedures ...............................82  
      3.3.5. Cost Estimate ..............................................................................84  
      3.3.6. Software Maintenance (Oracle) .......................................................87  
      3.3.7. Conclusion of IS Maintenance Sub-project .....................................87  
   4. **COMPUTER EDUCATION FOR TEACHERS (CEFT) PROJECT** ...............88  
      4.1.1. Introduction to CEFT Sub-project ....................................................88  
      4.1.2. Selection of Methodology for Preparation of CEFT Project .............88  
      4.1.3. Institutional Organization of Montenegrin Educational System to University Level ..........................................................88
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1.4. MEIS Project</td>
<td>88</td>
</tr>
<tr>
<td>4.2. DEFINITION OF REQUIREMENTS FOR THE DEVELOPMENT OF CEFT</td>
<td>89</td>
</tr>
<tr>
<td>4.2.1. Objectives of CEFT Project</td>
<td>89</td>
</tr>
<tr>
<td>4.2.2. CEFT Project Implementation Tasks</td>
<td>90</td>
</tr>
<tr>
<td>4.3. CURRENT LEVEL OF COMPUTER USE AND TEACHERS’ COMPUTER SKILLS</td>
<td>91</td>
</tr>
<tr>
<td>4.3.1. Current Level of IT Education in Primary and Secondary Schools</td>
<td>91</td>
</tr>
<tr>
<td>4.3.2. Problems in IT Training of Teachers and Students in Primary and Secondary Schools</td>
<td>92</td>
</tr>
<tr>
<td>4.3.3. Proposals for Overcoming Problems in IT Training of Teachers</td>
<td>92</td>
</tr>
<tr>
<td>4.4. ORGANIZATION OF CEFT PROJECT</td>
<td>93</td>
</tr>
<tr>
<td>4.4.1. Categories of Users of CEFT Project</td>
<td>93</td>
</tr>
<tr>
<td>4.4.2. Education and Testing Centres</td>
<td>94</td>
</tr>
<tr>
<td>4.4.3. CEFT Implementation Support Staff</td>
<td>98</td>
</tr>
<tr>
<td>4.4.4. Planning IT Training of Teachers and Students in Primary and Secondary Schools</td>
<td>100</td>
</tr>
<tr>
<td>4.5. DEFINITION OF PRIORITIES</td>
<td>101</td>
</tr>
<tr>
<td>4.5.1. Criteria for Selection of Priorities in IT Education System</td>
<td>101</td>
</tr>
<tr>
<td>4.5.2. Priorities in IT Education System Development</td>
<td>102</td>
</tr>
<tr>
<td>4.5.3. Stages in IT Education System Development</td>
<td>103</td>
</tr>
<tr>
<td>4.6. ORGANIZATION OF TEACHER IT TRAINING DEVELOPMENT FUNCTIONS</td>
<td>104</td>
</tr>
<tr>
<td>4.6.1. Project Management</td>
<td>104</td>
</tr>
<tr>
<td>4.6.2. Operational Training of Teachers and IT Staff</td>
<td>105</td>
</tr>
<tr>
<td>4.6.3. Trend of Further Development of IT Training in the Montenegrin Educational System</td>
<td>110</td>
</tr>
<tr>
<td>4.6.4. Training Materials</td>
<td>111</td>
</tr>
<tr>
<td>4.7. DEFINITION OF IT EDUCATION SYSTEM DEVELOPMENT PLAN</td>
<td>111</td>
</tr>
<tr>
<td>4.7.1. Provision of Preconditions for Starting the Project</td>
<td>111</td>
</tr>
<tr>
<td>4.7.2. Definition of Necessary Resources for the Main Education and Testing Centre</td>
<td>114</td>
</tr>
<tr>
<td>4.7.3. CEFT Implementation Costs by Phases</td>
<td>115</td>
</tr>
<tr>
<td>4.8. COURSE PROGRAMME</td>
<td>117</td>
</tr>
<tr>
<td>5. ORGANIZATION OF MEIS DEVELOPMENT FUNCTIONS</td>
<td>124</td>
</tr>
<tr>
<td>5.1. IS IMPLEMENTATION ENTITIES</td>
<td>124</td>
</tr>
<tr>
<td>5.1.1. Project Council</td>
<td>124</td>
</tr>
<tr>
<td>5.1.2. Project Management</td>
<td>125</td>
</tr>
<tr>
<td>5.1.3. Implementation Teams</td>
<td>126</td>
</tr>
<tr>
<td>5.1.4. IT Centre</td>
<td>126</td>
</tr>
<tr>
<td>5.1.5. Coordinators</td>
<td>126</td>
</tr>
<tr>
<td>5.2. PERSONNEL OF IT CENTRE</td>
<td>127</td>
</tr>
<tr>
<td>5.3. TIME SCHEDULE OF MAIN PROJECT IMPLEMENTATION PHASES 1 AND 2</td>
<td>128</td>
</tr>
<tr>
<td>5.4. TOTAL EXPENSES OF MEIS INTRODUCTION AND MAINTENANCE FOR PHASES 2 AND 3</td>
<td>129</td>
</tr>
<tr>
<td>5.5. KEY PROBLEMS IN MEIS IMPLEMENTATION AND PROPOSED SOLUTIONS</td>
<td>131</td>
</tr>
</tbody>
</table>
1. MEIS MAIN PROJECT TASKS AND OBJECTIVES

The task of the Main Project of MEIS (Montenegrin Education Information System) is to define the necessary resources, concrete methods and technologies for the implementation of a modern IS in education. The main project encompasses a number of projects (sub-projects) as follows:

- MEIS Logical Architecture Project (LA-MEIS),
- MEIS Physical Architecture Project (PA-MEIS), which includes:
  - Computer Network Sub-project,
  - Hardware and Software Requirement Definition Sub-project,
  - Hardware and Software Maintenance Sub-project,
- Computer Education for Teachers (CEFT).

All these projects are integrated in the Main Project. It ends with the overall time schedule and cost estimate of the project implementation.

The strategy identifies the project phases. The first phase is completed with the preparation of this document, which states the information important for the implementation of the following phases, i.e., phases 2 and 3. The fourth and later phases are not discussed in this document primarily because their implementation will start in two or three years. Considering the dynamic changes in information technology and price of equipment, the definition of the fourth and subsequent phases of MEIS in this document would be approximate only.

The objectives of introducing ICT in the educational system were described in the preliminary design entitled «Strategy of ICT Introduction in the Montenegrin Educational System» (hereinafter: «the Strategy»). The Strategy has been adopted by the Government of Montenegro.

General Objectives

- The development of the modern educational system in Montenegro in which all the pupils in primary and secondary schools may acquire information and computer literacy, needed for their inclusion in the contemporary information society;
- Training of all teachers, in primary and secondary schools and at the university (teachers’ education faculties: Philological Faculty – Nikšić, Faculty of Mathematics and Computer Science – Podgorica and academies), in the use of information and communication technology in the process of teaching and learning;
- Use of management information system created on the basis of the experience of the E states in the management and evaluation of quality of the educational system in Montenegro.

Special Objectives

- Make it possible for all pupils regardless of sex, social, cultural or ethnical origin or physical characteristics to manage ICT;
- Integrate and incorporate ICT in the process of changes in the educational system, in order to achieve its full impact;
- Provide ICT education programme for everybody included in the educational system: teachers, school management and pupils;
- Provide adequate maintenance of the system for the collection of data so that investments in information and communication technology may facilitate the achievement of the set targets through optimum use of hardware and software;
- Provide ICT training and equipment for children in special schools;
- Before 2010, supply all schools with multimedia computers and Internet access;
MEIS MAIN PROJECT TASKS AND OBJECTIVES

- Establish and develop network with quick access to Internet and optimum speed of data transfer;
- Provide technical assistance in incorporating ICT in curricula, development training programmes, evaluation and certification procedures;
- Standardize the primary and didactical software;
- Supply schools with appropriate multimedia computers, presentation equipment and didactic material, in accordance with curricula and teaching plans as well as ICT implementation plan;
- Educate teachers and trainers in modern learning techniques through application of ICT concepts and technologies with constant improvement of knowledge by means of appropriate training programmes;
- Provide the structure for establishing, supporting and implementing ICT in the Montenegrin educational system;
- Ensure the project sustainability through maintenance, upgrading and connection cost recovery, technical support, etc.;
- Provide training and equipment for children in special schools so that they can use ICT;
- Ensure that the outcome of the competed process of ICT strategy implementation in Montenegro be the 1:5 computer to pupil relationship.

The main project is one of the most important steps in the execution of the set targets.
2. LOGICAL ARCHITECTURE OF MEIS PROJECT (LA-MEIS)

2.1. Introduction to MEIS Sub-project

The heterogeneous character of the educational system in the Republic of Montenegro up to
the university level is reflected in its functional, organizational and geographic complexity of
its main parts: Ministry of Education and Science, Examination Centre, School System
Institute, Institute for Textbooks and Teaching Aids, Professional Training Centre and the
network of preschools and schools. Every of these parts is a relatively complex system of its
own, both in organizational and functional respect. Such fragmentation of the system has
often led to partial solutions and disharmony in the work of individual sub-systems. All this
puts the Montenegrin educational system into a group of typical heterogeneous distributed
business systems. In addition to the heterogeneity and distribution as the main
characteristics relevant for the development of the information system, the educational
system in Montenegro also has the following features:

• A large number of participants of diverse profiles in the process of education
  (teaching staff, treasurers, secretaries and directors of schools, employees in the
  Ministry, employees in the institutes and centres, pupils and their parents, etc.);
• Geographically distant locations – all municipalities have schools, of which some with
  separate units in remote rural areas a couple of kilometres from the parent school;
  the Ministry, the institutes and centres are in Podgorica;
• There are periods when a lot of activities are carried out simultaneously (e.g.,
  enrolment of pupils, constitution of classrooms and selection of optional subjects at
  the beginning of the school year; the conclusion of final grades at the end of
  semesters; final examinations, registration in the main record books, taking of
  remedial, additional or differential examinations, etc. at the end of the school year);
• Incomplete legislation – not all the rules and regulations necessary for the functioning
  of all segments of the educational system have been passed;
• The combination of old and new legal regulations – the old regulations will apply to
  the pupils that have started the school before the enactment of the new ones;
• The combination of old and new methods of teaching – some schools applied
  experimental instruction, requiring a different manner of organization, monitoring and
  evaluation of pupils.

Single information system for the education system in the Republic of Montenegro up to the
university level should be a backbone in the building of a modern educational system in
Montenegro. The information system is supposed to enable:

• Maintaining records and almost full automation of all the processes in education up
  the university level, including the records of resources and staff, monitoring of
  teaching processes, administrative and financial operations;
• Easy, fast and simple communication among all the parts of the educational system;
• Easy reference and simple extraction of data related to all stakeholders in the
  educational system (teaching staff, pupils and their parents, employees in the
  Ministry, institutes and centres), including the use of existing mobile technologies;
• Automatic generation of reports needed for the work of individual segments of the
  educational system;
• Reviewing positive and negative trends in education, based on reports from various
  segments of the system;
• Integration of existing solutions in the new educational system;
• Management and quality evaluation in the educational system;
• Possibility of hardware and software upgrading of the system;
• Inclusion in the conception of electronic government ("e-government") in the Republic of Montenegro. 

In the description of jobs, processes and procedures within the educational system and their mutual connections, the Oracle 9i Designer tool was used, as it offers the possibility of modelling and determining the hierarchy of processes description of dataflow in the system and presentation of data models.

The proposed solutions introduce some new concepts in the Montenegrin educational system including:

• The pupil's personal card that will follow the pupil's development and activities during the process of education until entering the university;
• The teacher's personal card, with information about the teacher's training, activities, rewards, employment history, etc.;
• Overall documentation of the school and web presentation of the school's activities;
• Integration of all segments of the educational system;
• Automated processing of usual school data related activities, such as the creation of semi-annual and annual reports on success, absence, discipline and rewards of pupils, maintaining registration files, issuing school certificates, taking examinations, etc.;
• Standardized approach to administrative and financial operations in all segments of the educational system;
• Precise and updated records of staff and other resources in the educational system.

2.2. MEIS Three-tier Architecture

Before we explain the choice of software architecture of the system and indicate the specific features of the proposed solutions, we will discuss the basic objectives that software architecture needs to meet for any business system. A well-designed application needs to meet the following conditions:

• **Robustness**
  Information system is an important component in any organization, including the educational system of Montenegro. Software system needs to be reliable, sage and without code errors. It must contain all relevant information needed for efficient and swift management of a heterogeneous system such as the Montenegrin educational system.

• **Solid performances and scalability**
  The application must meet the performance requirements set by the users. At the same time, it must possess a sufficient level of scalability, i.e., the possibility to support incremental data input, with appropriate hardware resources. The scalability is especially important for Internet applications, where it is difficult to anticipate the number of users and their behaviour. Reaching the satisfactory degree of scalability most often requires putting several server instances in a cluster.

• **Possibility to use object-oriented development principles**
  Object-oriented principles of development provide significant advantages in the development of complex systems such as ICT. Application of the design patterns significantly simplifies the process of design and implementation.

• **Avoidance of too complicated solutions**
  The process of analysis must ensure that the user's requirements are not subject to an overly naive and simplified treatment. On the other side, due to large
number of components offered by modern architectures, one can easily get into
the situation to accept the solutions that are more complex than the user’s
requirements. The principle "the simplest thing that could possibly work" should
be applied. Additional complexity contributes to increased expenses in every
phase of life of the software system.

- **Simple maintenance and enhancement**
  Maintenance is the most expensive phase in the life cycle of the software. Choice
  of software architecture is a strategic decision and represents the key of
  information operation organization for many years, because it should provide for
  adjustment to new business needs of the organization. Simple maintenance and
  enhancement of the software system is mostly the result of clear system design.

- **The system must become functional in the agreed timeframe**
  Productivity is vital to development.

- **Simple testing of the system**
  Testing is the basic activity throughout the life cycle of the software. Implications
  of design related decisions on the ease of testing must be taken into account.

- **Support to various types of users**
  There is an implicit assumption that various users will accede the application in
different ways (through web applications, "stand-alone" programmes that might be
written in Java or in other tools, etc.). The so-called "thin clients" are typically
used, as they accede through web-browsers.

- **Information system must fit in the general development strategy of the
  business system.**

Upon the review of the above mentioned facts and objectives that the information system is
expected to achieve, the project team opted for the creation of a multi-tier application based
on "thin web clients", application and web servers at middle tier and document and database
servers at the level of data. The Figure 1 illustrates the typical appearance of a three-tier web
application.

![Figure 1– Typical appearance of a Web application](image)

The first tier consist of the users that accede the system through web browsers that have
standard applications on user computers, which simplifies the process of system
development and significantly reduces the expenses. For the processes that are more
important for the functioning of the educational system, especially from the aspect of data
security, such as financial operations, the possibility of direct work with databases is
foreseen, in the so-called "stand-alone" regime (Figure 2).
The middle tier are web and application servers that regulate traffic through the network and describe the "business logic" of the educational system. This tier may be further disintegrated into sub-tiers that manage user's requirements related to web and that part that makes the "business logic" of the educational system. It is very important that this tier be able to facilitate adding of new components to the system, both functional and hardware ones, depending on the new user requirements and system performance. As platform for the middle tier Oracle 9i Application Server (Oracle 9iAS) is proposed, being a modern and open system containing both web server and support for J2EE. Figure 3 represents a scheme of three-tier architecture based on Oracle 9iAS application server.
Figure 4 shows the internal organization of Oracle 9iAS application server.

The advantages of the proposed software architecture are:

- System extendability (hardware extendability – adding clusters in the Web tier, Application server tier and database tier, as well as software extendability – adding components, Figure 5);

- Reduction of design and maintenance expenses, because "open source" tools may be used;
- Support to XML (especially as the possibility of data exchange in the current processes of integration in South-East Europe);
- Support to "wireless" technologies;
- Simple and flexible security system;
- Openness to various tools, components and servers;
- Possibility to use Web-service technologies (SOAP, UDDI, WSDL, ebXML) for connection with systems in the immediate environment and the whole world;
- Open possibility for application of data warehousing (Figure 6);

Figure 6– Basic Architecture for data warehousing

- Support to "business intelligence" and integration with "e-business" and "e-government" systems.

Figure 7 shows the basis of the proposed architecture of J2EE technology.

2.2.1. Advantages of J2EE Platform

Foreseen for the development of distributed applications, J2EE platform offers several advantages:

- Simplified architecture and design,
- Freedom in the selection of servers, development tools and components,
- Integration with existing information systems,
- Scalability,
- Flexibility and simple security model.

2.2.1.1. Simplified Architecture and Design

J2EE platform offer a simplified design model based on components and Java 2 programme platform (J2SETM platform), and in that way it meets the concept of portability "Write-Once-
Run-Anywhere™, that is supported by all the servers which support J2EE standard. The typical appearance of a web-client and a "stand-alone" client in J2EE environment is shown at the following figures (Figure 8 and Figure 9).

Application design model based on components increases the productivity in several ways:

- It is easily transposed into the application functionality – J2EE platform offers several methods for configuring the application architecture depending on the type of user requirements, level of access to source data and other requirements. The design based on components simplifies the application maintenance because the new functionality of the system is achieved by changing the existing and adding new components.
- A high level of code writing automation – due to high level of service standardization, a great part of the code may be generated automatically, with minimum interventions by the programmer. Also, components expect that standard services be accessible at the moment of execution and are dynamically connected to other components, so that the largest part of the application behaviour may be adjusted in the process of installation, without need for repeated code writing.
- It supports job segregation – job segregation in the design team in accordance with skills and capacities of individual members, which facilitates the application maintenance.

2.2.1.2 Integration with Existing Information Systems

J2EE platform, together with J2SE platform, includes a number of industrial standards for access to existing system, such as:

- J2EE Connector architecture – infrastructure for interaction with various types of information systems, including ERP, CRM and other "legacy" systems;
- JDBC™ API – used for access to relation data from Java programming language;
- Java Transaction API (JTA) – governance and coordination of transactions through heterogeneous information systems;
• Java Naming and Directory InterfaceTM (JNDI) – access to information about names and system directories;
• Java Message Service (JMS) – receipt and sending of messages through the system of messages such as IBM MQ Series and TIBCO Rendezvous;
• JavaMailTM – electronic mail;
• Java IDL – mechanism for inviting CORBA mechanism;
• Java APIs for XML – support for integration with other systems and applications and for implementation of Web services.

2.2.1.4. Scalability
J2EE provides mechanisms for simple expansion and enlargement of functionality of distributed applications. Since J2EE may have components with support for transactions, connection with database, life cycle governance and other qualities that may influence the system performance, these components are developed in such a way as to ensure scalability in these areas. Special attention is devoted to connections with databases and Web traffic.

2.2.1.5. Flexible and Simple Security Model
J2EE security model is created so as to support the so-called "single sign on" access to application services. The development team may specify the security requirements at the method levels to ensure that only the clients with appropriate privileges may have access to certain data. Enterprise JavaBeans technology and Java Servlet API-s enable programmer’s control of security. The principal mechanism of security safeguard is foreseen during application installation, by defining the user groups with particular privileges, which enable greater security and better control.

Finally, one should not ignore the fact that the Faculty of Mathematics and Computer Science in Podgorica is educating a generation of students that have already acquired a certain level of knowledge of Java-technologies and will be able, promptly upon graduation, to participate in the upgrading and maintenance of the system based on J2EE architecture.
LOGICAL ARCHITECTURE OF MEIS PROJECT (LA-MEIS)

IT Centre

- Linux advanced server
- Web Server
- Linux advanced server
- ORACLE 9i
- Storage
- Database server
- Application servers
- File server
- MIPNET

Educational Institution

Classroom

- Win XP/Unix
- Internet browser

Figure 10 – Three-tier architecture of MEIS
2.3. MEIS Process Description

The objective of developing MEIS logical architecture is to create a comprehensive automated US in educational institutions.

The IS in education is divided into 5 sub-systems, as follows:

1.1. Main Processes in Education
This sub-system records processes that are specific for educational institutions. It provides automation of the most important processes such as, e.g., registration of instruction given, electronic grade book, recording of curricula and teaching plans, recording of examinations, etc.

1.2. Monitoring of Resources
This sub-system is universal and comprises the monitoring of major resources, primarily staff, aids and equipment, materials and financial flows. This sub-system is incorporated in all educational institutions.

1.3. Administrative Operations
This sub-system includes the keeping of school journal, enrolment book, internal delivery books, issuing of certificates and performing of all other administrative processes and records foreseen by the Law on Office Operations. This sub-system is incorporated in all educational institutions.

1.4. Management Support
This sub-system is for the automatic generation of reports at various levels and synthetization of data according to desired criteria. That provides a detailed insight and “cross-section” of the situation for the management at all levels and contributes to higher quality management and planning. The sub-system also issues execution orders by the management and monitors the execution by way of the IS.

1.5. IS Administration
This sub-system is not a part of the logical architecture in the narrow sense, because it is a consequence of IS automation and comprises the processes of DB server administration, unauthorized access safeguards, central code maintaining, etc.

'Monitoring of Resources' and 'Administrative Operations' are universal sub-systems in all educational institutions and will be automated in each educational institution.

The processes are described in detail within the repository. The following is the short description of a part of the more significant processes (about 200 in total, while the group of processes that are described in the repository includes about 500 of them).

2.3.1. Main Processes in Education

Main processes in education (1.1) are divided in sub-processes that are related to:

- The central level (1.1.1) that includes the processes characteristic for educational institutions at the central level. For example, in the Examination Centre, the records of student accomplishment at the ‘Matura’ (final high school) examination, etc. will be automated. A great number of reports, generated from information entered in any of educational institutions, will be provided. The
processes in these institutions are mostly covered by the sub-systems 1.2, 1.3 and 1.4.
- \textit{Educational institutions (1.1.2)} that include the automated processes in preschool institutions, primary and secondary schools, specialized institutions, students' dormitories, etc.

\subsection*{2.3.1.1. Central Level}

The central level comprises the specific processes related to the following institutions:
- \textbf{Ministry of Education and Science}, with the following specific processes:
  - Maintaining the register of the school network in Montenegro,
  - Recording and verifying the curricula. This sub-process includes keeping records of curricula, including records of textbooks, instruction methods, number of lessons, exercise description, practical instruction description etc. It also includes records of qualifications of teaching staff for individual programmes.
- \textbf{Institute for Education}
- \textbf{Centre for Vocational Training}
- \textbf{Examination Centre (EC)} – The concept of the new educational system in Montenegro foresees the introduction of the quality system. Important segments of the quality system are the obtained knowledge, skills and competence of pupils/students and subjects of education. That is why the Examination Centre (EC) has been formed as a separate institution within the Montenegrin educational system, with the task to perform external testing of knowledge, in order to establish the acquired knowledge standards. It is planned to conduct external testing every third year for the primary education, and to organize admission and 'Matura' and practical, vocational final examinations as external examinations. The organization of these examinations has the following elements: examination application, examination period and examination schedule, definition of examination bodies, organization of examinations in schools (examinations in the school are performed in the order prescribed by the minister; examinations are led by the examination board; the examination board appoints examination committees) and evaluation. These examinations will be organized in the form of tests. Tests, unlike traditional oral or written examination and evaluation, eliminate subjective factors, and have a number of advantages in comparison to classic verbal and written evaluation. Automation would provide examination uniformity in the whole Republic, examination transparency, application procedure done through computer network, obtaining of information before and after the examination itself, announcement of results (grades) through computer network. The grades obtained on admission or any of final examinations will be automatically included in electronic grade books of pupils. During enrolment of pupils in secondary schools, the admission points will be automatically generated.

The process related to \textbf{Examinational Centre} will include all the elements relevant for conducting external examinations:
- Proposal of examinations by the Institute for Education and Vocational Training Centre (resulting in various examinations: 'Matura examination', final, admission examinations … with mandatory and optional subjects);
- Formation of a bulletin board indicating the examination period (from when to when);
- Registration of pupils that will take the examination;
- Formation of examination board for a given school year;
• Formation of examinational committees;
• Taking the examination;
• Evaluation (if for the ‘Matura’ examination, the results are entered in the ‘Matura’ book, and if for secondary school admission examination, the ranking list is formed according to which the pupils are to be enrolled),
• Possible complaints about grades, course and conditions of examination, etc.

**Institute for Textbooks and Teaching Aids** – Institute for Textbooks and Teaching Aids (hereinafter: the Textbook Institute) is a public institution. Its tasks are: to prepare and publish textbooks and other teaching aids for primary, secondary and special schools, to publish approved textbooks and other publications for the faculties and art academies, to issue publications and newsletters as needed by the education system. Automation of these activities would mean that we can be regularly informed about the part of the educational system that concerns issuing of textbooks needed for the teaching. The process also includes the plan for publishing new or expanded editions of textbooks (required number of textbooks…). These data are visible beyond the Institute because of the network environment. The subprocesses of the process are:
• Registration of publications,
• Publishing textbooks according to appropriate curriculum,
• Planning the required number of textbooks.

**Inspection** – Education inspection (hereinafter: Inspection) will perform inspection supervision in the area of compliance with law and regulations and organization of work in educational institutions. Inspectors visit educational institutions, make their reports and undertake appropriate legal measures. Automation of education inspection, i.e., the work of inspectors in the education, will: provide records of the inspectors’ work; collect data about deficiencies in the work of educational institutions; provide details about the situation in educational institutions; send details about penalty measures against educational staff directly into special records of disciplinary matters. The process will comprise the following sub-processes:
• Visits to institutions,
• Cases of noted deficiencies in work,
• Issued measures, actions and timeframes for the removal of deficiencies,
• Complaints about the inspector’s orders,
• Processing of data related to school competitions that are under the competence of educational inspectors, including records of main information about the competitions, areas that are the subject of competition, evaluation committees and the tasks asked. After the competition, the results, possible complaints and final ranking lists are recorded. At the end, awards and diplomas are printed. For the competitions outside the scope of educational institutions, relevant details about the accomplishments of pupils from Montenegro are also recorded.

### 2.3.1.2. Educational Institutions

The process includes the educational institutions, and the processes in them, as follows: preschool institutions, primary and secondary schools, specialized institutions, adult education institutions and pupils’ and students’ dormitories. This process is decomposed into the following sub-processes:

• **Monitoring of current work processes in educational institutions** such as instruction, examinations, school competitions, etc.;
• **Configuration of institutions**, which covers maintaining main records of educational institutions when established or subject to legal status changes. In addition to main information about the schools, these records include details about the school founder, managing board and key documents, such as, e.g., bylaws, annual plan, job description and classification scheme, etc.

**Monitoring of current work processes in educational institutions** is decomposed into:
- Preschool institutions,
- Primary schools,
- General and vocational secondary schools,
- Specialized schools,
- Schools for adults.

Monitoring of work process in preschool institutions includes the following sub-processes:
- Preschool periodical information, decomposed into:
  - Recording of changes at the beginning of the year,
  - Recording of shifts,
  - Forming of groups,
  - Assignment of staff by groups,
  - Children enrolled;
  - Continued monitoring of work of the preschool institutions.

**Monitoring of current work processes in primary schools** generally includes:
- **General processes** in schools, i.e., those that are universal in all schools. This is a global process used in all other schools; its description is given in the section about primary schools and will not be repeated later;
- **Recording of specific processes in primary schools.**

**General processes** are decomposed into:
- School periodical information related to periodical enrolment, creation of schedule of classes, and:
  - Preparation of annual plans,
  - Recording of shifts and their beginning,
  - Formation of classrooms – e.g.: the classroom II h is formed, in the 2003/2004 year, major: social sciences,
  - Assignment of teachers – records of assignment of teachers to given classrooms and subjects (teacher/classroom/subject),
  - Records of schedules of classes,
  - Records of optional subjects to be chosen by pupils,
  - Development of statistics;
  - Continued monitoring of work includes numerous processes that may generally be decomposed into:
    - Monitoring of classrooms,
    - Monitoring of the work of the school,
    - Monitoring of individual pupils.

**Monitoring of classrooms** consists of all the actions related to keeping the grade book, record book and enrolment book of a classroom, as defined by the Rules of Pattern and Method of Keeping Records and Public Document Forms in Primary Schools (Official Gazette of Montenegro, No. 61/92, pg. 1121), Rules of Contents, Form and Method of Keeping Pedagogical Records Secondary Schools (Official Gazette of Montenegro, No. 61/92, pg. 1158), and Rules of Public Documents Issued by Secondary Schools (Official Gazette of Montenegro, No. 61/92, pg. 1159). It covers actions and processes that are
mostly the responsibility of the homeroom teacher, including taking care of "grade book". The process automates the majority of operations related to the classroom statistics (pupils' success and average grades, absenteeism, number of lessons held and planned, etc.). The process of entering data into record book or enrolment book is also automated. The processes covered by monitoring of classrooms are:

- **Keeping grade book** that automates the majority of operations related to keeping of grade books and consists of the following sub-processes:
  - Schedule of subjects – a table showing the list of subjects and teachers that give instruction in these subjects,
  - Schedule of classes – for a classroom,
  - Weekly review of instruction – weekly records of planned and held classes and observations about the instruction by homeroom teacher, principal and supervisor, as well as number of absentees per week,
  - Changes in number of pupils – table showing the number of pupils arriving in or leaving the classroom, by success and gender,
  - Success and absence – the sub-process which, at the semester end, automates fulfilment of grade book pages with accomplishments and absence details of pupils, and the number of planned and held classes. It consists of the following sub-processes:
    - Classes held – the table of planned, held and non-held classes during a year,
    - General success – the table of pupils' accomplishment at the end of a school year,
    - Tabular review – summarized list of pupils' accomplishment by semesters, including:
      - General success for the semester,
      - Conduct,
      - Grades by individual subjects,
      - Instruction by subjects,
      - Aggregate rate of absence;
    - Written tests – schedule of written tests, dates of tests and corrections, topics and tasks,
    - Excursions and trips – records of excursions and trips made,
    - Remedial instruction – records of pupils assigned to remedial instruction and content of such work,
    - Mandatory courses,
    - Annual plans that comprise the following plans and activities:
      - Homeroom teacher's plan – plan of his work,
      - Implementation of homeroom teacher's plan,
      - Council's plan – plan of work of the grade council,
      - Implementation of the council's plan,
      - Cooperation with parents,
      - Free-time activities – records of pupils' free-time activities,
      - Observations about the pupils' work;
    - Other forms of instruction,
    - Practical instruction;

- **Keeping record book** – covers the processes related to record book that is automatically filled out in other processes (enrolment in primary school, enrolment in secondary school, final success in primary schools, final success in secondary schools), and includes:
  - Issuing of school certificates,
  - Issuing of duplicate certificates;
• **Keeping enrolment book** – the same process as the previous one, but related to secondary schools, including:
  - Issuing of school certificates,
  - Issuing of duplicate certificates;

• **Change of homeroom teacher and individual teachers** – change of homeroom teacher or individual teachers during the school year, showing the history of changes.

**Monitoring of work of schools** covers the processes related to the school activities (other than instruction) and the activities of expert bodies in educational institutions (teachers' council, grade councils, various committees, etc.), and includes the following sub-processes:

• **Book of Teachers and Pupils on Duty** – This process automates the filling out of the book of persons on duty that is maintained in schools for each day. Such automation results in electronic book of persons on duty from which one can get data about various activities in and outside the school, visits to the school, performances, absence of teachers and their substitutes in various forms, in a fast and comfortable way, by means of the following sub-processes:
  - Entering of dates, and teachers and pupils on duty,
  - Entering of notes about absent teachers and their substitutes,
  - Entering of data about remedial, supplemental and preparatory instruction, and free-rime pupils' activities,
  - Entering of data about excursions, visits, performances and events.

• **School bodies** – This process records all educational bodies in the school (teachers’ council, grade councils, school board, principal, committees...). In addition to records of the work of educational bodies, electronic minutes of meetings is provided; the decisions made at the meeting are easily recorded in internal and other books kept in the office operations of the educational institution. Since the work of the majority of these bodies is similar, automation of their work is performed in a similar way.

  The work of these bodies includes:
  - Formation of bodies,
  - Appointment of body members,
  - Meetings held,
  - Decisions made at the meetings and their recording in administrative books.

**Monitoring of pupils** is based on the concept of personal file of a pupil. This concept means that appropriate parties in the educational system may obtain the required information about the pupil at any time. Such information does not include only the grades, the conduct and absenteeism (received from electronic grade book), but also data about his activities, and evaluations made by psychologists and pedagogues. The history of moving from one school to another, the social profile, type of examinations taken, accomplishments and participation in competitions are also included in this process. The process includes the following sub-processes:

• **Validation** – The procedure of validation of a foreign school certificate or diploma is initiated by submitting the validation application to the Ministry of Education and Science. If it has been ascertained, during the validation process, that the educational programme of a foreign institutions is largely different from the educational programme with us, then the obligation to take differential or additional examinations is established. A committee is formed for the organization of these examinations.
The process of **validation** automates the validation procedure. It enables electronic records of validations performed, automatic recording of obtained documents through administrative books, electronic filling in of the validation application, issuing report (register) on validations performed, and includes the following sub-processes:

- Submitting application for validation, i.e., equivalence,
- Decision by committee on the need for taking differential or additional examinations,
- Submitting complaints about the committee work,
- Taking differential and additional examinations,
- Validation of school certificates (the book of validated certificates is permanently kept) and recording of all the obtained documents in the validation procedure,
- Possibility of issuing reports on validations performed.

**Evaluation of pupils**—covers all the actions related to the evaluation of pupils. All the grades are recorded, the process of concluding the final grades is carried out and the record book or enrolment book are automatically filled in. The process includes the following sub-processes:

- Evaluation of the oral part,
- Evaluation of the written part,
- Conclusion of final grades by teachers, before the meeting of the teachers' council,
- Conclusion of final grades at the teachers' council and automatic entry of grades in record book,
- Conclusion of grades at the teachers' council and automatic entry of grades in the enrolment book, referring to the secondary schools;

**Discipline of pupils** - covers records of the pupils' conduct and any disciplinary measures applied. The records include the following sub-processes:

- Homeroom teacher’s reprimand,
- Council’s measure,
- Decision on exclusion,
- Disciplinary measure inscription;

**Attendance at classes** - covers records of pupils' absence from classes and relevant excuses. The processes automatically warn homeroom teachers of any number of absences that exceeds the defined number of absences. The summarized absence information is generated for a desired period. The sub-processes are:

- Absence registration – the teacher registers any absent pupils,
- Receipt of excuses – the homeroom teacher receives excuses from parents or guardians,
- Registration of excuses – the homeroom teacher may justify the absence on the basis of the received excuses.

**History of transfers** – covers records of a pupil's moving from one school or one classroom to another,

**Extracurricular activities (participation)** – covers a selection of activities that are of interest to the pupils,

**Extracurricular activities** – comprise records of all extracurricular activities of pupils (participation in competitions, specific group work, activities in organizations outside the school such as sports clubs, NGOs and other organizations),

**Social profile** – covers the social status of pupils (whether he comes to school from distant area on foot, distance from school, meals provided in the school, living and working conditions, etc.), including the following sub-processes:

- Pupils coming to school from distant areas on foot,
• School meals,
• Living conditions;

**Psychological-pedagogical profile** – records of a pupil's discussions with psychologist or pedagogue and registration of the pupil's characteristics noticed during these discussions;

**Physical capacities** – for pupils in primary schools, special records are kept about their height and weight and results in individual sports activities;

**Taking examinations** – the process describing the participation of pupils at examinations (remedial, admission, differential examinations), from the time of application till the inscription of results in permanent documents. The process consists of the following actions:

- Examination application – submitting application for examination and blank minutes and entry of applications in administrative books,
- Formation of examination committees – examination committee consists of homeroom teacher, teacher of a given subject and at least one more member. The process automates the said actions and proposes to the director the composition of the committee for each subject,
- Definition of questions – teachers for a given grade propose the list of topics or tasks for the written part and questions for the oral part of the examination,
- Written part of the examination,
- Oral part of the examination,
- Taking minutes of conducting the examination – the committee chairman takes minutes of the examination procedure (filling in the minutes is a fully automated process),
- Publication of results,
- Complaints about the course of examination – administrative recording of possible complaints about the examination course,
- Examinations passed (entry) – entry of results of examinations in the record book or enrolment book,
- Taking minutes of the committee work – recording the work done by the committee in a special notebook (Rules of Form and Method of Keeping Records and Public Document Forms in Primary Schools).

**Recording of specific processes in primary schools** covers the following sub-processes:

- **Enrolment in primary school** - Enrolment in the first grade of primary school is specific, because it includes filling out of a sheet in the record book for the pupil and obtaining of information from relevant municipal bodies about the candidates for enrolment in the first grade. The process includes all the phases starting from collection of information about possible first graders, through testing, until the assignment of pupils to individual classrooms. The actions automated by this process are:
  - Possible first graders – automatic generation of data about possible first grade pupils from relevant municipal authorities, according to place of residence,
  - Test planning – informing the parents of future first graders about the dates of testing,
  - Testing,
  - Psychologist's opinion – report with the opinion of the psychologist or pedagogue about the child's capacities,
  - Submission of documents – applying for enrolment and administrative recording,
  - Enrolment in classroom – determining the particular classroom and generating appropriate information in record book;
• **Pupils moving from one primary school to another** - When a pupil moves from one school to another, a document (transfer certificate) has to be fulfilled. That certificate is fulfilled partly by the school left and partly by the new school. The moving of pupils is in that way monitored. The first and the second page of the transfer certificate are fulfilled by the school left (general details, current grades and data from the record book). The third page is completed and recorded in the new school. The transfer certificate fulfilled in that way is returned to the old school where the rest of the third page is completed and the withdrawal from that school is finally recorded. Automation of the process will mean that it will not necessary to transfer the pupil's details physically from one school to another, but to adjust the current information for the change of classroom (and school) only. This prevents errors in the transfer of the pupil's details. The whole administrative part of the work related to moving of the pupil will be performed through automated administrative operations.

  The process has three sub-processes:
  • Fulfilling the page 1 and 2 of the transfer certificate (all the data fulfilled by the school left by the pupil),
  • Fulfilling the page 3 of the transfer certificate (all the data fulfilled by the new school),
  • Pupil’s withdrawal from the old school.

Monitoring of work processes in general and vocational secondary schools is covered by the process **general and vocational secondary schools** which, like with primary schools, may be decomposed into:

• **General processes** that are global processes already described with primary schools,

• **Specific processes in general and vocational secondary schools**, including in particular:

• Enrolment in secondary school - This process covers the review of results of admission examination (whether external or internal), forming of ranking list of candidates, candidates' application for enrolment and their assignment to individual classrooms.

2.3.2. **Monitoring of Resources**

This process is decomposed into:

• **Staff,**
• **Fixed assets,**
  • Facilities/equipment,
  • Library,
• **Monitoring of materials,**
• **Accounting operations.**

2.3.2.1. **Staff**

This process comprises all information about an employee, from the main details, such as skills, foreign language proficiency, social status, discipline, etc, to the details about his work, career development, and evaluation by colleagues and students. The process also includes professional training, as a form of life-long education of the teacher, in the area of teaching and education, which, in addition to study programs for individual and formal education, offers teachers opportunity to renew, expand and deepen professional, pedagogical,
didactical, methodical and general education skills and keeping up with innovations in this field.

Automated processing of details about an employee results in electronic employment booklet, simplified application for specialized training or for promotion in title, possibility to review the points collected during the previous work, membership in educational institutions and school organizations (school board, examination board, grade council, general education council...). Institute of Education will have information about the needs for organizing seminars or workshops, additional work, issued publications etc. The employee advanced training and point collection process is separated as a special sub-process.

The **staff** process covers the following sub-processes and information:

- **Recording of main information** (name, address, personal identification number, gender, telephone...),
- **Recording of employee social status** (living premises, distance from work, marital status, children...),
- **Recording of data on employee education**,
- **Recording of data on employee discipline** (possible violations and penalties),
- **Manner of fulfilling the 40-hour work week**, 
- **Employment record booklet**, 
- **Teacher evaluation by pupils**, 
- **Employee training and point collection** – This sub-process includes information about:
  - Employee computer skills,
  - Employee professional examination,
  - Teacher’s work on school magazine,
  - Foreign language skills,
  - Employee personal file,
  - Employee advanced training - (response to seminars offered, employee work and successfulness at seminars); entry and publication of training programs offered by the Ministry of Education and Science for the next year, as well as the training outside the Catalogue,
  - Definition of code index of concepts for additional work (freedom in possible addition and definition of employee additional work),
  - Teacher training for a mentor, researcher, advisor or senior advisor,
  - Calculation of points (due to title promotion) for all the teachers – Institute of Education is offered a list of teachers who have fulfilled all the conditions for election for a title or are close to that (sorted in a downward order), but have not completed yet the training for that title (and the Institute would then organize such training based on such information),
  - Listing of all additional assignments, attended seminars, trainings, opinions, etc, until the final election of a given employee for a title, 
  - Listing of teachers proposed for promotion since the last election (three times in a year). Confirmation of election for a title.

### 2.3.2.2. Fixed Assets

Fixed assets include recording of all fixed assets (equipment) in an institution, and are decomposed into the following:

- **Recording of fixed assets** that are decomposed according to the type of facilities or equipment into:
• **Buildings** – rooms and room areas, yards, heating, water supply, floors, access roads, distance from parent school, etc. are described. With respect to maintenance, necessary investments are recorded with respect to degree of reconstruction and urgency needed, changes in infrastructure needed, etc. Fixed assets are recorded and inventories are taken. Here it is especially important to automate the recording of computer equipment and its maintenance.

• Recording of equipment – where the equipment, its issuance and return are recorded,

• Computer equipment – which is separately updated, taking into account computer components, installed software, IP address etc.

• **Libraries** – the process that automates the work of libraries in schools. Today the library can be deemed an institution collecting, processing, storing and offering for use books and other library materials and providing various library services to its users. The task of school libraries is to improve all forms and methods of educational process, assist in teacher training and create a reading habit among pupils and habit to use library services. Professionally organized library includes procurement of library materials, inventory taking, classification, designation, catalogue arrangement, annual revisions and write-offs, preparation of daily, monthly and annual statistics, preparation of operating plan and annual report of the library operations. The books in school libraries must be arranged on the free access to book principle, and the library materials should be classified according to the universal decimal classification (UDC). Categorization and classification, i.e. professional presentation of book resources are performed in schools, as well as in all other libraries, according to custom tailored international standards and rules. International standards for bibliographical description of monograph publications ISBD (M) and serial publications ISBD (S) (hereinafter: the Standards) prescribe maximum unification of description – all obligatory elements of description are grouped into certain areas, and the order of areas and elements in them is strictly defined – which enables faster communication and exchange of information among libraries, and will serve to the achievement of a uniform library information system.

Having in mind basic tasks of a school library and Standards, we have set aside the following processes that need to be automated:

• **Work with customers** – finding an appropriate publication and issuing it for use to the library member looking for it. This process consists of several sub-processes:
  • Book search – on the basis of book details given by the customer, the database catalogue and concrete copies in the library are searched through. The search may be made by the title, author, UDC codes, key words and other description elements. The result of the search is a concrete book or list of books satisfying the desired criteria. If a relevant book is found, then follows the process of charging/making the customer responsible for that book; otherwise, the request is recorded.
  • Customer request for being issued a book (not to be automated),
  • Charging a customer for a book – the book is charged to the library member who took it,
  • Recording of requested books or magazines (currently taken from the library) – books and magazines that are listed in the catalogue but do not have available copies in the library are recorded here,
  • Recording of requested books or magazines that are not kept in the library – books and magazines requested by the customer but not
listed in the catalogue are recorded. The records of these requests may serve for planning new book and magazine supply,

- Returning the book to the library – the date of return is recorded
- Customer request for magazine issue,
- Magazine search,
- Magazine charging,
- Magazine returning;

- Recording the code index of libraries – appropriate data that need to be assembled later in the catalogue description of a book or magazine are recorded. A special process is foreseen for each table. Some of these processes may run during the catalogue description of a publication.
  - Entry of UDC codes – there is a main table (for area) and ancillary tables (format, place, nation,) for UDC codes.
  - Entry of book and magazine positions – shelves, rows in shelves and partitions in rows where publications are kept are recorded.

- Catalogue description of library books – comprises formulating the designation for a book and its connection to appropriate elements of description, i.e. Standard ISBD (M).
  - Formulating the designation for a book in library – the book receives a code that specifically determines it and a designation (that may be, e.g., the title or the author’s surname or both) indicating which is the book concerned. In addition, we enter here other details about the book that are uniform, such as ISBN, format, date of issue.
  - Connecting the designation to the UDC code index of the book – the book may have several UDC codes, which is evidenced by the UDC code sequential number.
  - Entry of key works about the book;

- Inventorying of books in the library – consists of two sub-processes:
  - Entry of new copies of books – every library registers the books it contains. Every copy of a certain book is separately registered, as well as the place in the library where that book is stored. The previously prepared catalogue is used for that.
  - Change in book copy status – written off or damaged books are recorded.

- Registration of library members – consists of two sub-processes:
  - Enrolment of new members – we register new library members who may be new pupils or employees in the library unit,
  - Change in library member status – termination of active library membership is recorded.

- Library statistics – preparation of periodical (daily, monthly, annual) statistics and library work reports is grouped in several processes:
  - Forming of inventory book for the library – based on information about the book copies, a report is prepared in the form of an inventory book,
  - List of books taken and still no returned and members keeping them,
  - List of books and magazines used by a particular member in a given period,
  - List of books used in a given period – a list of books used in a given period and of library members who used them,
  - List of books and magazines requested and not obtained by the library members,
  - Request for appropriate report, i.e., statistics (not to be automated),
  - Forming of inventory book for magazines in the library,
  - List of non-returned magazines,
• List of magazines used in a given period;
• Catalogue description of library magazines – similar to the catalogue description of books;
• Inventoring of magazines in the library:
  • Entry of new copies of a magazine issue.

2.3.2.3. Monitoring of Materials
Details of reception of consumable materials are recorded, e.g. oil for heating. Also, details of consumption and remaining quantities of materials are recorded.

2.3.2.4. Accounting Operations
Accounting operations may globally be decomposed into the following sub-processes:
• Salaries,
• Financial book-keeping,
• Book of fixed assets,
• Calculation of royalties.

Salaries represent the process that serves to calculate salaries of employees in educational institutions.
This process has a maximum number of parameters. All elements of salaries, such as starting amount, benefits, employer’s and employee’s taxes and contributions, etc. – may be added without changing the software. For example, a new benefit is simply added or removed for one or all employees in the institution.

All the processes in this part are grouped in the following way:
• Selection – enables selection of a desired activity in the salary calculation process.
• Salary parameter adjustment – enables centralized adjustment of parameters related to salary calculation, for a certain month, such as minimum labour cost, labour cost per general collective agreement, number of work hours in a month, valuation coefficients for various types of sick leave and overtime.
• Selection of current month – Selection of current month for the processing of salaries and reports related to them.
• Salary calculation for all employees – A complex process that iteratively and automatically processes salaries for all employees in an institution, by applying the process salary calculation for one employee. This process provides for group adjustment of various parameters in the current salary calculation, which is particularly useful in case of changes in laws and regulations applicable to all employees, e.g., modified percentage of a withholding tax.
• Salary calculation for one employee – is the main process for salary processing. It refers to one employee and consists of several phases:
  • Specification of main details about the employee (years of experience, etc.),
  • Creation of main data for salary calculation for the current month,
  • Carrying forward of necessary information from previous calculation and from parameters defined for that month,
  • Carrying forward from previous calculation and direct definition of starting amounts such as years of experience, functional benefit, activity, which are part of starting net pool of salary funds,
• Calculation of gross pool of salary funds from net pool of salary funds (parameterisation of this phase by means of a coefficient is possible; currently, it is 1.64),
• Entry of work hours achieved – regular work hours, all kinds of sick leave, overtime work, work on holidays, night work – and calculation of gross achieved amount,
• Carrying forward from previous calculation, and direct definition of compensations,
• Carrying forward from previous calculation, and direct definition of benefits,
• Carrying forward from previous calculation, and direct definition of non-taxable amounts,
• Calculation of gross salary, taxable basis (from gross achieved amount, compensations and benefits),
• Tax calculation,
• Definition of employee contributions,
• Definition of employer contributions,
• Calculation of net salary,
• Definition of deductions (penalties, alimonies, etc.),
• Definition of employee loans, definition of instalment to be deducted,
• Calculation of amounts for payment.

• **OPD1** – Process for the creation of the Form OPD1, calculation of taxes and contributions for any given month,
• **OPD2** – Process for the creation of the Form OPD2, calculation of taxes and contributions,
• **OPD3** - Process for the creation of the Form OPD3, calculation of taxes and contributions,
• **UZ** - Process for the creation of the Form UZ,
• **OZ** - Process for the creation of the Form OZ,
• **Payroll** – Generation of a detailed payroll, for each employee individually, for a certain month, for the whole institution,
• **List of disbursements for the month** – Generation of payroll, for a certain month, at the level of the institution,
• **Specification of contributions** – Generation of aggregate report of both employer and employee contributions, for a certain month, at the level of the institution,
• **Electronic exchange of data** – Module foreseen for exchange of information with other systems.

**Financial bookkeeping** is the process that serves to maintain the general ledger at the level of the institution.
The process is focused on the current financial year, while all the documents related to previous years are retained. A simple transfer from one year to another is possible.
The chart of accounts is defined at the level of the institution and may be carried forward from the previous year.
The conception of the process enables that analytical entries to be made completely through the chart of account, but not only in that way. Within the items of an order in the financial bookkeeping, it is possible to specify not only the target account but also the employee, institution and ordering party, so that the analytical specification is done by all categories, without burdening the chart of accounts. Of course, the process facilitates certain reports in this way, e.g., the card under a certain account for a certain employee.
The process contains flexibly designed reports, such as the account card, recapitulation according to initial digits of the account, recapitulation according to exact number of digit,
gross balances, and aggregation at a desired level. The reports designed in this way enable efficient monitoring of entries and aggregation from the level of a class to the arbitrary depth.

- **Definition of the current year** – The current year for financial year for the work with parameters, chart of accounts, orders and reports is selected.
- **Definition of the chart of accounts** – The chart of accounts for the current year is defined. At the beginning of the financial year, it can be copied wholly from the previous year. It is possible to add, delete and update accounts and to print the chart of accounts.
- **Work with orders** – The main process for the work with orders in financial bookkeeping comprises the entry of basic information, types of entries, dates of entries. It also includes entry and changes in order items, account verification, adding up of interim sub-total, verification of credit and debit side balance, booking and printing of orders.
- **Selection of Financial Bookkeeping (FB)** – Enables selection of a desired activity in the process for financial bookkeeping.
- **Reports of Financial Book-Keeping** – Enables generation of financial bookkeeping reports: accounts cards, employee accounts cards, institution account card, client account card, recapitulation by initial digits of the account, recapitulation by exact number of digits of the account, gross balance; aggregation at a desired level.
- **Definition of financial bookkeeping parameters** – Enables centralized adjustment of parameters related to financial bookkeeping, such as types of order and types of entries.

**Book of fixed assets** represents the process for the calculation of fixed asset depreciation at the level of an educational institution.

The process is oriented to the yearly depreciation of the assets, and as part of that calculates depreciation by months. Depreciation is performed by rates and methods (proportional and digressive), depending on the group and type of property to which the asset belongs. Assets are also classified according to the type, location and organizational unit. It is possible to define the lower limit of depreciation, as well as the value adjustment. Inventories of fixed assets are registered.

- **Adjustment of fixed asset parameters** – Centralized adjustment of parameters related to calculation of fixed asset depreciation; groups and types of property, rates, methods; types of assets, statuses, organizational units, locations.
- **Inventory taking** – Inventory taking of fixed assets at the level of the institution; entering of date and committee; entering of inventory items.
- **Calculation of fixed asset depreciation** – The main sub-process which relies on the asset details, as well as on the previous calculation. Taken into consideration are: status of assets (active, written off), procurement date and value, possible disposal date and value, book value and quantity, quantity as entered in the inventory listing. The asset value adjustment is possible. By applying method appropriate for the type of assets (proportional, digressive), monthly rates and values of depreciation are calculated. Annual depreciation, new value and price are calculated.
- **Fixed asset reports** – Reports on fixed asset depreciation: by periods (annual, monthly); by organizational units, types; by types and groups of property.
- **Work with assets** – Entry of fixed assets (code, name, quantity, purchase price, supplier, location); data modification; entering of current quantity.
**Royalties** represent the process for recording and providing automated calculation of royalties and printing the transfer orders. The process is decomposed into the following:

- **Configuration of royalties** – which serves to enter initial configuring data, such as purpose of payment, gyro accounts of legal and/or natural person, tax rate configuration, etc.
- **Entering of royalties** – where transfer orders are entered individually, either for royalties or for other purposes, including royalties for groups of persons.
- **Royalty reports** which are used for printing various reports, by arbitrarily set criteria and for generating the Forms IPPO-2 and IPPO-1.

2.3.3. **Administrative Operations**

The process *Administrative Operations* (1.3) automates the execution of the decree on office operations of state administration authorities. This decree covers reception of submissions, documents and other mail, classification and sorting of cases, recording of documents, delivery of documents and return of resolved cases to the filing office, and case archiving and storing.

Automation of the decree on office operations results in simple recording of documents received through the books (simple “clicking” on the mouse will enter that data into the internal ledger, mail book, bill book or place book or archive book), simple tracking of a started case, and simple “clicking” on the mouse will return the resolved cases to the filing office.

All the documents produced during the work in the education (decisions, complaints, record book entries, enrolment book entries...) are recorded through the process of administrative operations via administrative books. This recording is performed by sending the documents to be recorded in the background, and the employee in the administrative service gets only the list of documents sent for recording. This ensures comfortable work and provides quality and correct work in administrative operations in all educational institutions.

The process *Administrative Operations* (1.3) includes the following sub-processes:

- **Mail reception** (1.3.1) that includes the following sub-processes:
  - **Recording of documents and cases** (1.3.2). This process has the sub-processes:
    - Recording into the journal,
    - Recording of first degree administrative proceedings,
    - Recording of second degree administrative proceedings,
    - Recording of issued certificates;
  - **Internal movement of cases and documents through the internal delivery book or book of bills** (process 1.3.6),
  - **Movement of cases and documents through the place book or mail book** (process 1.3.7),
  - **Return of resolved cases to the filing office** (process 1.3.4). The employee from the filing office selects the returned cases from the offered list of returned cases. The cases are sorted again.
  - **Archiving of closed cases** (process 1.3.8).

2.3.4. **Management Support**

The sub-system *Management Support* comprises generated reports at various levels and synthetic gathering of data according to various criteria. For example, by crossing the data on classrooms, staff and teaching, we will get reports on redundant staff, lacking staff, etc. Also this sub-system issues orders for execution of jobs given by management. The execution of orders is monitored. The sub-system is divided into:

- **4.1. Management processes within school institutions.** Here we obtain reports within institutions that serve the purposes of the management of these institutions.
4.2. Management processes within the central level. Here we obtain reports by synthetic gathering of data of all the institutions that serve for global monitoring of the educational system and for management by central level institutions.

2.3.5. IS Administration

The sub-system IS Administration (1.5.) is decomposed into:

- **Access protection (1.5.1)** where the data about the operator are recorded for the purpose of data protection against unauthorized access and unauthorized user action. It records applications, application domains and domain operators, so that a particular operator is authorized to work on particular business functions and particular database transactions only. For example, the operator who is a teacher (teacher domain) may look at the application for curricula, but cannot change it, while in the application for entering of grades for his own subject he can perform all operations, but only for the classrooms that he teaches. Also, the operators who are psychologists (psychologist domain) are the only who have access to and may enter information about pupils with psychological problems. This is also where data back-ups are recorded.

- **Work with application (1.5.2)** implies all controls in the strict hierarchical series in order to prevent unauthorized access to data.

- **Software and hardware maintenance (1.5.3)** represents the sub-process that serves the user in the sense of technical support in case of problems that may arise on equipment in institutions and will be explained in more detail below.

- **Identification of need for entering a code in the code index (1.5.4)**. The operator on a location identifies the need for entering a particular code in a code index. Code index keeping is centralized so that the operators, by locations, send requests for adding new codes through this process.

- **Entering of codes in code index (1.5.5)**. A code is entered in the code index by an operator in the IT centre, if found needed. Also, the request for adding a code is answered here.

2.3.5.1. Software and Hardware Maintenance

The process Software and Hardware Maintenance is intended to work on two levels. The first level is the possibility of intensive communication among all participants in the process of communication. It is achieved in the form of a forum. The forum is organized in the following way:

- At the highest level, the forum is organized in the form of topics. Topics serve to classify appropriate areas to which the problem may refer. Topics may include software, hardware, etc., or anything that might be of interest for the users. There is the possibility to add topics, in order to satisfy additional requirements in the future. Topics may be created by an IT centre employee only.

- The second level are questions. Any side in the communication may ask questions. A question consists of the question title (may be automatically undertaken from several first words in the next field) and the question text detailing the problem.

- The third level are answers. An answer, like in the previous case, may be given by any side in the communication which wants to describe its experience with that question or which may know solution to the problem.

- The fourth level are comments to answers, i.e., answers to answers. It serves to stress whom the service user is addressing, but the contents must relate to the question.

The second level is the exchange of formal documents such as applications, orders and reports, effecting the formal communication among the participants. There are several kinds
LOGICAL ARCHITECTURE OF MEIS PROJECT (LA-MEIS)

of documents. These are failure report, screening order, execution order, then offer and completion report.

- **Failure reporting by local administrator** – The local administrator in the school may first visit the forum. The forum also has a search option, by entering the key words related to the problem. If nothing can be found, the local administrator may raise a question under the appropriate topic. He can follow any answers to the put question. If a satisfactory answer cannot be found following the above procedure, the local administrator creates and order for reporting the failure, which is updated upon the database. Failure is reported through an informal text that contains general description of the problem, indicating possible known reason that caused it.

- **Failure recording** – An IT centre employee receives information that new requests have arrived and opens them for processing. It is possible to process by priorities. It is possible to send an answer within the order itself. If the answer has not resolved the problem, the following process is initiated – creation of either screening order or execution order.

- **Creation of screening order** – The IT centre employee creates order for screening the situation when it cannot be ascertained on the basis of the above communication. Screening order refers to a legal person that is in charge of maintaining the equipment in the given institution. It consists of an informal text with problem description.

- **Creation of execution order** – The execution order may be a consequence of either an offer sent by the legal person or a need to incorporate an additional component or install additional software on equipment in the institution. The execution order consists of items and is connected with the appropriate legal person that is supposed to perform the repair/incorporation, or software repair /installation. The execution order is binding.

- **Service offer** – Service offer is the result of the screening order. It consists of an informal document defining actions to be done on the equipment, according to the opinion of the legal person (service company), and the offered price.

- **Completion report** – This report is created by the legal person (service company) and it is a formal document describing the actions completed and the precise cost of each action individually. It is created as the result of an execution order.

- **Recording changes on equipment** – After processing the completion report, the IT employee records the appropriate changes in the database.

- **Asking questions** – If the forum search has not resulted in finding the information that may assist in removing the problem, the question is asked under the topic that the user considers most appropriate for the question concerned.

- **Answering the questions** – any participant connected to the forum may give the answer to the question. Such participants will describe some experience related to the problem, which would hopefully assist in resolving the problem without the need for a field visit. In addition to answering the question, there is a possibility to comment the answer, in other words to answer to the answer. The answers are the true purpose of the forum, because the idea is with time to collect a database of problems and their solutions that would provide for much more efficient response to problems.
2.4. Provision of Quality in Implementation of LA-MEIS Project

2.4.1. Standardization

Involvement of all segments of the society in global developments is an indispensable precondition of development and survival in general. The common denominator of those integrations is the respect of international standards, without which any communication would be impossible today. To that end, the educational IS must be in line with world standardization trends, regarding both the binding postulates and recommendations, to a maximum possible extent.

The LA-MEIS project is implemented in accordance with the guidelines given in the standard JUS ISO 9000-3 and guidelines for the application of ISO 9001 for the development, supply and maintenance of software, as well as the guidelines contained in the standard JUS ISO/IEC 12207 – Information Technology – Processes of Software Life Cycle. Control and improvement of all processes and activities defined within these standards as well as of the tasks will be provided.

The LA-MEIS project covered the development processes in accordance with activities defined in JUS ISO/IEC 12207 as follows:
- Analysis and specification of user requirements and
- Software product designing.

2.4.1.1. Analysis and Specification of Software Requirements

In the project preparation, user requirements were assessed considering the criteria contained in the JUS ISO 12207 (5.3.2.2):
- Requirement justification for the system and system design;
- External consistence with system requirements;
- Internal consistence;
- Examination suitability;
- Software project feasibility;
- Exploitation and maintenance feasibility.

2.4.1.2. Designing

During the designing, user requirements for certain elements are translated in the software architecture that describes its structure from top to bottom and software components are identified, in which:
- Architecture of any software element is documented through the process model;
- The main project is documented from top to bottom and for external interface of software elements and among software components of software elements.
- The project for database is developed and documented by way of model data.

The designer undertook reviews in accordance with 6.6. (JUS ISO/IEC 12207) by organizing valuation of status and results of activities in the designing phase. The reviews were performed at the project management level and at the technical level.

The process of verification, which represents establishment of compliance with needs, was performed at the phase of project preparation at the level of model process, data flow diagrams, functional decomposition diagram and object-connection model.

2.4.2. Quality

The quality system (JUS ISO 9000-3, point 4) during the preparation of the main project is provided through:
- Participation of users towards establishing compliance of project solutions with user requirements,
- Verification of project solutions,
Documentation of the given life cycle phase (JUS ISO 12207 Information Technology – Processes of Software Life Cycle).

The quality system for the software life cycle activities (JUS ISO 9000-3, point 5) is provided through:
1. Application of standard design methodology, appropriate for the information system that is being designed (Standard IEEE 1016.1);
2. In the phase of system analysis and specification, through the use and application of uniform methodology, the results of which are written in the form of dataflow diagrams;
3. Specification of database and application of uniform methodology for development of model data by IDEF1X standard;
4. Use of methods and tools implemented in CASE tools:
   - Model functions and processes presenting model functional needs, independent of any mechanism or method of processing;
   - Model data (implementation of IDEF standard representing software standard for modelling techniques) independent of any method of data access and manner of data storing;
   - Documentation that fully corresponds to the projected solution;
   - Procedures for generating database and preserving its integrity in accordance with expressed and verified user requirements.

2.5. Implementation Plan (Application Specification)

2.5.1. Implementation Phases

Implementation phases are:
1. Database physical generation;
2. Application implementation (development);
3. User documentation writing;
4. Application testing;
5. Application maintenance.

2.5.1.1. Database Physical Generation

The database is automatically physically generated through Oracle Designer tools for the designing. The database was earlier formed in the phase of model data development during the designing.

2.5.1.2. Application Implementation (Development)

The standards indicated in the specification of application in the design description will be used for the implementation of the application.

A uniform manner of designating the sub-systems, designating the applications within them, packages, procedures, etc. will be determined in the specification for the defined sub-systems, which will provide that the following may be performed during the maintenance phase (standard JUS/ISO 12207):
- System modification for improvement or adjustment to changes occurring in the environment (changed legislation, internal policies or organization that influence the designed system),
- Expansion by introducing new functions that have not been implemented in the business system work environment at the time of designing the system,
- Transfer of software in the new software and hardware environment,
• Easy identification of segments that need to be changed upgraded or used in new applications. Every programming system should contain:
  • Applications for maintaining the related code indexes,
  • Applications for processing of all related documents,
  • Reports.
In the specification of applications descriptions that support the three-tier architecture should be used. It is necessary to develop standards for:

• **Interface**
  - Generation of standard screen forms characterized by uniform outward appearance, operations performed by them and menu options. The observed principle will be that a well designed screen may increase and accelerate the human processing of presented data and information, reduce human errors and fasten the computer processing of data entered through the screen.
  - Standard options for each application for processing a document (e.g.: save, cancel, change, preview, help, exit, etc.).
  - Standard sub-heading of each application (place showing the sub-system name, document name and form elements referring to the document).
  - Standard TOOLBAR that will appear in all formats, or on all screens appearing at the user.
  - Applied standards in the definition of user interface will enable their easy use, which is considered one of significant criteria that has to be met by the system design.

• **Business Functions**
  - Standardized implementation of business functions through classes;
  - Obligatory definition of domain;
  - Definition of procedures for preserving object integrity;
  - Uniform verification in the phase of data entering, updating or access.

• **Transaction Functions over the database:**
  - Select a record;
  - Insert a record;
  - Change a record;
  - Update a record.

2.5.1.3. **Formation of User Documentation**
User documentation will be made in accordance with the standard JUS ISO 9127- - Systems for Processing Information – User Documentation and Related Information for Mass Software Packages and will consist of:
  - Implementation instructions,
  - Maintenance instructions,
  - User instructions.

2.5.1.4. **Application Testing**
Application testing will be performed at the following levels:
  - Application testing by developers;
  - Application testing by users.
2.5.1.5. Application Maintenance

IS maintenance includes the following activities:
1. Conversion of existing databases and transfer to another database,
2. Exploitation of application,
3. Database administration,
   Within the database administration, the following is performed:
   - Database integrity maintenance,
   - Data protection from unauthorized use,
   - User administration,
   - Database backup,
   - Database recovery in case of the system failure.
4. Communication management,
5. Application upgrading and modification,
   Upgrading and modification of applications will be made in case of:
   - Error in application,
   - Changes in legislation,
   - Correct objections and suggestions by users.

The best solution for application maintenance is to hire the same team which was engaged in developing the application. After the application is accepted, it has to be maintained during the warranty period. We propose it for at least 6 months. After the warranty period, application should continue to be maintained. The maintenance terms and conditions would be defined by a contract.

2.5.2. Cost of Implementation (I-MEIS) and Application Maintenance

Tentative cost of developing the application under this project is about € 180,000. The proposed cost of application maintenance is € 18,000 on an annual basis, or 10% of the application development cost.

2.5.3. Implementation Time Schedule (I-MEIS)

Project implementation period is 12 months and is described in detail in the time schedule (Table 1).
### Table 1 - Time Schedule of I-MEIS Project Preparation

<table>
<thead>
<tr>
<th>Project Activity</th>
<th>Control Points</th>
<th>Control Point I</th>
<th>Control Point II</th>
<th>Control Point III</th>
<th>End of Project</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Months</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Tender publication and selection of contractor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hiring IT staff in IT Centre</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training of IT staff in IT Centre</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training of programming team for application software and database server</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preparation of standard classes for programming</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical generation of database and application from ORACLE designer - testing administration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Development of applications</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Installation and testing of application</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>User training in work with application</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data entering</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Application maintenance and upgrading</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2.6. Description of MEIS Logical Architecture Development

Logical architecture of IS is developed on the basis of relevant legislation and user requirement, among which particularly:

- A set of existing laws and regulations in the area of education in Montenegro;
- A set of proposals and draft laws in the area of education in Montenegro, that are in the phase of pre-adoption;
- Proposals and suggestions of project technologists engaged by the Ministry of Education and Science in Montenegro;
- Documents with existing international indicators of successful education.

Complete infrastructure of user application will be centralized on servers. The database will be of sizeable dimensions, with over 300 tables over which complex inquiries and transactions will be performed. A greater number of tables will have dozens of millions of records. The number of simultaneous users will be about 300.

Based on these parameters, we have chosen Oracle 9i database platform, and therefore for Oracle Designer designing tools. The use of these tools will enable comfortable and standardized description of IS logical architecture and will generate both the database and initial applications. One of significant consequences of work in this tool is also the standardization of applications. All designing data are kept in the repository (Oracle database with project data).

By means of this tool the project team developed the logical architecture of information system LA-MEIS, whereby they have provided the required level of quality in the designing and project documentation, as prescribed by the current standards.

2.6.1. Contents of LA-MEIS

The contents of the logical architecture (LA-MEIS) are divided into:

2.6.1.1. Process Model

The structure of processes is represented by individual processes, from upper to lower level, ending with trivial processes. The process model is made in the “Dataflow Diagram” tool. The reason for preparing DTP diagrams is that entities and process are related in this Oracle tool, and it later results in initial generation of the applications.

Most processes that are decomposed are also shown in diagrams made in the “Process Modeller” tool.

They also describe a kind of activity diagram, as well as the distribution of processes by organizational units.

The processes are described in detail within the repository. The previous chapter contains description of a number of more important processes (about 200 in total, while the repository contains description of a set of about 500 processes).
2.6.1.2. **Object-Relationship Model**
Entities, attributes, domains and more important relationships are described in detail. All the advanced modelling techniques offered by the Designer were used, such as sub-entities, arcs, etc. Diagrams are divided by sub-systems. The number of entities is around 380. The Database relationship model is also made. The database numbers about 310 tables.

2.6.1.3. **Relationship between Processes and Entities**
The report presents and describes the functions, i.e., processes, attributes of functions, events that initiate functions, CRUD matrices of entity-function etc.

**Note:** Due to the size of the LA-MEIS project (about 1000 pages mostly generated from Oracle Designer repository), the book presents only a small part of the logical architecture.

**Error! Reference source not found.** shows diagram of all entities and their relationships, as an illustration of the model complexity.
Figure 11. Entity-Relationship Diagram
3. PHYSICAL ARCHITECTURE OF MEIS PROJECT (PA-MEIS)

3.1. Montenegrin Educational Network (MEN) Sub-project

3.1.1. Introduction to MEN Sub-project

This proposal specifies the activities related to the implementation of the Montenegrin Education Network (MEN). As the Terms of Reference for the preparation of this proposal served the material titled “STRATEGY OF ICT INTRODUCTION IN THE MONTENEGRIN EDUCATIONAL SYSTEM” (hereinafter: the ICT Strategy) prepared by the group of authors from the University of Montenegro and the Ministry of Education and Science (hereinafter: the Ministry).

By confronting the compiled requirements from various segments of this material, the project team will have to address the following tasks:

- Within the technical capacities, to provide connection of local networks of schools and other educational institutions to the optical network;
- To make the project for the development of two independent and mutually protected computer networks, management and educational, in the Montenegrin educational system, in focus schools and appropriate educational institutions;
- Provide protection and security of data and user operation;
- Enable access to and exchange of information within the didactical software, and on the other side, the protection of data from administrative database, by installing two independent networks, or in other way, in accordance with technical capacities and economic viability;
- Standardize equipment and manner of installation of local networks in the function of system compatibility;
- Connect the network to Internet, with all related security measures;
- Enable that most educators (teachers, school pedagogues/psychologists, school principals and pupils) have their own username on Internet, and that a significant number of classrooms have their group username on Internet;
- Direct the process towards the establishment of Montenegro Educational Network that would provide constant access and Internet communication to all educational institutions at all levels of education. The network would provide exchange of ideas in the process of education at all levels, common work on projects and resolution of problems, formation of shared databases, conferences, debates, remote learning, etc.
- At the first phase, this network would connect 30 focus schools (20 primary schools and 10 secondary schools).

3.1.2. Key Factors Determining the Network Concept at LAN and WAN Level

Based on the mentioned ICT Strategy and the compiled requirements presented in the introduction, the following assumptions can be easily noticed:

- Local computer networks (at the level of an institution) should have at least two mutually independent segments. The first segment should be accessible to pupils and the second one to the school staff. The rules of accessing the communication, server and other resources by participants are not pre-determined and they should be made programmable – through the definition of policies etc.
- Local network should be able to access the centralized resources at the level of the Ministry, with clear definition of who can access which resources.
Local networks should have access to Internet in a uniform, organized and secure way.

School staff and pupils should have their individual and group usernames for the needs of Internet communication (mail, messenger etc.).

Very small number of schools has local networks on an ad-hoc principle, at the level of one or more classrooms.

There is no form of organized computer communication among the schools.

The existing communication infrastructure in Montenegro enables the construction of private WAN networks through the lease of transport links from Telecom Montenegro (link capacity is in the range of nx64Kbps, 2 Mbps, 34Mbps, 155 Mbps), or through the lease of capacity at Internet Crna Gora, which is currently the only company which possesses IP network at the level of the Republic.

Telecom Montenegro works on the development of IP MPLS (MIPNET) network that will function at the level of the whole Republic and will offer large flows and a big number of services. The commercial operation of MIPNET is expected to start in May 2004.

In developing the network concept, economic viability of the investment should be taken into consideration.

All this indicate that the educational IT network concept should be developed from the beginning, through standardized solutions, while the existing LAN infrastructure should be later on connected to the developed standardized solutions.

Considering the distribution of focus schools, at certain locations the educational network could also have, in addition to LAN and WAN segments, also the MAN segment (network of several schools at the city level).

3.1.3. LAN Level

According to the material contained in ICT Strategy, the project for 30 LAN networks (20 primary and 10 secondary schools) is currently in preparation. The project team is expected to produce a standard solution that will satisfy all previously defined criteria, and at the same time fit into the financial limits defined in the CIT Strategy.

3.1.3.1. Passive Infrastructure

For implementation of LAN networks, it is proposed to choose IT network of Ethernet type by the IEEE 802.3 standard, and to do cabling by the ANSI/EIA/TIA-568-A, 569, 570, 606, 607 and TSB-67 standards. Local cable infrastructure in an institution, on a horizontal basis, is based on UTP/STP (Unshielded/Shielded Twisted Pair) cable of 5e (or higher) category and in a star topology, and are mostly concentrated at one place.

3.1.3.1.1. Short Explanation of the Proposed Star Topology

The main advantage of a star network is the operative endurance. Cable lines are insulated from each other, which means that the failure of one of them will not impede others. The overall cabling is neater because there are less cables leading to each node. In such topology makes it easier to move computers and change connections and work groups. It is also possible to provide transparent connections among various computer systems and their peripherals into a single computer network.

By proper planning and good designations at the start of the project implementation, it is very simple to form work groups with various demands according to traffic intensity, and to turn on/turn off, i.e., to switch from one group to another.
3.1.3.1.2. Passive network components

3.1.3.1.2.1 UTP/STP Cable of 5e Category
Thanking to low price and high flows that it provide, today this is the most often used media for dataflow in local networks. It is a four-pair cable of characteristic impedance of 100 Ohm, with wires 24 AWG thick. Every wire is coloured differently so that it is easier to differentiate among individual pairs. The connection of RJ45 connectors will be performed by the T568B standard.

One should be aware that the total length of the cable from the computer to the active network component should not exceed 100m, which means that, in practice, maximum length of wall cable should be 90m, with two 5m fly patch cables. One should also be careful about the distance of cabling from big electric devices, in order to avoid electro-magnetic interference.

3.1.3.1.2.2 Wall Plugs and Patch Panels
On the remote side, the connecting cable ends on the wall plug, and on the side of active communication equipment, it ends in the PATCH panel. All wall plugs and patch panels should be made by world-known manufacturers (Panduit, Mod-tap, Belden, Unicom ...) and certified to satisfy the category 5e criteria.

3.1.3.1.2.3 Cable Rails
Complete cabling of UTP and fibre cables will be performed through the protective cable rails. The wall UTP cable will be placed into plastic rails along the whole length, thus increasing the level of safety of cables to the highest level, with very neat appearance at the same time.

3.1.3.1.2.4 Racks
On the side of central or floor concentration, the complete passive (patch panels) and active equipment (switches, UPS) should be placed in a separate rack. The rack should be lockable and should have the possibility to include fan and thermostat. For rack it is recommended to install a cable organizer and electrical multiple socket (with 5 or more plugs) in a rack version (19°). The design specifies the racks with a size of 9 and 12 HE. Since the security at the LAN level is directly related to the positions of individual computers on the switches, i.e., on the patch panel, the control of the access to concentration, i.e., the rack is very important.

3.1.3.1.2.5 Existing Electrical Cabling Infrastructure in Buildings
For a reliable and correct functioning of communication equipment, since it is very dispersed in space but physically connected, the quality of existing electrical installations in buildings is an extremely important element, particularly the quality of grounding and the balance of phases. Since the buildings concerned are of different age, with generally old electric installations and unknown earthing state of repair, this problem must receive utmost attention.

3.1.3.1.2.6 Layout of Passive Components of Network
The schematic layout of passive components of all the 30 LAN networks has been made, but is not presented in this book due to its size. The layout is made in a standardized manner for each network. The drawings were made on the basis of visits and sketches of each individual site. Figure 12 presents the standard layout of a LAN ("Maksim Gorki" Elementary School).
3.1.3.2. Installation and Start-Up

3.1.3.2.1. Cabling
For the placement of cabling it is necessary to document all the modifications, amendments and deviations from design documents, and they are subject to approval by the designer or the supervising engineer.
The termination of UTP/STP cables on the user side should be on-wall or in/wall mounted. Socket outlets are to be installed at least 30 cm above the floor level and at a proper distance from other installations. It is recommended to use socket outlets with modular connections of the 2xRJ-45 type. Non-used modular connection plugs should be closed by empty module.
Cables are to be installed through wall or built-in rails or pipes (or floor rails), with a cross section that can satisfy the mechanical requirements (during and after the placement of cables), as defined by the producers. The use of plastic rails is allowed in the following circumstances:
- stable low level of electro-magnetic interference,
- low level of emission of cables running through the rails,
- placement of optical cables.
For the installation to be good, it is necessary to use cable rails (pipes or floor rails) wider than minimum allowed diameter of cable bending during and after the installation or it is necessary to use additional elements with widening in order to meet the prescribed requirement.

3.1.3.2.2. Placement of equipment and switch
All active network equipment and tach concentrators must be placed in racks. All racks must be either stand-alone or fixed to the wall. The place of concentrators and racks should be chosen so to ensure comfortable handling of cabling and devices inside the racks. Also, it is not recommended to install the racks in a room exposed to humidity (sanitary facilities,
kitchens, etc.). The racks must be properly grounded. All electrical devices in the racks (with metal casing) must be grounded to the coupled grounding of the racks.

3.1.3.2.3. Route for Placing Cables
Cables are placed along the marked route, horizontally and vertically. Diagonal placement is not allowed. Minimum allowed distance from sources of electro-magnetic interference must be taken into account (Table 2).

<table>
<thead>
<tr>
<th>Cabling /source of electro-magnetic emission</th>
<th>&lt; 2kVA</th>
<th>2-5 kVA</th>
<th>&gt;5kVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unshielded rail/unshielded energy cable</td>
<td>12.7 cm</td>
<td>30.5 cm</td>
<td>61 cm</td>
</tr>
<tr>
<td>Shielded and grounded rail/unshielded energy cable</td>
<td>6.4 cm</td>
<td>15.2 cm</td>
<td>30.5 cm</td>
</tr>
<tr>
<td>Shielded and grounded rail/shielded and grounded energy cable</td>
<td>-</td>
<td>15.2 cm</td>
<td>30.5 cm</td>
</tr>
<tr>
<td>UTP / transformers and electric motors</td>
<td>1.02 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UTP / Fluorescent lighting body</td>
<td>30.05 cm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.1.3.2.4. Cable Termination (Connector Placement)
Cable termination means assembly of connectors at the cable ends. In cable termination, the following principles should be adhered to:

- connectors must be installed carefully and properly;
- connector placement must be done by trained and experience staff of the contractor;
- cable extending is not allowed;
- the length of the removed protective layer on UTP (FTP/STP) cable must be minimum possible and not exceed 5 cm;
- FTP/STP cables must be grounded on the side of patch panel.

3.1.3.2.5. Performance and Acceptance Testing
The works on the placement of passive equipment should be entrusted to an experienced contractor who will fully meet the previously mentioned standards. The future stability of the network functioning will largely depend on the quality of these works. After the placement of passive infrastructure has been completed, the complete installation needs to be tested in order to be certified for category 5e. The printed attest should be enclosed to the performed network design.

3.1.3.2.6. Maintenance and Repairs
After the tests and start-up, the passive network infrastructure does not require any special maintenance, except in the case of damage or addition of new socket outlets, cables, etc. In such activities, the performed network design must be consulted, and if new elements are added, such design needs to be updated.

3.1.3.3. Active Network Components
According to the requirements defined in the ICT Strategy, a network modelled at the level of individual LAN should consist of at least two independent segments (pupils and staff). The standard form of satisfying these requirements is accomplished at the logical level through the use of VLAN technology. To enable the traffic among various VLANs, it is necessary to terminate them on a Layer 3 device (Layer 3 Switch, Router, Firewall). In addition to the
functions of active components in LAN environment, one should take care about their position in the context of the complete educational network (that will be discussed more in the chapter on WAN segment).

Generally, Ethernet communication network is recommended, which includes 10/100Mbps, 100 Mbps and 1000 Mbps. Active components at LAN level should support the following characteristics:

- Standard connection in the network should be 10/100Mbps;
- The network should be based on switches;
- Since there is a lot of rather old computer and communication equipment in schools, it is mandatory to use autosense technology which enables that the card or active device recognize the work rhythm of the device on the other side and to adjust its own to it;
- Standard connection for active components and servers should be 100Mbps or 1Gbps;
- active equipment should satisfy IEEE standards, which would ensure the desired functionality (IEEE 802.3u, IEEE 802.3z, IEEE 802.3ab, IEEE 802.1d, IEEE 802.1Q, IEEE 802.1p);
- all switches should support VLANs and standard protocols for VLAN tunnelling;
- L3 switches should support VLAN routing;
- The devices should support SNMP (SNMPv2) management (MIB).

### 3.1.3.4. Standardized Solution at LAN level

Standardized solution at LAN network level consists of two components: L2 and L3 Switches. Both the components should satisfy the previously defined characteristics. L2 switches are intended for connection of workstations, divided into VLANs. L3 switches should primarily enable routing among VLANs and participate in defining policies for the needs of VPNs. Servers and possibly workstation of teaching staff should be connected on the ports of L3 switch. L3 switches, in addition to previously defined general features, should also support routing protocols RIP1/RIP2 and OSPF.

![Figure 13 - Standard solution of LAN](image)

### 3.1.3.5. Recommended Protocols in LAN

It is recommended to use TCP/IP network protocol, because of its simplicity, flexibility and obligatory use as protocol for access to Internet network. TCP/IP is currently the most used LAN and WAN network protocol so that the compatibility of the equipment is guaranteed, and
the programming support for this protocol is extensive. In addition, TCP/IP in comparison to other more wide-spread LAN network protocols (Novell Netware IPX, NetBIOS...) also offers much better use of performances, larger possibilities for transfer through WAN network, better supervision of network stations, better security functions, etc.

3.1.4. **WAN level**

3.1.4.1. **General requirements for the development of WAN network**

As it has been already stated at the beginning of this document, the following requirements for the development of the WAN network could be singled out:

- A project for the development of two independent and secured computer network (administrative and educational) in the Montenegro educational system, focus schools and proper institutions of the system;
- Provide the security and safety of data and a user’s operations;
- Enable access and exchange of data within a didactic software on the one hand, and the protection of data from the administrative base by installation of two independent networks or on some other way depending on technical possibilities and economic justification, on the other hand;
- Enable the Internet access to all local computer networks.

3.1.4.2. **Calculation of link speeds**

Average number of computers in LANs (30), and services which should function easily on the WAN level, require a minimum interconnection speed ranging from 15 Kbps to 64 Kbps per computer, i.e. the aggregated link speed for easy functioning should be from 512 Kbps to 2 Mbps.

3.1.4.3. **Possible ideas for the development of WAN network**

As it has already been mentioned, the existing communication infrastructure in Montenegro enables the creation of private Wan networks by leasing the transfer capacities (transfer links) from Telekom Crne Gore or by leasing the capacities withinpublic networks for data transfer.

3.1.4.3.1. **Leasing transfer links from Telekom Crne Gore**

An institution that uses this method to create WAN networks leases transport capacities from a national Telecom. The capacities used are nx64Kbps, 2 Mbps, 34Mbps, 155 Mbps, dark fiber. This is the most expensive concept and it is used only in exceptional cases when there is no existing specialized infrastructure for data transfer (public data networks), or it exists but has no suitable capacities. We consider that the creation of this type of network is not economically justified and thus shall not be discussed in details.

3.1.4.3.2. **Leasing capacities in public data networks**

Two public data networks operate on the territory of Montenegro. Those are CGPAK (Telekom Crne Gore, X.25 network) and Internet Crne Gore – the only commercial Internet service provider in the Republic, at the moment. Besides these two networks, it is important to emphasize that a modern and powerful public data network the MIPNET is being developed, which will be one of the most modern networks in the region regarding its capacities and services.
3.1.4.3.3. **The examination of the possibility to use the existing X.25 network of Telekom Crne Gore**

Telekom Crne Gore owns the public X.25 network. This type of network has been functioning since 1996 and it connects all the administrative centers in the Republic – the total of 21 municipalities. The communication speed is ranging from 19.2 Kbps to 64 Kbps.

In accordance with the aforementioned general requirements, the use of the existing X.25 network does not satisfy the minimum criteria, and the critical points are:

- too low WAN speed (the required speed is minimum 128 Kbps);
- inevitable purchase of equipment (routers and similar) for the conversion of the X.25 to the Ethernet/TCP.

The use of the X.25 protocol on backbone in the present conditions, which the CGPAK centre has at its disposal, is limited to the maximum 64 Kbps to the final destination. The existing interfaces on the X.25 concentrators are limited to 64 Kbps on the hardware level (V.35, X.21, G703), so that with the available hardware the potential migration to the Frame Relay will not enable higher end speeds.

**As it can be concluded from the aforementioned, there are only two possibilities to rely upon when developing the WAN network. One of them is the creation of the WAN network, which would depend on the Internet Crna Gora network and is available forthwith. The other one is leasing the MIPNET capacities that, according to the information from Telekom Crne Gore, will be available from may 2004.**

3.1.4.4. **Proposed solution for the development of WAN network**

The project team recommends a solution which will use the advantages of the aforementioned solutions (Internet CG and the MIPNET) so to build the network in two phases: in the first one through the Internet CG infrastructure, and in the second phase, which is the final and aimed at, through the MIPNET. The advantages of this solution are the following:

- it is possible to start immediately with the building of the network in the WAN;
- it is possible to develop all services and tune the system in the first phase;
- the operating system may migrate to the MIPNET at the appropriate time (in the second phase), which is completely transparent to users;
- all the equipment from the first phase can be used in the second one.

3.1.4.5. **The first phase of the WAN network development – lease of capacities from Internet CG**

Since only the Internet CG offers adequate resources for data transfer and that one of the requirements for the WAN network is the use of the Internet, it is reasonable that these resources are used and developed in the first phase.

Focus schools are located in the areas where Internet CG has its own backbone and can offer required speeds (512Kbps-2Mbps).

The connection of separate or all the focus schools would be achieved through VPN (Virtual Private Networks) in the star architecture. The creation of the education network can start
immediately by using the Internet CG capacities and creating the VPN through public internet infrastructure.

The first step in the creation of the network by this concept would be the connection of the central location (the Ministry, the University, or some other location the Ministry designates as the central node), and subsequently location by location is connected in phases.

Test locations shall be connected to the ICG network in two ways:

- by leased lines at different speeds 192Kbps-2,3 Mbps;
- through dial-up connection to the ICG access servers, through ISDN or POTS.

LAN networks of some locations are connected to the central location through two separate VPN tunnels. Access to the Internet or other resources is achieved through the central location.

3.1.4.6. The concept and the phenomenon of Virtual Private Network (VPN)

VPN is a private network that uses the Internet for interconnection of remote locations and users. Instead of to use expensive leased lines with telecom operators, VPN uses a “virtual” connection through the Internet.

From a user’s point of view, VPN function transparently by giving a remote user the same impression as if working in LAN. Access to mail servers, databases, the Internet, the VOIP applications and so on through VPN is perfectly comfortable.

3.1.4.6.1. A traditional method of realization of the access among remote locations

Traditional forms of the realization of WAN networks require direct links among remote locations and the central location. For the realization of these LAN-to-LAN connections companies usually lease expensive private lines (E1, E3, STM1, dark fiber, and so on).

3.1.4.6.2. Remote dial-up access

The traditional remote access - client-to-LAN uses slow dial-up connections via modem pools installed in the central location combined with complicated access servers (RAS). This type of dial-up connection is expensive since phone calls are made between remote locations (long-distance calls and international calls).

3.1.4.6.3. The VPN concept

The advancement of the internet technology and especially the opportunity to use the broadband access to the Internet has opened up the new possibility to use the Internet and the VPN networks, which entirely replace the traditional, expensive WAN and RAS connections. VPN enables companies to use benefits of the remote access without using the expensive and complicated infrastructure and at an acceptable price per connection.

Figure 14- VPN Concept
3.1.4.6.4. **VPN to a remote location**
LAN-to-LAN VPN application sends network traffic to a remote location via internet connection instead of routing it via a leased line between these two locations. This type of connection considerably reduces initial expenses for equipment, and especially monthly expenses for a link lease.

3.1.4.6.5. **A remote user’s access to VPN**
Client-to-LAN VPN application sends required traffic via a local internet connection at the price of a local access (dial-up, ADSL, Cable connection, and so on), which is many times cheaper than a call to the central location which may be realized as a long-distance or an international call).

3.1.4.6.6. **Benefits of VPN**
In addition to the obvious benefits arising from the reduced expenses, VPN provides the following benefits:

- Widens possibilities and positions of a network access – via the VPN connection remote users can access information resources in their company from any geographical position and at any time.
- Increases job performance of employees – according to the research in some western countries (the latest one was done by the Gallup Organization and Opinion Research), the concept of access to a company's information resources via the VPN increases job performance of employees from 22% to 45%. This is achieved by eliminating strict terms for using resources and enables an employee to opt for a place of access and the most suitable moment which enables the best working conditions (concentration, continuity, comfort and similar).
- Improves the Internet security – Access to the Internet itself carries potential risks for information resources available from the Internet. Most of the VPN connections imply standard security mechanisms such as the firewall and anti-virus protection and a number of additional security mechanisms and precautions.
- A simple scalability - VPN enables companies to use a remote access via an internet service provider infrastructure. Thus, a company can expand its access capacities without investing in its own infrastructure.
- A simple network topology on a user’s side – with the elimination of modem pools and access servers, network infrastructure on a user’s side is simpler for administration and management.

3.1.4.6.7. **How VPN functions**
The VPN connection enables interconnection between remote locations of a company or an organization, as well as the access by remote individuals to its IT resources. The Internet is used for establishment of interconnection. Each of the remote users connects to a local internet service provider (ISP) the same way as accessing the standard way (leased line, dial-up, cable, ADSL, ISDN wireless, and so on). The so-called tunneling process is used for data transfer via the Internet. The tunneling itself is not sufficient to protect privacy. In order to prevent a potential data sniffing, a complete traffic via VPN is encrypted.
3.1.4.6.8. Tunneling

Basically, tunneling is a process of transferring the entire source data packets to new packets (which provide routing information) and sending it via the Internet. The route this data goes through is called the tunnel. In order to create the tunnel, both participants in the tunnelling process – the tunnel client and the tunnel server must use the same tunneling protocol.

Two popular tunneling protocols are PPTP (Point To Point Tunneling Protocol) and IPSec (Internet Protocol Security). The advantage of the PPTP is that it is natively supported in the Windows operating system (Microsoft Windows) and enables Windows users a secured connection to a company’s VPN server (gateway). On the other hand, the IPSec’s requires client software for remote users. The advantages are in providing a better overall security with stronger encryption and better performances than the PPTP.

3.1.4.6.9. Encrypting

Encryption is a process of encoding (encrypting) data which one computer sends to another. Only the destination computer can decode the obtained form and vice versa. IP packets containing data that should be sent via the Internet are first encrypted and then wrapped up (packed) in another IP packet. Routers along the way (internet, corporation and other) see this new packet (wrapper), while the internal data stays placed in a payload section of the first packet.

The IPSec protocol uses DES (Data Encryption Standard) for encryption and decryption of data. The length of the encryption key ranges from 56 bits (DES) to 168 bits (3DES). The encryption on 168 bits (3DES) is the strongest encryption mode available. It is exponentially harder to break than the ordinary DES key.

Microsoft PPTP uses 40-bit or 128-bit encryption key.

3.1.4.6.10. Authentication

One of the most important security elements in using VPN is the identification of users. This is necessary in terms of determining rights and resources a person is allowed to use. The IPSec devices use the procedure called the Internet Key Exchange (IKE) for forwarding the security keys. The Microsoft PPTP uses the existing user authentication technology, such as the PPP PAP (Password Authentication Protocol) and the CHAP (Challenge Handshake Authentication Protocol).

3.1.4.7. The WAN network components and the organization method by the Internet/VPN concept

Connection of remote LAN networks by this concept is achieved through firewall devices through which LAN networks access the Internet and the tunnels for access to remote resources on a central location are created. Two solutions are possible when selecting the Firewall devices:

- purchase and installation of professional firewall devices, such as Cisco Pix, Netscreen and similar;
- installation of the Linux Firewall.
Selection of a Firewall type should depend on the dynamics of implementation of the complete education project (servers, applications, and similar). Since the implementation of the whole system is planned for the first quarter of 2004, which was discussed about in work meetings of the project development team, then development of the network through capacities to be provided by the MIPNET should be orientated to in every respect. A test network, which shall facilitate in delineating the planned services, should be developed in the first phase. If it proves that the MIPNET is late for some reason, development of the network by the test concept could be continued with.

Regardless the fact that the MIPNET concept should be relied upon, the project team is of the opinion that variants of the Internet/VPN connection should be elaborated in this project in case the MIPNET does not become functional for some reason.

3.1.4.8. Equipment specification for the realization of the Internet/VPN connection with Linux Firewalls

In the first phase of the project and services implementation the proposed concept with the VPN networks can be also realized through Linux Firewalls started in one computer for every school. The specification of a computer that may play the role of Firewall is given in the following table:

Table 3- Cost estimate for purchase of PC - firewall

<table>
<thead>
<tr>
<th>Linux Firewall Description</th>
<th>Qty</th>
<th>EUR</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intel Pentium Celeron 2.0 GHz processor or faster</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>256 MB Total RAM</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Hard Drive (any)</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Netcard 10/100 TX UTP, 3Com or Intel</td>
<td>3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>TOTAL PER SERVER (EUR)</strong></td>
<td>30</td>
<td>650</td>
<td>19,500.00</td>
</tr>
</tbody>
</table>

*Hardware shall be provided by the M, and the installation by the Internet CG.

The DSL modems provided by Internet CG shall be used for the connection of LAN networks to the Internet CG nodes. Access via ISDN or POTS dial-up connection should be provided for LAN networks which cannot access the Internet CG backbone via leased lines. The characteristics of standard xDSL modems, which Internet CG uses for installation, are given in the following table:

Table 4- Characteristics of standard xDSL modems

<table>
<thead>
<tr>
<th>COMMUNICATION EQUIPMENT Description</th>
<th>Qty</th>
<th>EUR</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed: up to 2.3Mbps</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance: up to 1.5 km</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mode of operation: master/slave</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of operation: transparent bridging / routing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Services: DHCP, NAT, DNS proxy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Configuration: via Web, Telnet or VT100 terminal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>IDSN TA or POTS Modem</strong></td>
<td>m</td>
<td>120</td>
<td>nx120</td>
</tr>
<tr>
<td><strong>TOTAL FOR COMMUNICATION EQUIPMENT</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
PHYSICAL ARCHITECTURE OF MEIS PROJECT (PA-MEIS)

* Internet Cme Gore provides and installs the hardware
** The Ministry provides the hardware. It is possible to use TA integrated in NTU, which is the Telecom standard offer.

The capacities to be leased from Internet CG are given in the following table:

<table>
<thead>
<tr>
<th>Description</th>
<th>Qt</th>
<th>EUR</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internet connection at the speed of 2Mbps with the protocol towards the Internet of 256 Kbps*</td>
<td>1</td>
<td>1200</td>
<td>1200</td>
</tr>
<tr>
<td>Connection speed towards the Internet of 256 Kbps**</td>
<td>n</td>
<td>300</td>
<td>nx300</td>
</tr>
<tr>
<td>Connection towards the Internet- ISDN/POTS, double connection</td>
<td>n</td>
<td>40</td>
<td>nx40</td>
</tr>
<tr>
<td>Mail/Proxy DNS installation, one-off</td>
<td>5</td>
<td>150</td>
<td>750</td>
</tr>
</tbody>
</table>

*Connection for the central education location in Podgorica
**Connection for town locations (schools)

The entire WAN infrastructure is oriented towards the central location in Podgorica. Local schools networks connect to the central location via the VPN connection, and then to the Internet, that is to a server/services in the network. The connection of schools with a possibility to lease lines towards the Internet CG backbone requires monthly lease of lines, and the connection of schools which access the Internet via dial-up connection requires monthly lease of a dial-up connection plus charges for telephone impulses. It is important to emphasize that telephone impulses are charged at the price of a local telephone call.

Two types of VPN are used for creating the connection towards the central site (the MPN central location – the Ministry of Education and Science). The primary type of VPN is the VPN which connects LAN networks, i.e. the so-called "Site-to-Site VPN". In addition to this type, it is preferable to provide the connection of individual computers to VPN central locations, the so-called "Single user VPN". The latter type is suitable for the connection of teaching staff from their homes, some remote location outside a school, and so on. The following picture (Picture 3) shows the topology of the connection of schools to a central location from both of the VPN types.

Figure 16 - Typical model of schools’ connection to the MPN connection – the Ministry of Education and Science
3.1.4.8.1. Upgrade of the VPN/Internet network – introduction of professional Firewalls

If the connection via the MIPNET were not to be used for some reason, then the reasonable step in the upgrade of this network would be based on the replacement of the Linux based firewall by professional firewall devices. The weakness of Linux firewalls is that they are complex for maintenance and complicated for the upgrade. On the other hand, professional firewalls are delivered together with the well-designed software for management and maintenance and that, by standard, they have better characteristics than PC based firewalls.

Characteristics of Firewalls should be the following:
- Designated hardware-software platform L2 and L3 work mode, Access lists
- ICSA certified Stateful Packet Inspection Firewall
- Support for all the required services – NAT, PAT, DHCP
- VPN functionality ICSA certified IPSec VPN
- Site-to-site and Remote VPN; Complete hardware implementation of DES, 3DES, AES
- Bandwidth management, possibility of defining limits for certain types of traffic.

Cost estimate for a typical firewall solution for central and remote locations (schools) is proposed in the following table:

**Table 6. Cost estimate for a typical firewall solution**

<table>
<thead>
<tr>
<th>Description</th>
<th>Qt</th>
<th>EUR</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>NetScreen 25* auto-sensing 10/100 Base-T Ethernet ports; bandwidth of 100 Mbps without encryption, 20 Mbps with 3DES or AES VPN encryption; supports 8,000 simultaneous connections, 25 site-to-site VPN tunnels, and 100 VPN clients.</td>
<td>1</td>
<td>4500</td>
<td>4500</td>
</tr>
<tr>
<td>NetScreen 5XT ** Untrust 10/100 interface and four Trust 10/100 interfaces, console port and modem port; bandwidth of 70 Mbps without encryption, 20 Mbps with 3DES VPN encryption; supports 2,000 simultaneous connections and 10 VPN tunnels, backup ISDN/POTS port.</td>
<td>1</td>
<td>800</td>
<td>4800</td>
</tr>
<tr>
<td>NetScreen 5XP ** Untrust and Trust 10 BaseT interface; bandwidth of 20 Mbps without encryption, 13 Mbps with 3DES VPN encryption; supports 2,000 simultaneous connections and 10 VPN tunnels, backup ISDN/POTS port.</td>
<td>6</td>
<td>650</td>
<td>3900</td>
</tr>
<tr>
<td>TOTAL FOR Firewall EQUIPMENT ver 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL FOR Firewall EQUIPMENT ver 2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Since there are more institutions on certain towns’ locations which should be networked, it is necessary to develop an action plan of the MAN network MPN on those locations.

### 3.1.4.8.2. MAN networks MPN in towns which connect more locations

According to the locations of the selected focus schools, there are few schools selected in many towns which should be connected as WAN MPN. The questions regarding the realization of the MAN network come down to the following two:

- Is there a common institution on a town’s level which could provide technical prerequisites for the installation of the MAN core?
- Is this cheaper than typical single connections

When speaking about the necessary technical assumptions that an institution on a town’s level could be the central site of the MAN network, the following questions arise:

- Does the selected institution have a sufficient number of quality copper pairs towards the Telekom so as to provide the connection of all institutions to itself, and then all of them to the Telekom?
- Could the selected institution provide an uninterrupted power supply, i.e. does it have the UPS and aggregated devices? If there were not any, how much would the installation of these devices cost?
- Does the selected institution have an adequate space to place the communication equipment for connection to other institutions, and is it possible to provide physical security for the equipment?
- Could the selected institution provide staff for the maintenance of the MAN core?

The project team has learned from experience that the answer to most of these questions (questions about technical possibilities) is negative.

Another question is what is cheaper. It seems that a cheaper alternative is the establishment of the common MAN and a unique connection to the backbone provider. However, according to the present term of connection in Montenegro, this is not true. The reason is that, by leasing a link from the only ISP provider in Montenegro – Internet CG, one gets the connection equipment (DSL modem), and the connection price includes a lease of a copper pair. If the MAN core was to be built, then the DSI equipment and a more expensive firewall should be bought separately (a pair of DSL for each location)

The conclusion is that, according to present technical and market conditions in Montenegro, the concept of typical connection of each location separately to the backbone provider (Internet CG) is more worthwhile and feasible.

Standard connection of various locations from one municipality to the WAN network MPN is shown in the following picture. (Figure 17)
This is a standard solution for the connection of education facilities (UO), that is, the selected primary and secondary schools’ connection to the backbone, i.e. to the WAN network MPN in this phase.

New education facilities, which are not at the moment in the group of focus schools, are connected the same way. The connection of the education facilities, which have no possibility of leased line connection to the Internet CG, is achieved via dial-up connection preferring the ISDN.

WAN network MPN, formed in this standard way, would look as in the following picture (Figure 18).
PHYSICAL ARCHITECTURE OF MEIS PROJECT (PA-MEIS)

Observed from the level of LAN network, the connection to WAN MPN is provided with only one connection, by a leased line or dial-up connection. Establishment of a double connection is recommended for locations which require a high security WAN MPN connection. The primary link would be achieved through a leased line (LL) connection to Internet CG, and the secondary through the alternative dial-up connection to the Internet CG Access servers. If it comes to a disruption on the primary link (LL), the connection is automatically established via the secondary dial-up link. Figure 19 shows the form of this connection.

Figure 19 - Connection with the backup connection

Whether and which locations shall have this type of connection is for the Ministry of Education and Science to decide. It is important to emphasize that when purchasing firewall equipment it is necessary to opt for the devices that enable the backup connection, which is offered with most of the professional firewall devices. The specification of the firewalls which maintain this functionality was given in the preceding tables.

3.1.5. Connection via the MIPNET

3.1.5.1. The MIPNET – Montenegrin IP NETwork

Telekom Crne Gore intends to develop a reliable, quality and upgradeable network, at an acceptable price, and which shall provide professional public service for data transfer.

The primary aim of the Montenegrin national "data" network is the provision of a reliable and scalable service with transport and access mechanisms for a wide range of users – from the Government and its institutions, via economy and non-economy institutions, to private citizens. The network shall contain 21 nodes all over Montenegro. The key nodes are in Podgorica, Bar and Bijelo Polje. The second level of nodes includes eight towns, and the third level includes the remaining ten towns. A special component of the network is the infrastructure on the level of Podgorica (MAN Podgorica).
Each node contains interfaces for connection to other nodes and interfaces for users’ access. Generally speaking, the interconnection among nodes shall be achieved through the existing fiber optics infrastructure (dark fiber and STM-1 SDH resources). Users’ access shall be achieved in many ways- from Ethernet/Fast Ethernet connection (copper pairs, wireless links, optical link - single/multimode) to a serial E1 access. Figure 21 illustrates a standard solution expected on the level of each node.

Especially important characteristics of the network shall be the scalability and a modular design as regards performances, interface capacities, services and functionality.

The network management shall be centralized through the network management center in Podgorica. All the resources for network management, users’ support and provision data required for the billing system shall be provided within this center.

Pursuant to the market requirements and needs, both current and prospective, a phased development of the network is anticipated. Backbone of the IP network and interfaces for users` access shall be developed in the first phase. In the next phase, the MIPNET shall grow into a multi-service network to support extra services such as the IP telephony, virtual
tanks, distance learning, unified messaging, video at request, application hosting and content delivery.

3.1.5.2. About the MPLS protocol and its implementation in the Ministry of Education and Science network

MPLS (Multi Protocol Label Switching) is a protocol which has become the unavoidable solution in the development of complex networks for data transfer in the last few years. It came from the need to adjust the IP protocol, which is nowadays a requirement, to the transport environment. The IP is the protocol which functions on the third level of the OSI model, and a protocol from some other level has to be used for physical transport of data. The second-level protocols are connection-oriented protocols, which is not suitable to the non-connection nature of the IP protocol. The necessity to adjust the non-connection nature of the IP protocol to the connection nature of the second-level protocols (especially the ATM) has encouraged a development of the MPLS protocol.

At first, the ideas and standards (IEFT) of multi protocols, after which the MPLS got its name, referred to the adjustment possibility to numerous third-level protocols, which was very soon abandoned as a concept. The only third-level protocol which is now supported in the MPLS concept and will be the only one supported in the future is the IP protocol. Nowadays, the MPLS technology refers to the independence from the second OSI level technology. Almost all the standard second-OSI-level technologies (Ethernet, ATM, Frame Relay, PPP, SDH, HDLC) may serve as a core for the development of the MPLS network.

The MPLS network is an IP network. The difference between the MPLS network and other IP networks is the way in which the IP routing process was worked out. In the traditional routing environment a packet is forwarded through the network on the so-called hop-by-hop basis using the Interior Gateway Routing Protocols (IGRP) such as RIP or OSPF, or using the Exterior Gateway Routing Protocols (EGRP) such as BGP. These procedures are carried out by determining the destination of L3 address in the IP header and in accordance with routing tables for the next hop. The router has to search all routes on the basis of the L3 destination in the IP header. This has to be done in order to determine the next hop and forward the packet further to its destination. L2 destination address interchanges then with the address of the next router (L2 address of the next hop), and the L2 address interchanges with L2 address of the current router, and so on. This process repeats on every hop in order to deliver the packet to its final destination. In large networks these processes are very intensive and they often become bottlenecks.

The basis for forwarding in the MPLS network is a **label**. The label represents an additional header of fixed size which is added to an IP packet. Traffic commuting within the MPLS network is carried out exclusively on the basis of a label. The label is of local importance when identifying the flow of IP data between two adjacent MPLS nodes. The line of labels that connects a source to a destination makes up the **LSP** (Label Switched Path), i.e. the one-way communication between end nodes within the MPLS network. The control basis of the MPLS network is the **LDP** protocol (Label Distribution Protocol). It is a standard protocol which supports nodes in interchanging labels required for the encapsulation of IP packets intended to reach a destination.

The MPLS network consists of two important components: the **core and the edges of the network**. The core of the network comprises devices for commuting of MPLS packets (LSR – Label Switch Router), while the network edge consists of devices which, from one side, receive standard IP packets, label them and send to the core of the MPLS network to commute (LER or Edge LSR), and on the other side towards exit of the MPLS network they take off labels and forward IP packets to their destination. The sources of the MPLS traffic can only be the edge (Label Edge Router - LER) MPLS routers. Figure 22 illustrates a standard structure of the MPLS network:
In the MIPNET architecture LSR routers are located in Podgorica, Bijelo Polje and Bar. LER routers are placed on the total of 21 locations, i.e. in all the administrative centers in Montenegro.

Functionally, the commuting of packets through IP network is carried out in four phases. (Figure 23)

In the first phase, IP packets, generated in a local computer network (IP Packet) and intended for transport (through the MIPNET) to a remote destination (Central MPN location), reach the MIPNET access router (LER) which functions on the network edge. LER receives the incoming packet and defines LSP on the basis of the packet data and the redefined logic within the MIPNET.

In the next phase the incoming packets are processed and the L3 service type that needs to be worked out is determined (VPN, QoS, and similar). On the basis of the routing information and polices LSR generates and adds the label (Label IP Packet) to each packet and forward them to the network.
In the third phase, the packet travels through the MPLS (the MIPNET) network. LSR routers read the labels of each packet, change them in accordance with the table (LSP), and forward them to the network edge.

On the network edge LER routers take off the labels, read the forwarding address from the IP header, and finally, forward the packet (IP Packet) to its destination (Central MPN location).

The main benefit of the MPLS is the possibility to add labels which have a special meaning, i.e., to designate the service which should be provided through the public operator network. MPLS label is compared to the redefined switching tables in the network core (held by LSRs) which contain the Layer 3 information, enabling each switch router to automatically work out the appropriate IP service to every packet. Tables are redefined in a way to reprocess a packet on every hop. This enables not only the separation of traffic by type (e.g., to give advantage to voice traffic), but also provides a significant network efficiency improvement. Labels have exclusively the local meaning and it is impossible to route the traffic without them. This characteristic is crucial for the implementation of advanced IP services such as QoS, VPNs, traffic engineering.

The key functional characteristics of the MIPNET are MPLS VPN services, that is, the concept of developing virtual private networks through public MPLS infrastructure.

### 3.1.5.3. MPLS VPN service

MPLS technology offers a possibility to develop mutually independent, private IP networks on the basis of public MPLS infrastructure. These networks use all the advantages of an IP network (optimum traffic management, simple adding of new nodes), and at the same time retain the advantages of the second-OSI-level technologies (security, quality service, isolation from the effects of other traffic, and so on).

The upgraded MPLS network for the needs of VPNs is simply called MPLS VPN. The service may be implemented in any MPLS network and it is independent from other available MPLS services. The important advantages of the MPLS VPN service are: it allows overlapping of different VPNs in an IP address space; provides security and separation of traffic in the fashion (and with the same quality) as classic Frame Relay and ATM services. The only restriction (if it can be considered as a restriction) is that the IP protocol has to be used for the communication between users’ locations.

MPLS VPN service works exclusively with the support of devices located on the edge of the MPLS network (LER). They receive a user's IP traffic and label it so as to provide security, isolation, and overlapping of an IP address space. The network core is responsible for label packets’ commuting. For MPLS VPN service requirements additional supervision functions are introduced in MPLS network, and that process is completely transparent for users.

Each VPN network within the MPLS network retains all the important MPLS network characteristics, of which the most important is the possibility to communicate to all destinations within VPN. A user connects to VPN by one connection and sends IP packets to VPN, i.e., the connection to the VPN network is achieved on the IP level (thus a user’s devices do not use the MPLS protocol). MPLS VPN network takes care itself for the correct routing of the user’s IP packets towards destinations within the VPN.

We discussed the classic IP VPN networks in the previous section. MPLS VPN is a step forward and a technology which offers a lot more on the VPN level.

What are the advantages of the MPLS VPN?

Standard IP VPN solutions require tunneling and/or encryption (e.g., IPSec). In a classic L2 VPN networks based on ATM or Frame Relay the VPNs are achieved on the Point-to-Point basis, requiring the configuration (usually manual) of numerous virtual channels (VCs). Since IP traffic in these networks is sent through virtual circuits or encrypted tunnels, a network
cannot recognize the type of traffic it transfers. VPN network should be able to distinguish traffic by the application type, such as voice, e-mail, mission-critical applications, and so on. That way the network can simply separate traffic based on the service it refers to, without a complex management, point-to-point connection, and similar.

Compared to traditional IP VPN networks, MPLS networks can separate traffic and provide privacy without encryption and tunneling. MPLS provides privacy on the network-to-network basis; the same as ATM or FR do on the connection-to-connection basis. ATM and FR provide basic transport, while MPLS networks support scalable VPN services and additional qualities on IP-based services.

In MPSL VPN networks, a provider assigns each VPN a special identifier called Route Distinguisher (RD) that is different for each intranet or extranet within a provider network. Forwarding tables contain unique addresses called VPN-IP addresses formed by connecting an RD with a user's IP address. VPN-IP addresses are unique for each end node in the network, and records on them are located in forwarding tables of each node in the VPN.

BGP (routing information distribution) protocol which, by using multi-protocol extensions and community attributes, defines who can talk to whom. In one MPLS-enabled VPN, BGP distributes information on VPNs only to the members of the same VPN, thus providing the absolute security through the separation of traffic. An additional security is provided through routing the entire traffic on the basis of LSPs which define the unique route through network which cannot be altered without authorization.

A provider (not a user) assigns specific VPN for every interface (when a VPN service is secured). Within the provider's network, an RD is attached to every packet, so that packet spoofing or some current technology for the violation of security cannot endanger the security of VPNs. A user may participate in an intranet or an extranet only if he/she works on an authorized physical port and has an adequate RD. Such a construction makes MPLS-enabled networks resistant to intrusions and provides the same security level as with leased lines, ATM, or Frame Relay.

VPN-IP forwarding tables contain labels which correspond to VPN-IP addresses. Traffic within a VPN is routed on the basis of these labels. Since labels are used instead of IP addresses, a user may keep his/her private addresses within a corporate intranet, without the need to perform NAT in order to go through the provider's network. Traffic is divided between VPNs by using logically determined forwarding tables for each VPN (the so-called VRF tables – VPN Routing and Forwarding tables). Every VPN has its own VRF table within a router, so the access to the routes within a table is allowed to any user or a network which belongs to that VPN. Each LER (or PE–Provider Edge) router in the MPLS/VPN network contains certain number of VPN routing tables and a global routing table which is used for forwarding to other routers in a provider’s network or to external destinations (Internet).

On the basis of requests related to the MPN network, the implementation of VPNs may be carried out on the basis of VLANs integration into VPNs. Therefore, information on VLANs within a LAN network is distributed to LER where each of the VLANs is connected to a separate VPN.
QoS (Application Aware QoS) may be configured for every VPN and set up business policies for every user. Users may transparently use their private IP addresses without NAT.

Administration of VPNs is simple. To add a new location, for example, within the VPN of the Ministry of Education and Science, Telekom CG should provide a user’s (CPE) router with the information how to get to the MIPNET, configure the LER (PE) access to recognize a new VPN membership in the CPE. The BGP will automatically update all VPN members. The same process with traditional IP VPNs is much more complicated.

### 3.1.5.3.1. Extranet VPN

This is a simple extension of a classic MPLS VPN that enables a location to exist simultaneously in more VPNs. Since VPN-ID represents a membership in some VPN, membership in numerous VPNs (Extranet VPN) can be achieved simply by assigning the VPN-ID to more separate VPNs. Membership in numerous VPNs may be achieved through one physical connection between a user and the provider (Telekom CG), which diminishes the complexity and the price. This possibility is important for the MPN network because it enables the Ministry to coexist both in the network of state bodies, along with other ministries, and in the network of educational institutions which shall be created as a special complex VPN.

### 3.1.5.3.2. Carrier-to-Carrier MPLS VPN Services

MPLS VPN, which was created within the Telekom CG network, may be expanded through other networks that support MPLS VPN. This possibility is often called the inter-autonomous MPLS VPN service. Two separate autonomous systems can intercommunicate by exchanging IPv4 NLRI (Network Layer Reachability Information) in the form of a VPN-IPv4 address. For information exchange, border routers use EBGP (Exterior BGP). Afterwards, the IGP (Interior Gateway Protocol OSPF, IS-IS) distributes network layer information for VPN-IPv4 prefixes through each VPN and for every autonomous system. This functionality makes it possible to integrate the MPN network in similar networks in the region. To this moment, MPLS-enabled VPN networks have been developed in Serbia, the Republic of Srpska, and they already exist in FYR Macedonia and Croatia.
3.1.5.4. Implementation of the Ministry of Education and Science network through the MIPNET resources

The key service that is expected from the MIPNET and which has been previously considered is the VPN service organized as the so-called Site-To-Site Intranet VPN. This service will offer the Ministry of Education and Science a reliable, safe and fast data communication (and video and voice communications, when needed) between locations, which function within the whole Montenegro, even (if needed) with near and remote locations, as it has been explained earlier.

Not less important is the fact that, by offering the service for data transfer in the organization offered by the MIPNET, Telekom CG provides highly professional help in the implementation and maintenance of the network, which relieves a user of the need to prepare expensive projects, engage and retain highly skilled staff, and so on.

3.1.5.4.1. Required equipment for the access to the THE MIPNET (Devices on the side of a user)

Depending on the required type of service and available infrastructure (fiber optics, copper), the connection of LAN networks on the MIPNET is offered with a wide range of access equipment – from SDSL modem in bridge configuration, through the Router-SDSL combination, to the wireless access.

A connection device (router, bridge) is placed in every location thus connecting a LAN network of a location to the MIPNET. Participants in a local network can access the VPN network through the MIPNET resources.

The key service that is expected from the MIPNET and which has been previously considered is the VPN service organized as the so-called Site-To-Site Intranet VPN. This service will offer the Ministry of Education and Science a reliable, safe and fast communication (and video and voice communications, when needed) between locations which function within the whole Montenegro, even if needed with near and remote locations, as it has been explained earlier.

Not less important is the fact that, by offering the service for data transfer in the organization offered by the MIPNET, Telekom CG provides highly professional help in the implementation and maintenance of the network, which relieves a user of the need to prepare expensive projects, engage and retain highly skilled staff, and so on.

3.1.5.4.1. Required equipment for the access to the THE MIPNET (Devices on the side of a user)

Depending on the required type of service and available infrastructure (fiber optics, copper), the connection of LAN networks on the MIPNET is offered with a wide range of access equipment – from SDSL modem in bridge configuration, through the Router-SDSL combination, to the wireless access.

A connection device (router, bridge) is placed in every location thus connecting a LAN network of a location to the MIPNET. Participants in a local network can access the VPN network through the MIPNET resources, the Internet, and similar through this connection. Figure 25 illustrates a typical access method:

![Figure 25 - Typical access to the MIPNET](image)

It is important to emphasize that a connection device in some locations has a key role in ensuring the differentiation of the service quality. Mechanisms for ensuring the quality service (enabling the priority access to the MIPNET) should be implemented in a connection device. Edge MIPNET devices (PE devices) can determine the priority of a user's traffic only on the basis of the classification performed on the user's device. The main configuration complexity is transferred to the provider’s network (the MIPNET), where, on the basis of the IP address chosen to communicate to and a membership in an individual VPN, the communication method between devices is determined. All complex requests that may appear in the course of functioning are implemented in the provider’s devices. It is important to notice that the MPLS protocol is applied only in the network core, so that connection devices used for access to the MIPNET do not have to use the MPLS protocol.

In accordance with current technologies for access to public networks for data transfer, and in accordance with the MIPNET projections, one of the following types of access will be available to users:
3.1.5.4.2. Access via SHDSL modems with bridge/router interface

This access is very simple and cheap to implement. It relates to the connection of smaller networks where special requests for QoS (quality of service) are not required. Figure 26 illustrates this type of connection.

![Figure 26 - SHDSL access to THE MIPNET](image)

The access to the MIPNET can be defined on the basis of static routing or on the basis of RIP2 routing protocol which these devices usually support.

3.1.5.4.3. Access via Router and SHDSL modems with serial interface

This is one of the standard ways of access to public networks for data transfer (Figure 27). Its main characteristics are scalability and possibility to provide an added value service, first of all the QoS service.

![Figure 27 - Access to THE MIPNET via modem serial router connection](image)

Depending on the type of router, it is possible to provide a user with different traffic priority levels through this type of connection, thus making it possible to enforce the traffic which is in business segment, VoIP traffic, and so on. Communications towards the provider is achieved through a leased copper pair and via SHDSL modem with a standard range from 64 Kbps to 2 Mbps. If needed and the pair’s characteristics are satisfactory, it is possible to achieve a flow of some 4.6 Mbps and to the distance of up to 4km with a four-wire connection (two copper pairs).

3.1.5.4.4. Wireless access via Wireless bridge

This type of access is mainly used in situations when it very difficult or even impossible to provide the access capacity through copper pairs or fiber optics. A wireless bridge and Yagi directional antenna are installed on the side of a user. The device functions as a bridge, and the very communication can be provided by WEP (Wired Equivalent Privacy) encryption.
which is based on using the key and the RC4 algorithm for encryption. Figure 28 illustrates the wireless access model.

Radio communication is carried out in the so-called ISM (Industrial, Scientific & Medical) frequency scope which is internationally accepted as the license-free scope. The ISM, in fact, comprises three scopes of frequencies: 902 - 928 MHz, 2,400 – 2,483. 5 MHz and 5,728 – 5,750 MHz, of which the most used one is the scope of 2.4GHz. Standard 802.11b, usually called the Wi-Fi (Wireless Fidelity), is used and it is backwards compatible with the 802.11 Speed connection of 11Mbps is established through the implementation of the device with this standard.

3.1.5.4.5. Access through fiber optic cables infrastructure
It is believed that Telekom CG will provide the connection of central network nodes through fiber optic cables for the biggest users, which will enable a high aggregate speed through users’ central resources. The assumption is that direct optical communication (dark fiber) will be provided for this purpose on the relation CPE – PE.

The project team recommends connecting all focus schools locations to the MIPNET by permanent connection, and the connection of other schools to be defined in the next phase in accordance with the previous experience regarding focus schools.

3.1.5.4.6. Anticipated costs for link lease with the MIPNET
The anticipated costs for link lease with the MIPNET are given in Table 5. The Telekom is still not able to define the price of a link lease, but the project team has calculated the price on the basis of the fact that the average price of link lease with Internet CG (equivalent by speed) is around EUR 400 per annum, so that these expenses cannot be lesser with the Telekom.

<table>
<thead>
<tr>
<th>MIPNET connection</th>
<th>Qt</th>
<th>EUR</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Link lease (including the communication equipment) per month</td>
<td>30</td>
<td>400</td>
<td>12,000</td>
</tr>
<tr>
<td>Link lease (including the communication equipment) per annum</td>
<td>36</td>
<td>400</td>
<td>144,000</td>
</tr>
</tbody>
</table>

3.1.5.4.7. Internet access
We propose the centralized Internet access, that is, access to the Internet exclusively via the central network location. The infrastructure for the Internet access (Firewalls, IDS devices,
servers, and similar) should be set up on the central location. Although the Internet access is achieved through the MIPNET as the access to the VPN of the Internet Service Provider (ISP), which can be achieved via the same infrastructure and the same physical cord, the access via a separate infrastructure is proposed. The reason is, first of all, in the fact that if the same infrastructure is used, a potential DoS attack could completely stop the whole network. Figure 29 shows the proposed connection of the MPN network to the Internet.

![Figure 29– Internet access model](image)

LAN networks of schools access the Internet through the central location and protect with the common firewall, so it is not necessary to install firewall devices in individual LANs. Privacy and protection of data are certainly the most important elements when considering the use of permanent Internet connection variants. A stable connection is created on the integrated security platform, which supports all, or most of the security mechanisms:

### 3.1.5.4.8. Firewall

Firewall provides a solid barrier between a private network and the Internet. It can be adjusted so as to limit the number of open ports, type of packets, the accepted protocol and similar.

An acceptable type of security implies a high quality firewall based on the Stateful Packet Inspection technology with a mandatory translation of addresses (NAT – Network Address Translation) through which the internet non-routable addresses shall be hidden and protected from DoS attacks (Denial of Service). Firewall can provide additional security on the application level by using proxies and filters which block specific internet contents.

### 3.1.5.4.9. Antivirus protection

Computer viruses are one of the main threats to LAN networks connected to the Internet. Users may introduce a virus into their personal computer by negligence, and then into other computers in his/her surroundings, causing a corruption or loss of all data and even a complete failure of the complete information system in the immediate surroundings. Viruses may be used as access mechanisms which an intruder may use even when a firewall stands on his/her way.

Good security concept implies the real time antivirus protection which is both efficient and does not introduce a significant slowdown into a system. Antivirus software should have the
ICSA\(^1\) (ICSA Labs) certificate, and test incoming and outgoing data (e.g. incoming and outgoing e-mail).

### 3.1.5.4.10. Content Filtering

Filtering of content from the Internet enables administrators to control which content may and which may not reach the computers in LAN. Filtering also enables URL blocking which is based on permanent updating of filter lists, and disables connections to the URL which is on the “black filter list”. Besides the aforementioned blocking by URL, blocking of cookies, Java and Active X, blocking by key words and similar are often used.

### 3.1.5.4.11. Remote access to MPN network

The infrastructure of the MIPNET also provides a reliable remote access to individual VPNs for remote users. If a user accesses via dial-up connection, it is possible to access directly to the MIPNET Access Servers, and after authorization, automatically access the redefined VPN. This procedure is very simple and recommends installation of the VPN client (IPSec) on the side of a user who accesses via the dial-in service.

Connection of remote users, who reach the MIPNET via the Internet and one or more ISPs, implies connection of a remote location to the VPN MPN in the so-called "Site to site" connection type where the global internet network is used as a transport network (for data transfer) that tunnels the traffic between two sites on a completely transparent way for them, using thereof the protocols which enable the encryption of traffic on the L3, i.e. the IP level. A remote location is connected to the global internet network by a link to a local ISP, which assigns to that location an IP address from its public address space. Between a router of a remote location and the access router in the public part of the MIPNET network (or the earmarked-access router on the central site MPN) the IPSec tunnel is established (devices interchange security parameters and thus authenticate), which translates from public to private space of a separate VPN MPN.

### 3.1.5.5. Network management

It is necessary to provide the WAN network of the Ministry of Education and Science with a complete management, configuring, performance measurement, and detection of errors in the network. Network management software should support the SNMP through the TCP/IP protocol. The RMON support is desirable (alarms, events, history, statistics). The software should have an integrated "Smart Agent" which increases the control over the LAN and allows for the automatic set of limits (Alarm) values in accordance with the parameters recorded in the real operation. The software should function in the graphic environment (Windows 2000/Windows NT). Active network equipment should support the SNMP management.

The concept and the realization of the MIPNET imply a complex management system, not only in the core and edges of the network, but also users’ access devices management. It is for a user to decide whether to implement the network management himself/herself (and invest in it) or to use the MIPNET resources in this segment.

The organization of the network management, which is recommended and offered by the MIPNET, offers highly professional assistance in the implementation and maintenance of the network by the Network team of Telekom CG, which relieves a user from the preparation of expensive projects, purchase of the management software, hiring highly skilled staff, and similar.

In accordance with the aforementioned, two types of the MIPNET services will be offered:

---

\(^{1}\) ISCA Labs – A part of the "TruSecure" company that certifies about 95% of the world’s industries of antivurus software, firewalls, encryption programs, IPSec products and similar.
3.1.5.5.1. Type 1: Telekom CG implements and maintains a user's access network

In this version, the expert team of Telekom Crne Gore installs, manages and supervises the devices (for the access to the MIPNET) on the side of a user. This is a recommended variant for a user as he/she is guaranteed a highly skilled assistance, timely response, permanent supervision, and similar.

3.1.5.5.2. Type 2: A user implements and maintains the access network by himself/herself

Here a user himself/herself installs, maintains and monitors the devices on his/her side. A user must have an expert team which understands the functionality of the MIPNET and the request that the equipment on the side of a user (CPE) must meet in order for the services to function normally. This type of service is recommended only to big institutions with specific requests regarding the functionality of some services and which have the staff or partner companies that can implement and maintain those services.

3.1.5.6. Training

The system functionality to a large extent depends on the skilled staff, which implements the network maintenance procedures. Regardless of a chosen model of maintenance and implementation of the access network, a user shall take care of the maintenance of LAN networks, computer and server infrastructure, applications and services. It is important to make a profile analysis of the available technical staff in an MPN and, accordingly, determine administrative procedures to be followed as a part of the system maintenance. Pursuant to the written procedures training, for which the MPN has available staff at the University of Montenegro, should be conducted.

3.1.6. Conclusion of the subproject MEN

Proposal for the development of the Ministry of Education and Science network is functionally divided and worked out through three levels:

The first level refers to the set up of passive elements in LAN networks of some education facilities, so a unique solution with a detailed elaboration of the purpose and conditions for its development was offered in this segment.

The second level relates to active components of LAN networks and a unique solution with a typical implementation of L2 and L3 switches was proposed in this segment.

The third level refers to the interconnection of LAN networks and development of a unique WAN network of the Ministry of Education and Science. Two solutions are proposed in this part. The first one is based on the analysis of the existing resources in Montenegro for data transfer and the proposed solution is the use of the “Public Internet” as a transport medium and development of virtual private networks (VPNs). The second one is at the same time the aimed solution, and it relies upon the future infrastructure of the Telekom Crne Gore Public Network for data transfer (MIPNET – Montenegrin IP Network). The first solution enables a fast implementation, and the second one relies on the anticipated inception of the MIPNET. In both solutions, the connection devices (xDSL Modem Routers and similar) are expected as a part of a service provider’s offer (Telekom CG or Internet CG). The project team proposes, when purchasing the LAN equipment that is generically defined, to take into account that the selected L3 switches support both forms in the development of the WAN. This L3, in addition to the generally defined characteristics in the point 3.2, would also support the following:

- WAN access with the possibility to create backup links (ISDN, POTS);
- Possibility of a firewall configuration on a switch;
Physscal architecture of Meis project (PA-Meis)

- Possibility of creating the VPN tunnel with the hardware IPSec encryption.

This way the development of the whole network would not be related to the deadlines for the MIPNET development, and it would be possible to temporarily carry out the Internet/VPN solution and subsequently move to the aimed solution, that is, to the MIPNET.

The project team expects the following costs for the installation of the active equipment on the levels of L2 and L3 switches:

<table>
<thead>
<tr>
<th>COST OF THE ACTIVE EQUIPMENT, the second level</th>
<th>Qt</th>
<th>EUR</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical L2 switch, with the characteristics described in the projects</td>
<td>60</td>
<td>700</td>
<td>42,000.00</td>
</tr>
<tr>
<td>Typical L3 switch, with the characteristics described in the projects</td>
<td>30</td>
<td>1,900</td>
<td>57,000.00</td>
</tr>
</tbody>
</table>

The total price for the ICT implementation in schools, based on all the anticipated costs, amounts to EUR 227,625.95, which can be seen from the following table:

Table 8 - Estimated costs for the installation of ICT networks in the focus schools

<table>
<thead>
<tr>
<th>TOTAL COSTS OF THE INSTALLATION OF ICT NETWORKS IN THE FOCUS SCHOOLS</th>
<th>Qt</th>
<th>EUR</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical L2 switch, with the characteristics described in the projects</td>
<td>60</td>
<td>700</td>
<td>42,000.00</td>
</tr>
<tr>
<td>Typical L3 switch, with the characteristics described in the projects</td>
<td>30</td>
<td>1,900</td>
<td>57,000.00</td>
</tr>
<tr>
<td>Set up of passive elements</td>
<td></td>
<td></td>
<td>62,310.50</td>
</tr>
<tr>
<td>Passive equipment</td>
<td></td>
<td></td>
<td>66,315.45</td>
</tr>
<tr>
<td>TOTAL FOR THE PROJECT IMPLEMENTATION</td>
<td></td>
<td></td>
<td>227,625.95</td>
</tr>
<tr>
<td>Link lease (including the communication equipment) per annum – Telekom CG or Internet CG, including the required connection equipment</td>
<td></td>
<td></td>
<td>144,000.00</td>
</tr>
<tr>
<td>TOTAL FOR THE PROJECT IMPLEMENTATION AND COSTS FOR THE ANNUAL LINK LEASE</td>
<td></td>
<td></td>
<td>371,625.95</td>
</tr>
</tbody>
</table>
### 3.2. Definition of Required Hardware and Software

#### 3.2.1. Server and Client Architecture, System Software and Related Equipment

Conceptual relationship among the programme systems should be carried out through the general three-tier architecture, which consists, from the programming aspect, of: database, application core, and user interface, and, from the physical aspect, of: database server, application and web servers and user workstations of various kinds. The communication among individual parts of the system will go, as a rule, through the application and web server.

Regarding the specification of hardware components, it is especially important to procure brand name servers that are apt to scalable upgrading. Scalability relates, primarily, to the possibility of adding new processor units, new disc units, adding RAM memory, adding new interface cards etc. The specification of servers with respect to disc capacity should be made so as to meet the IS needs for the following 3-5 years.

#### 3.2.1.1. Server Architecture

General characteristics of scalable servers in accordance with the above recommendations and the IS needs are presented in the following table.

<table>
<thead>
<tr>
<th>Technical Specification</th>
<th>Database Server</th>
<th>Application Server</th>
<th>Web Server</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Processor</strong></td>
<td>Intel Xeon Processors MP at, 2.5 GHz X 4</td>
<td>Intel Xeon Processors MP at, 2.8 GHz X 2 Upgradeable to quad processing</td>
<td>Intel Xeon 3.06GHz processors available in two versions to satisfy a variety of applications Up to 2 processors supported</td>
</tr>
<tr>
<td><strong>Cache Memory</strong></td>
<td>1-MB Integrated Level 3 Cache</td>
<td>Cache Memory 1 MB level 3 cache</td>
<td>Cache Memory 1 MB level 3 cache</td>
</tr>
<tr>
<td><strong>Memory</strong></td>
<td>6 GB / 32 GB Max (4 processor models) PC2100 DDR SDRAM running at 200MHz, with Advanced ECC capabilities</td>
<td>6 GB / 32 GB Max (2 processor models) or 1 GB Standard / 32 GB Max (1 processor models) PC2100 DDR SDRAM running at 200MHz, with Advanced ECC capabilities</td>
<td>2 gb to 8 GB (Maximum) of 2-way interleaved capable PC2100 DDR SDRAM running at 200MHz, with advanced ECC capabilities</td>
</tr>
<tr>
<td><strong>Storage Controller</strong></td>
<td>Smart Array 5i Plus Controller, Dual Channel, Ultra3 (supports RAID 0, 1, 1+0, and 5 across internal hard disk drives) with 64 MB of memory.</td>
<td>Smart Array 5i Plus Controller, Dual Channel, Ultra3 (supports RAID 0, 1, 1+0, and 5 across internal hard disk drives) with 64 MB of memory</td>
<td>Smart Array 5i Plus Controller (integrated on system board)</td>
</tr>
<tr>
<td><strong>Slots</strong></td>
<td>6 Total PCI Slots (5 Available): 4 Hot Plug, 2 Non Hot Plug</td>
<td></td>
<td>3 PCI Slots: 2 64-bit/100 MHz Hot Plug</td>
</tr>
</tbody>
</table>
The given servers must be placed in the rack cabinet with common access to appropriate server (KWM switch), appropriate backup devices and appropriate UPS. Tabela 9 contains the specification of equipment.

### 3.2.2. Workstation Architecture

Two types of workstations have been designed (WS1 and WS2) with respect to physical conception of the network in educational units, as two independent and mutually protected networks:

- The network intended for the training of and use by pupils (workstations WS1);
- The network intended for the training of and use by the teaching staff employed in a given educational unit (workstations WS2);
We can also classify given workstations in the network 2 by their purpose into:

**WS2a** – workstations intended for the advanced training of and use by teachers;

**WS2b** – workstations intended for administrative employees in an educational institution;

**WS1** – workstations intended for the use by and training of pupils. The client segment of the application intended for the education of pupils in the educational system should operate on these stations. At the stage of IS introduction into education, it is foreseen to install one IT classroom with 16 WS1 computers in each of 30 selected focus schools (20 primary and 10 secondary schools).

**WS2a** – workstations intended for the use and professional training of teachers. The client segment of the application intended for the education of teachers should operate on these stations. At the stage of IS introduction in the given schools, 9 workstations should be installed (staff-room - 5, ICT coordinator - 1, pedagogue-psychologist unit - 1, library - 1, presentation set - 1)

**WS2b** – workstations intended for administrative staff in an educational unit. At the stage 1 of IS introduction, it is planned to install 4 given computers in each of the focus schools. The client segment of the application intended for the exchange of information relating to efficient administrative and financial operations in educational institutions should operate on these stations.

General characteristics of workstations in accordance with their purpose are given in Table 2 below.

**Table 9 – Overview of Workstation Characteristics**

<table>
<thead>
<tr>
<th></th>
<th>WS1</th>
<th>WS2a</th>
<th>WS2b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chassis description</td>
<td>Small Form Factor</td>
<td>Convertible Minitower</td>
<td>Convertible Minitower</td>
</tr>
<tr>
<td>Operating systems included</td>
<td>Microsoft® Windows® 2000 SP3 or Microsoft® Windows® XP Professional SP1</td>
<td>Microsoft® Windows® 2000 SP3 or Microsoft® Windows® XP Professional SP1</td>
<td>Microsoft® Windows® 2000 SP3 or Microsoft® Windows® XP Professional SP1</td>
</tr>
<tr>
<td>Processor / CPU</td>
<td>2.4 GHz Intel® Pentium® 4 with HyperThread</td>
<td>2.2 GHz Intel® Celeron™ max: 2.4 GHz Intel® Pentium® 4 with HyperThread</td>
<td></td>
</tr>
<tr>
<td>Cache description</td>
<td>512-KB Integrated ECC L2 Cache</td>
<td>256 KB Integrated ECC L2 Cache</td>
<td>512-KB Integrated ECC L2 Cache</td>
</tr>
<tr>
<td>Chipset</td>
<td>Intel® 865G chipset</td>
<td>Intel® 865G chipset</td>
<td>Intel® 865G chipset</td>
</tr>
<tr>
<td>Memory description</td>
<td>256 MB DDR PC3200</td>
<td>256 MB DDR PC3200</td>
<td>512 MB DDR PC3200</td>
</tr>
<tr>
<td>Memory upgrades</td>
<td>Expandable to 4 GB DDR SDRAM</td>
<td>Expandable to 4 GB DDR SDRAM</td>
<td>Expandable to 4 GB DDR SDRAM</td>
</tr>
<tr>
<td>Memory slots</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>
### PHYSICAL ARCHITECTURE OF MEIS PROJECT (PA-MEIS)

<table>
<thead>
<tr>
<th>Component</th>
<th>40 GB (7200 rpm)</th>
<th>40 GB (7200 rpm)</th>
<th>80 GB (7200 rpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard drive, internal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hard disk controller</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optical drive (CD ROM / DVD)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drive bays</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal audio</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I/O (input/output) ports</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Keyboard</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mouse / pointing device</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chassis description</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graphics card(s) available</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monitor</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.2.3. **Printers**

The specification of printers should be divided into two categories:

1. Personal printers
   These printers should cover periodical needs for smaller quantity of printing. Roughly it is about 100 printed sheets per day. They are used either as personal printers or printers for a smaller group of locally connected computers. It is recommended for an environment with 1-5 users.
   It is planned to install 10 printers of given characteristics in the given 30 focus schools.
Depending on the type of their printing technology, and subject to their use in schools, these printers may be divided in 3 groups:

Laser printer (7)
InkJet printer (1)
Matrix printer (1)

2. Group printers

These printers are intended for frequent printing or semi-intensive printing environment. It is roughly about 300 printed sheets per day. It is recommended to provide net autonomy for them, i.e., integrated network interface. They have to have at least two paper feeders. They are recommended for an environment with about 20 users.

It is planned to install one printer of given characteristics in IT classrooms in each of the 30 focus schools. By the printing technology, this printer must be laser printer.

General characteristics of these printers, in accordance with their purpose, are presented in the following table (Table 10).

<table>
<thead>
<tr>
<th>Personal Printer</th>
<th>LaserJet</th>
<th>A4, 1200x1200, 19ppm, 133MHz Processor, 16MB RAM, Instant on fuser, PCL 6, PostScript 2, Duty Cycle 10000 pages per month, drawer 250 sheets, USB 2.0+parallel port</th>
</tr>
</thead>
<tbody>
<tr>
<td>InkJet</td>
<td>Colour InkJet printer A3+, 11ppm black/9.5ppm colour A4, 8MB RAM, 600dpi black, 2400x1200dpi colour, HP PhotoRet III, 2 input trays, LPT/USB, 5000 pages per month</td>
<td></td>
</tr>
<tr>
<td>Matrix</td>
<td>9-pin impact dot matrix, 136 column, 16 fonts, 8 BarCode fonts, 494 cps HSD (10 cpi), ESC/P, IBM PPDS, 4 paper paths, single sheet and continuous, paper park, original + 5 copies, USB &amp; Parallel</td>
<td></td>
</tr>
<tr>
<td>Group Printer</td>
<td>LaserJet</td>
<td>A4, 1200x1200dpi, 24ppm, 48MB (288MB), HP PCL 5e, PCL 6, HP GL/2, PostScript level 3 emulation, 100-sheet MP tray, 250-sheet input tray, 50000 pages per month, LPT/USB, InfraRed port, Fast Ethernet 10/100Base-TX internal EIO print server, duplex</td>
</tr>
</tbody>
</table>

In addition to workstations and printers, each focus school should have the following equipment:

- scanner - (1) in the staff-room, for teachers;
- bar code reader – (1) in the library, for library operations;
- projector and projecting screen – (2) where one set would be for IT classroom and be static, and the other set would be portable as needed;
- backup drive in given educational units;
- constant supply for workstations in administration for the protection of local data in a given school.

General characteristics of these devices, in accordance with their purpose, are presented in the following table (Table 11).
### Table 11 – Overview of characteristics of ancillary equipment

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scanner</strong></td>
<td>digital flatbed scanner, Landscape, 2400x2400dpi, 48-bit colour, one-touch buttons, adapter for 35mm slides and negatives, automatic photo feeder 24 photos 10x15cm, USB2.0, MS Windows 98, 2000, Me, XP Pro, XP Home, Mac 9.1/10.1</td>
</tr>
<tr>
<td><strong>Projector fixed</strong></td>
<td>800x600 Portable LCD Videoprojector, 1700 ANSI Lumens, contrast ratio 400:1, weight 4.2 kg, VGA-SXGA, PAL, Secam, NTSC compatible. Horizontal and vertical keystone correction, ColorReality, remote control, cable set.</td>
</tr>
<tr>
<td><strong>Projector portable</strong></td>
<td>1024x768 XGA SuperMobile LCD Videoprojector, 1500 ANSI Lumens, contrast ratio 400:1, weight 1.9 kg, VGA-UXGA, PAL, Secam, NTSC compatible. Automatic keystone correction, remote control, cable set, soft case</td>
</tr>
<tr>
<td><strong>Bar code reader</strong></td>
<td>Metrologic MS 6720</td>
</tr>
<tr>
<td><strong>Backup drive</strong></td>
<td>EXTERNAL DVD-RW 5224WU, DVD REC DW400A, 4xDVD+R, 4xDVD+RW, 12xDVD, 16xCD-R, 10xCD-RW, 40xCD</td>
</tr>
<tr>
<td><strong>UPS</strong></td>
<td>Smart UPS 800VA/</td>
</tr>
</tbody>
</table>

The specification of all the mentioned equipment intended for 30 focus schools is presented in the following table (Table 12) by schools and by purposes in given schools.

### Table 12 – Specification of Needed Equipment of a Focus School

<table>
<thead>
<tr>
<th>Workstations</th>
<th>Personal printer</th>
<th>Group printer</th>
<th>Other devices</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WS1</strong></td>
<td>16</td>
<td>1</td>
<td>1</td>
<td>22</td>
</tr>
<tr>
<td><strong>WS2a</strong></td>
<td>9</td>
<td>5</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td><strong>WS2b</strong></td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td><strong>LaserJet</strong></td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td><strong>InkJet</strong></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td><strong>Matrix</strong></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td><strong>LaserJet A4</strong></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td><strong>LaserJet A3</strong></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td><strong>Scanner</strong></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td><strong>Projector fixed</strong></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td><strong>Projector portable</strong></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td><strong>Projecting screen</strong></td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td><strong>Bar code reader</strong></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td><strong>Backup drive</strong></td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td><strong>UPS</strong></td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>6</td>
</tr>
</tbody>
</table>

The total quantity of required equipment for Phase 2 of ICT development in education, with costs, is presented in the following table (Table 13).
### Table 13 – Estimated costs of Phase 2 of ICT development in education

<table>
<thead>
<tr>
<th>EQUIPMENT</th>
<th>No.</th>
<th>Unit Cost (EUR)</th>
<th>Total Cost (EUR)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Server</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Base server</td>
<td>1</td>
<td>25.000</td>
<td>25.000</td>
</tr>
<tr>
<td>Application server</td>
<td>2</td>
<td>9.000</td>
<td>18.000</td>
</tr>
<tr>
<td>Web server</td>
<td>1</td>
<td>6.400</td>
<td>6.400</td>
</tr>
<tr>
<td><strong>Rack</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With UPS + backup</td>
<td>1</td>
<td>12.000</td>
<td>12.000</td>
</tr>
<tr>
<td><strong>Workstation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WS1</td>
<td>480</td>
<td>860</td>
<td>412.800</td>
</tr>
<tr>
<td>WS2a</td>
<td>270</td>
<td>740</td>
<td>199.800</td>
</tr>
<tr>
<td>WS2b</td>
<td>120</td>
<td>950</td>
<td>114.000</td>
</tr>
<tr>
<td><strong>Personal printer</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LaserJet</td>
<td>180</td>
<td>360</td>
<td>64.800</td>
</tr>
<tr>
<td>InkJet</td>
<td>30</td>
<td>295</td>
<td>8.850</td>
</tr>
<tr>
<td>Matrix</td>
<td>30</td>
<td>400</td>
<td>12.000</td>
</tr>
<tr>
<td><strong>Group printer</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LaserJet A4</td>
<td>30</td>
<td>1.100</td>
<td>33.000</td>
</tr>
<tr>
<td>Laser Jet A3</td>
<td>30</td>
<td>2.600</td>
<td>78.000</td>
</tr>
<tr>
<td><strong>Other devices</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scanner</td>
<td>30</td>
<td>280</td>
<td>8.400</td>
</tr>
<tr>
<td>Projector fixed</td>
<td>30</td>
<td>1.560</td>
<td>46.800</td>
</tr>
<tr>
<td>Projector portable</td>
<td>30</td>
<td>2.650</td>
<td>79.500</td>
</tr>
<tr>
<td>Projecting screen</td>
<td>60</td>
<td>180</td>
<td>10.800</td>
</tr>
<tr>
<td>Bar code reader</td>
<td>30</td>
<td>245</td>
<td>7.350</td>
</tr>
<tr>
<td>Backup drive</td>
<td>60</td>
<td>460</td>
<td>27.600</td>
</tr>
<tr>
<td>UPS</td>
<td>120</td>
<td>115</td>
<td>13.800</td>
</tr>
<tr>
<td><strong>TOTAL:</strong></td>
<td></td>
<td></td>
<td>1,178.900</td>
</tr>
</tbody>
</table>

At the Phase 3, 50 schools will be covered with the same equipment specification (Table 12).

### Table 14- Estimated costs of Phase 3 of ICT development in education

<table>
<thead>
<tr>
<th>EQUIPMENT</th>
<th>No.</th>
<th>Unit Cost (EUR)</th>
<th>Total Cost (EUR)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Workstation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WS1</td>
<td>800</td>
<td>860</td>
<td>688000</td>
</tr>
<tr>
<td>WS2a</td>
<td>450</td>
<td>740</td>
<td>333000</td>
</tr>
<tr>
<td>WS2b</td>
<td>200</td>
<td>950</td>
<td>190000</td>
</tr>
<tr>
<td><strong>Personal printer</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LaserJet</td>
<td>300</td>
<td>360</td>
<td>108000</td>
</tr>
<tr>
<td>InkJet</td>
<td>50</td>
<td>295</td>
<td>14750</td>
</tr>
<tr>
<td>Matrix</td>
<td>50</td>
<td>400</td>
<td>20000</td>
</tr>
<tr>
<td><strong>Group printer</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LaserJet A4</td>
<td>50</td>
<td>1100</td>
<td>55000</td>
</tr>
<tr>
<td>Laser Jet A3</td>
<td>50</td>
<td>2600</td>
<td>130000</td>
</tr>
<tr>
<td><strong>Other devices</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scanner</td>
<td>50</td>
<td>280</td>
<td>14000</td>
</tr>
<tr>
<td>Projector fixed</td>
<td>50</td>
<td>1560</td>
<td>78000</td>
</tr>
<tr>
<td>Projector portable</td>
<td>50</td>
<td>2650</td>
<td>132500</td>
</tr>
<tr>
<td>Projecting screen</td>
<td>100</td>
<td>180</td>
<td>18000</td>
</tr>
<tr>
<td>Bar code reader</td>
<td>50</td>
<td>245</td>
<td>12250</td>
</tr>
<tr>
<td>Backup drive</td>
<td>100</td>
<td>460</td>
<td>46000</td>
</tr>
<tr>
<td>UPS</td>
<td>200</td>
<td>115</td>
<td>23000</td>
</tr>
<tr>
<td><strong>TOTAL:</strong></td>
<td></td>
<td></td>
<td>1,862.500</td>
</tr>
</tbody>
</table>
3.2.4. Software Specification
(System and DB Software)

All computers planned under the project are divided into:
Workstations installed in schools and other educational institutions
Servers that will be installed in the centre of information system (CIS). The software is divided in the same context.

3.2.4.1. Workstations – personal computers

For the needs of schools and other educational institutions, the following is planned for the basic software platform:

1. OPERATING SYSTEMS
   1.1. Windows XP Professional;
   1.2. RedHat Linux 9.0;
   Note: Both operating systems will be installed;

2. OFFICE PACKAGES
   2.1. MS Office XP Full;
   2.2. OpenOffice (for Linux - optional);

3. ANTVIRUS SOFTWARE

From the aspect of use of application for automation of educational processes, these are thin clients. Access to application will be through Internet browser. It is planned to install various software typical for particular schools at sites (multimedia software, programming software etc.).

3.2.4.2. Servers

Complete infrastructure of user application will be centralized on servers. The database will be of large dimensions and will contain about 300 tables, on which complex inquiries and transactions will be done. A great number of tables will have tens of millions of records. A number of simultaneous users will be around 300. Based on these parameters, we have chosen Oracle 9i database platform. The number of sites from which the database will be used is about 280, so we have chosen three-tier architecture, i.e., the application server (Oracle AS).
User application will be done in development tools Jdeveloper, Forms Developer and Reports Developer that are part of Oracle development tool Internet Developer Suite. Four servers are foreseen: database server (DBS), application server (AS1), application server (AS2) and Internet server.

We plan to install the following software on the servers:

1. OPERATING SYSTEM
   RedHat Linux Advanced Server 2.1 (on all servers);

2. DATABASE SERVER (SB):
   Oracle database Enterprise Edition (server with 2 processors);
3. APPLICATION SERVER (AS1 and AS2):
Oracle Application Server Enterprise Edition
(AS1 - 2 processor), (AS infrastructure and Reports server);
(AS2 - 2 processor), (AS - middle tier).

4. INTERNET SERVER
Web Mail Service *Endymion MailMan*
*Note:* This server should accommodate didactic software for schools, then Internet presentations of educational institutions, Mail server, presentations of pupils etc.

5. ANTIVIRUS SOFTWARE FOR SERVERS
Symantec AntiVirus Scan Engine (on all servers)

6. DEVELOPMENT TOOLS
Internet Developer Suite installed on some PC in the centre

3.2.4.3. **Cost of Software (System and DBMS software)**
The distribution to Phase 2 and Phase 3 is defined in the Strategy.

*Table 15 – Estimated costs of procurement of software in Phase 2 and 3 of ICT development in education*

<table>
<thead>
<tr>
<th>PHASE 2 (software)</th>
<th>Computer</th>
<th>Quantity</th>
<th>Cost (EUR)</th>
<th>Total (EUR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. OPERATING SYSTEMS:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1 Windows XP Professional OEM</td>
<td>PC</td>
<td>870</td>
<td>188.30</td>
<td>163.821</td>
</tr>
<tr>
<td>1.2 RedHat AS Standard Edition</td>
<td>Internet server</td>
<td>1</td>
<td>1813</td>
<td>1.813</td>
</tr>
<tr>
<td>1.3 RedHat AS Premium Edition</td>
<td>servers DBS, AS1 and AS2</td>
<td>3</td>
<td>3023</td>
<td>9.069</td>
</tr>
<tr>
<td>Subtotal 1</td>
<td></td>
<td></td>
<td></td>
<td>174.703</td>
</tr>
<tr>
<td>2. MS OFFICE:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1 Office Pro XP Professional</td>
<td>PC</td>
<td>870</td>
<td>550</td>
<td>478.500</td>
</tr>
<tr>
<td>3. MAIL software:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Endymion MailMan Professional Edition</td>
<td>Internet server</td>
<td>1</td>
<td>350</td>
<td>350</td>
</tr>
<tr>
<td>4. ANTIVIRUS software:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.1 Symantec AntiVirus Scan Engine per client licence</td>
<td>Internet server</td>
<td>870</td>
<td>9</td>
<td>7.830</td>
</tr>
<tr>
<td>4.2 Symantec Norton AntiVirus Corporate Edition</td>
<td>PC</td>
<td>870</td>
<td>14</td>
<td>12.180</td>
</tr>
<tr>
<td>Subtotal 4</td>
<td></td>
<td></td>
<td></td>
<td>20.010</td>
</tr>
</tbody>
</table>
### PHYSICAL ARCHITECTURE OF MEIS PROJECT (PA-MEIS)

#### 5. DBMS:

<table>
<thead>
<tr>
<th></th>
<th>Computer</th>
<th>Quantity</th>
<th>Cost (EUR)</th>
<th>Total (EUR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1 Oracle Database 9i Enterprise Edition</td>
<td>server DBS</td>
<td>2 CPU</td>
<td>35032</td>
<td>70.064</td>
</tr>
<tr>
<td>5.2 Internet Application Server</td>
<td>servers AS1 and AS2</td>
<td>2x2 CPU</td>
<td>17516</td>
<td>70.064</td>
</tr>
</tbody>
</table>

#### 6. DEVELOPMENT TOOLS

<table>
<thead>
<tr>
<th>Tools – Internet Developer suite</th>
<th>Computer</th>
<th>Quantity</th>
<th>Cost (EUR)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PC</td>
<td>1</td>
<td>4379</td>
</tr>
</tbody>
</table>

**Subtotal 5 and 6**

**TOTAL PHASE 2**

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>818.070</td>
</tr>
</tbody>
</table>

#### PHASE 3 (software)

<table>
<thead>
<tr>
<th>Name</th>
<th>Computer</th>
<th>Quantity</th>
<th>Cost (EUR)</th>
<th>Total (EUR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPERATING SYSTEMS:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1 Windows XP Professional OEM</td>
<td>PC</td>
<td>1450</td>
<td>188,3</td>
<td>273.035</td>
</tr>
<tr>
<td>OFFICE:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1 Office Pro XP Professional</td>
<td>PC</td>
<td>1450</td>
<td>550</td>
<td>797.500</td>
</tr>
<tr>
<td>ANTIVIRUS:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1 Symantec AntiVirus Scan Engine per client licence</td>
<td>Internet server</td>
<td>1450</td>
<td>9</td>
<td>13.050</td>
</tr>
<tr>
<td>3.2 Symantec Norton AntiVirus Corporate Edition</td>
<td>PC</td>
<td>1450</td>
<td>14</td>
<td>20.300</td>
</tr>
<tr>
<td>Subtotal 3</td>
<td></td>
<td></td>
<td></td>
<td>33.350</td>
</tr>
<tr>
<td>TOTAL PHASE 3</td>
<td></td>
<td></td>
<td></td>
<td>1.103.885</td>
</tr>
</tbody>
</table>

**TOTAL PHAE 2 AND 3**

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.921.955</td>
</tr>
</tbody>
</table>

**Costs in case of granted software from Microsoft company**

<table>
<thead>
<tr>
<th>Phase</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 2</td>
<td></td>
<td></td>
<td></td>
<td>164.867€</td>
</tr>
<tr>
<td>Phase 3</td>
<td></td>
<td></td>
<td></td>
<td>33.350€</td>
</tr>
<tr>
<td>Phase 2 AND 3</td>
<td></td>
<td></td>
<td></td>
<td>198.217€</td>
</tr>
</tbody>
</table>
3.3. Maintenance of MEIS

3.3.1. Introduction to IS Maintenance Sub-project

Maintenance of any system (including information system) is defined by a set of activities carried out in order to prevent any malfunction or error or failure of any function of the system (preventive maintenance) and activities carried out in order to remove any malfunction or error in case of failure of any function of the system. Maintenance of any functional system is a very important link in its proper exploitation and extends the life time of the system.

Observance of procedures prescribed by equipment manufacturer, timely and preventive servicing and quality spare parts are the guarantee of long life and good operation of any equipment and any system. Maintenance operations are defined by a series of complex procedures and instructions and their success is mainly dependant on the quality of preparations for the maintenance operations.

The objective of this document is:

1.1 To identify, discuss and synthesize all potential operations related to maintenance of the educational information system;

1.2 In accordance with that, to propose optimum organization of the system of maintenance within the Ministry of Education and Science;

1.3 To prescribe the malfunction reporting procedure and ways of acting in such cases;

1.4 To define and standardize accompanying documentation and

1.5 To foresee maintenance costs at the annual level.

The starting document for addressing this matter was the Strategy of ICT Introduction in the Montenegrin Educational System.

The main sample for the estimation of average annual maintenance costs at the level of an educational institution was the group of 30 focus schools, defined in the mentioned ICT Strategy. The average quantity of IT equipment per institution is defined in the sub-project titled «Equipment Planning for ICT Implementation in Educational System».

Inclusion of ICT in curricula is the first and principal step towards the introduction of modern information systems in the educational system, because it creates conditions for pre-training the users in proper use of equipment that will be available to them during the educational process. It is also a pre-condition for the efficient functioning of the system and reduction of maintenance expenses.

The next pre-condition for the efficient operation of the system is the definition of the quality policy and preparation of maintenance procedure rules in conformity with ISP 9000 quality system standard serial.
Technical normatives and internal standards of maintenance are determined on the basis of existing standards in the union of Serbia and Montenegro, appropriate international standards and previous own experience. These documents should contain as many descriptions to be followed by all participants in the process of interference as possible. It is also necessary to define priorities that are different for various institutions in the system, but are also often different for various organizational units within one institution within the IS.

Proper organization of maintenance unit would include the following activities, regardless of the hierarchical level of such service centre (central, regional, local):
- Definition of responsibilities for all types of servicing activities;
- Definition of procedures for preparation and implementation of servicing activities;
- Definition of quality control of the performed servicing procedures;
- Analysis of successful and unsuccessful servicing interventions;
- Troubleshooting and error analysis with proposals for user education seminars aimed at removing the causes of problems, where possible;
- Standardization of user manuals for proper operation of equipment;
- Definition of minimum quality and quantity of service unit operating tools.

System maintenance is more efficient, faster, cheaper and more reliable if performed by the servicing unit that follows this defined set of activities. Also, proper maintenance, in the long run, reduces the costs of system maintenance and increases and prolongs its functionality.

Precise records produce statistical overview of the realistic state of repair of the equipment by type and site, realistic equipment depreciation or appreciation in case of incorporation of new materials, as well as information about the degree of its exploitation by sites. Monitoring of problem statistics generate relevant information not only about the quality of equipment and level of possible loss during the supply or after the servicing interventions, but also about any inadequate operation of the equipment or lack of technical discipline, which implies certain institutional decisions.

3.3.2. Organizational Scheme of IT Services within Institutions of the Ministry of Education and Science

The Education Reform Strategy and the documents prepared under it have identified the existence of several departments/divisions within the institutions under the Ministry of Education:
- General, Investment and IT Operations Department – IT Department/Centre,
- Vocational Training Centre of the Republic of Montenegro – IT Support Division,
- Examination Centre – IT Support Department.

IT Centre within the General, Investment and IT Operations Department is supposed to be the unit with highest responsibility for the functioning of the educational information system. This division should carry out all the activities related to maintenance supervision, monitoring and coordination.

As said, the first precondition for the efficient maintenance is good prevention, and the precondition for the system failure and problem prevention are not only the technical conditions in which the equipment operates (which cannot be significantly influenced in some situations, particularly in the initial period), but also the manner or equipment operation. Following technical and technological normatives and standards, as well as the manufacturer’s instructions, is the basis for the proper use and long life of the equipment. That is why the Vocational Training Centre has a significant role in the system of
maintenance because it will be involved, among other things, in education of employees particularly those working on jobs directly related to the use of IT equipment. Modern aids and training equipment and constant education may give very favourable results in the preparation for the maintenance.

3.3.3. Maintenance Organization

A well and efficiently designed approach to the organization of maintenance will result not only in more reliable and efficient operation of the overall MEIS, but also in the following:

- Increased productivity of maintenance teams;
- Reduced claims and complaints on the performed maintenance services;
- Reduced expenses of direct maintenance of the system;
- Reduced stocks in the stockrooms of maintenance units and indirectly reduced maintenance expenses;
- Faster response and higher adherence to agreed system maintenance timeframe;
- Daily update of records of given and executed maintenance orders, material expenditure and financial commitments related to maintenance;
- Statistical analysis of required stocks per type of goods and future expense projection, i.e., optimisation.

3.3.3.1. Maintenance Plan

At all organizational levels, system maintenance units must prepare maintenance plans. The maintenance planning includes:

- Specification of policies, procedures, methods and instructions,
- Sequence of maintenance procedures and activities,
- Procedures in case of incompliance between actual situation on the site and recognized and specified maintenance procedures and methods,
- Control plans and supervision plans,
- Preparation of standardized documentation,
- Staff planning and their continued professional advanced training.

According to ISO 9001, mandatory plans that are implemented for the purpose of reaching standardized quality constitute the so-called «Quality Plan», and the following are relevant for the system maintenance operations:

1. Plans of control and examination (samples of spare parts or incorporated system components, including their functionality),
2. Plan of control of inputs (procurement of spare parts),
3. Plan of control of equipment and system parts,
4. Plan of staff education,
5. Incompliance forecasts,
6. Planning of uniform designation of problems, errors, users, equipment and materials,
7. Planning of preventive maintenance,
8. Servicing activities.

3.3.3.2. Organization of Maintenance System

The maintenance activities are supervised and coordinated, as said before, by the IT Centre. The main tasks related to system maintenance and prevention will be performed at the level of a school or institution within the educational system. Every school must have a teacher/professor or an associate that will carry out the main IT resource management tasks as part of his/her regular or extraordinary working assignments in the school. This coordinator will have a task not only to personally engage in the system protection, but also to create (through extracurricular activities – an IT group) a group of pupils who will help in
these tasks on a voluntary basis. Such team will be responsible to prevent any system failure and to analyse the failures that have occurred.

Direct responsibility for the maintenance tasks will rest with an authorized company with a developed servicing and selling network throughout Montenegro, qualified personnel (with appropriate certificates) and appropriate premises. Such company will be selected for the period of three years, by way of public tender, with the obligation to perform technical and financial analysis of operations at least annually during the period of the contract. This company will be the Maintenance Provider (MP). The MP shall organize the maintenance via 3 regional centres: Podgorica, Herceg Novi and Bijelo Polje. These centres will coordinate and perform maintenance tasks at the covered territory. The MP shall organize the maintenance work under its own company or through a stable business relationship with one of IT companies in these towns.

The Maintenance Provider, in cooperation with the Ministry of Education and Science, i.e., the IT Division (IT Centre), shall do the following in order to provide effective maintenance:

- Define and standardize forms in the process of maintenance;
- Define and standardize procedures and policies in the process of maintenance;
- Define and standardize a uniform system of designation in maintenance;
- Define minimum stocks of spare parts, software and equipment in servicing centres;
- Define control procedures and preventive maintenance procedures;
- Define and standardize tools, software and equipment needed by the service team to be able to perform servicing interventions, i.e., minimum technical equipment;
- Define minimum number of competent staff in regional service centres that will warrant prompt and effective response and successful repair.

**3.3.3.3. Documentation and Forms**

The forms that need to be standardized in the process of maintenance are:

- Failure reporting form,
- Intervention/service order,
- Work order,
- Intervention completion report,
- Periodical maintenance reports.

The significance of documentation of and of documenting all procedures and processes is enormous for the monitoring of quality and methods of maintenance. The standard breakdown of documents includes internal and external documents, i.e., reports, technical normatives and internal standards of maintenance and input and output documents. The internal documents define the rules, procedures and actions during the intervention, but also during preparations for the intervention, as well as reports about the course of the performed interventions. All these documents are produced in the maintenance unit and are intended for its internal use.

From the aspect of intervention, input and output documentation is created before and/or after the intervention and comes from the user, or is delivered to the user. The correctness of input documentation, proper description of the problem or error in part of the system is very important for determining the course of the intervention needed. Other input documents are: the receipts of goods acceptance in warehouse, direct orders from the Ministry of Education and Science for change of priority of intervention, incoming invoices for services provided (transport, night stays, meals etc.).

Due to importance of correctness of input documents, it is necessary to define uniform form for reporting a problem or error in the system, which would contain the reporting procedure and instructions. For the purpose of precision and simplicity in fulfilling the problem reporting form, it is necessary to determine the types of problems and errors in the system, assumed or empirical ones, to classify them in groups and sub-groups, by similar ways of
manifestation or similar ways to resolve the problem, and based on that to introduce a uniform system of designating and encoding the problem groups and sub-groups. The MP shall define the problem groups and sub-groups as precisely as possible, propose the manner of encoding and designation, and provide the description of the problems and errors, in consultation with the IT Centre and in accordance with its business experience. Also, for the problems occurring for the first time during the maintenance period, the MP shall define the group, sub-group, and code of problem/error and shall enter them in the current database for further use.

The uniform system of designation means that each group has its own identification number consisting of two digits, and each sub-group has a classification number consisting of 4 digits, so that each of possible problems is uniformly designated by a 6-digit number that represents first the identification number and then the classification number.

3.3.3.4. Preventive Maintenance

Preventive maintenance of equipment in any IS is necessary for the following reasons:
- equipment (hardware), as a rule, represents a set of electrical and mechanical parts that are subject to wear and tear (aging) and failure;
- some segments of IS equipment are installed in inadequate technical or technological environment or the environment does not meet the necessary technical or technological standards, which eventually results in more frequent problems and damages that can be precluded by prevention;
- users in schools and institutions, as well as pupils, often do not possess enough knowledge and skills to use the system segments, resulting in errors in the system operation, particularly in the software damages, primarily system and accessible application software. Some of these damages may be removed by preventive control before the failure of the system or part of system.

Preventive maintenance implies planning for the replacement of old parts of equipment, examination of functionality of equipment under exploitation, re-instalment of software partially damaged by incompetent operation, correction of databases etc.

3.3.4. Failure Reporting and Intervention Procedures

Software that will monitor, systemize and select information about problems in the system functioning is necessary. That would provide a more objective picture of real problems and priorities in the implementation. Just like an information system has a task, on the basis of many available information about the resources and procedures in a system, to support the efficient operation of that system, primarily in the domain of decision-making, this software will have the task to define priorities and propose ways to remove problems in the functioning of the information system of the Ministry of Education and Science. It is necessary to use a single database, to introduce uniform standards of designating system failures, and to identify and establish uniform procedures for failure reporting, request processing, intervention order issuing and, finally, intervention completion reporting.

Non-adherence to these procedures inevitably leads to the following problems:
- A great number of people involved in the system maintenance;
- An inert maintenance system and slow response to a change in the condition of equipment or an overall IS sub-system in the MEIS;
- Inability to use previous servicing experience with interventions for similar or identical problems;
PHYSICAL ARCHITECTURE OF MEIS PROJECT (PA-MEIS)

- Increased number of hours since failure reporting, through issuing service order, to making a field visit and remove the failure, which all together increases maintenance expenses and decreases the system functionality and efficiency.

The implementation of this sub-project would result in the following:
- Better communication among the system users (schools, institutions...), management structure in the system (Ministry of Education and Science, IT Department) and system maintenance, which in turn has an impact on:
  - Response time,
  - Quality of intervention performed and
  - Reduced maintenance costs.

The user's authorized persons will report himself/herself and fulfil the failure reporting form with necessary details on the Web. The description of the failure is made easier by offering a choice of groups and sub-groups of previous reported or potential failures or errors, with a detailed failure description, but also the ways how the failure can be eliminated or how similar failures were eliminated in the past. In this way, it is simple for the user to get involved in the problem resolution process, based on previous experience and in accordance with his/her skills and competence. If the user requests an intervention, the maintenance provider will determine a regional centre that will be assigned that problem, and the software will automatically assign the previously defined priorities and determine the date for completion of the intervention. The user's priority may be changed in individual cases upon he request of the IT Department. The communication among all the participants in the problem resolution is inter-active and real-time (Internet on-line communication).

The advantage of this solution is the speed of getting information, making decisions, inter-active consultation, prompt and on-going monitoring of the intervention status, materials spending, comparison of problem description with existing description in the database and reaction to the problem on the basis of previous similar experience.

All the failures and errors are uniformly classified and described, stored in the database together with repair description and in that way made available to all interested parties in the process of maintenance (user, institutions within the Ministry of Education and Science, IT Department, Maintenance Provider, regional service centres, etc.). In this manner, the procedure that starts from reporting a failure until the failure removal is accessible to all stakeholders, and includes all information about the manner and course of intervention. The approach to information or part of information is limited to the levels determined by the IT Department.

In addition to that, it is possible to track other information important for the course and outcome of the intervention:
- State of needed equipment, materials and software held in stock by the Maintenance Provider and regional service centres, in accordance with minimum required quantities and their regional disposition, as agreed between the Ministry of Education and Science and the Maintenance Provider;
- Spatial layout of personnel and structure of personnel implementing the interventions;
- Number of work hours spent and financial expenses during the intervention, which might lead to modification of the original intervention order and optimisation of overall expenses;
- Complete and automated statistics of the type, structure, nature, spatial dispersion and frequency of failures and errors in the system, average duration of intervention by groups of failures and errors, maintenance cost by various sites (places, cities, regions, etc.).
3.3.5. Cost Estimate

3.3.5.1. Types of Possible Costs

Maintenance costs are defined at the annual level as a certain contracted lump sum which includes a foreseen number of incidents and also a variable number of interventions that may be performed although they are not within the foreseen number of incidental situations. Also, the consumption of materials (spare parts) is a variable expense that can be only approximated at the annual level. All tasks of preventive maintenance are defined as part of the contracted lump sum.

The procurement of standardized equipment may largely reduce the expenses, as the variety of hardware failures is thus reduced and consequently the quantity of spare parts with MP (price factor in the offer).

An important factor is also the age of equipment. During the warranty period, part replacement is free of charge if the cause of the failure is the technical imperfection of the part. Upon statistical review of the service documentation of the largest Montenegrin distributor of IT equipment, Tradecom MN, it was found that the percentage of part replacement in the warranty period ranges from 3-6%, depending on the manufacturer and type of equipment.

Besides, the review of the service documentation of one of the largest Montenegrin system integrators, Cikom IT Engineering, has shown that the system failures are most frequent in the first 30 days of use (65%), regardless of whether it is the warranty right (4-5%) or typical errors caused by incorrect operation or cancellation due to force majeure (not subject to warranty rights) (95-96%).

Out of the errors that are not subject to warranty, only 12% are due to occurrence of force majeure. All other errors in the system are the result of wrong handling, either lack of antivirus protection, incorrect use of equipment or damages to system or application software.

The similar statistics relates to the communication equipment. Passive network equipment is of longer durability, damages are rare, but if they happen, interventions may be very complicated.

3.3.5.2. Warranty Period

Equipment maintenance within warranty period requires strict adherence to the procedures related to warranty rights. It requires the Maintenance Provider to monitor:

- Supply of equipment and spare parts,
- Distribution of equipment and storage of optimum quantities of spare parts,
- Claims from suppliers.

The request for monitoring supply of equipment and spare parts imposes the institutions and schools an obligation to inform the Maintenance Provider, by way of special forms (or software, if that option is accepted) on all procurements of equipment beyond the usual procedures in the Ministry of Education and Science, if they want that equipment to be registered as the subject of maintenance.

3.3.5.3. Planning Material Stocks

The Maintenance Provider is obliged to plan optimum quantities of spare parts for the equipment and to maintain records of their quantities and distribution with the following minimum details:
- Uniform designation of materials in conformity with designation (if possible) of failures and errors removed through the use of these materials,
- Date of procurement and date of warranty expiry of these materials,
- Quantity of materials in each of regional service centres,
- Minimum quantities of every material, which instigates the procedure of procurement of additional quantity and automatically notifies the supply unit. Minimum quantity is optimised by taking care of the quantity of equipment incorporating such materials (within servicing responsibility of each regional centre), the number of interventions and replacements, and time taken to procure them.

All the equipment procured and distributed by the Ministry of Education and Science from the state budget or granted funds is recorded by nature, type and serial number by the MP. This helps to monitor the state of equipment, number and type of interventions and part replacement on an on-going basis.

A very complex process is the receipt and recording of spare parts, at all levels, starting from MP, through regional centres, to the schools and institutions that are users of maintenance services.

It is necessary to prescribe the following stages during the receipt for all the materials that go through warehouse records, during supply and before being issued to servicing teams:

1. material preparation stage,
2. material claim stage,
3. servicing or warranty intervention processing stage.

The preparation stage encompasses the physical entry of equipment or materials in the warehouse and is defined by quantitative indicators. At this stage it is necessary to classify materials precisely and to assign them codes in the warehouse in accordance with the defined standardization, as an important precondition for correct recording and handling of materials in the issuance process.

The material claim stage comprises activities related to goods issuance before and during the service/warranty intervention. The procedure includes giving receipts or taking materials per working order.

The servicing or warranty intervention stage includes completion of documentation on every individual exit of materials from the warehouse and financial recording depending on whether it is a service or warranty intervention. At this stage the following is completed: working order, intervention reports, invoices or ledger credits, and all other correspondence during the problem removal.

### 3.3.5.4. Maintenance Cost Estimate on Annual Basis

As said before, the realistic picture of costs is obtained in a longer period (at least one year). The estimate of annual expenses is made on the basis of calculating the total cost of equipment that is to be maintained – computers and peripherals, communication active and passive equipment, and system and application software.

The expenses are calculated using the sample of 30 focus schools. The total assumed value of IT equipment in these schools is taken as a starting basis to which the statistical indicator showing the failure percentage in the three years of operation, obtained from the companies Tradecom MN and Cikom has been applied.
Table 16 – Maintenance Cost Estimate Based on Failure Statistics

<table>
<thead>
<tr>
<th>Type of Equipment</th>
<th>Price (EUR)</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer equipment, peripherals and system software</td>
<td>1,200,000.00</td>
<td>5% failure, share in equipment price 6%</td>
<td>6% failure, share in equipment price 6%</td>
<td>8% failure, share in equipment price 6%</td>
</tr>
<tr>
<td></td>
<td>72,000.00</td>
<td>72,000.00</td>
<td>72,000.00</td>
<td>60,000.00</td>
</tr>
<tr>
<td>Passive communication equipment</td>
<td>75,000.00</td>
<td>2% failure, equipment of higher value</td>
<td>2% failure, equipment of higher value</td>
<td>2% failure, equipment of higher value</td>
</tr>
<tr>
<td></td>
<td>3,750.00</td>
<td>3,750.00</td>
<td>3,750.00</td>
<td>3,750.00</td>
</tr>
<tr>
<td>Active communication equipment</td>
<td>80,000.00</td>
<td>5% failure, share in equipment price 9%,</td>
<td>5% failure, share in equipment price 9%,</td>
<td>6% failure, share in equipment price 10%,</td>
</tr>
<tr>
<td></td>
<td>7,200.00</td>
<td>7,200.00</td>
<td>7,200.00</td>
<td>8,000.00</td>
</tr>
</tbody>
</table>

**TOTAL:**

|                      | 82,950.00 | 82,950.00 | 71,750.00 |

This table gives the review of expenses in the first three years of operation on the basis of cost of replaced spare parts ONLY.

**NOTE:** At least in the first year of operation these parts are free of charge based on warranty rights, but the calculation of actual expenses was made in order to perceive the overall system maintenance expenses. In the third year, these parts have a smaller share in the total cost of equipment because their acquisition cost is lower.

**Cost of contracted annual equipment maintenance** in thirty focus schools in Montenegro, which includes two regular annual two-day service inspections and adjustments per each school and ten free one-day interventions per each school, with included travel expenses, amounts to EUR 84,000.00 on annual basis.

This amount is guaranteed to the MP even if the number of interventions in a year is smaller than the planned 300 and it includes the expenses of all preparatory activities for annual maintenance. The project team assumes that the number of service interventions in Year 1 will be higher than in the following two, primarily due to the user factor. The amount is obtained in the following manner:

1. 120 days of prevention servicing, 2 servicers, EUR 100 per technician/day (technician/day includes costs of gross salary, mobile phone and other work privileges - EUR 65.7 per day – food, fuel and vehicle amortization, counting 150 km in average in both ways from the regional service centre to the school), total EUR 24,000.00.
2. 300 service interventions, 2 servicers, EUR 100 per technician/day, total EUR 60,000.00

The expenses of maintenance at call, in case of exceeding the number of servicing intervention in a year, will be calculated in and analogous way. The project team believes that, except in Year 1, these expenses will be either minimum or none.
Table 17 – Cost Estimate of Maintenance at Call

<table>
<thead>
<tr>
<th>EXPENSE DESCRIPTION</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>TOTAL AMOUNT by type of expense</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardware replacement</td>
<td>82.950,00</td>
<td>82.950,00</td>
<td>71.750,00</td>
<td>237.650,00</td>
</tr>
<tr>
<td>Contracted annual</td>
<td>84.000,00</td>
<td>84.000,00</td>
<td>84.000,00</td>
<td>252.000,00</td>
</tr>
<tr>
<td>Maintenance at call</td>
<td>12.000,00</td>
<td>5.000,00</td>
<td>5.000,00</td>
<td>22.000,00</td>
</tr>
<tr>
<td>TOTAL FOR FOCUS SCHOOLS (30)</td>
<td>178.950,00</td>
<td>171.950,00</td>
<td>160.750,00</td>
<td>511.650,00</td>
</tr>
</tbody>
</table>

It should be noted that the costs in the Year 1, under warranty rights, will be reduced for the hardware replacement expenses, but it has not been presented here in order to perceive the overall system maintenance expenses.

3.3.6. Software Maintenance (Oracle)

ORACLE licence refers to the software at the time of purchase, and for all the future software versions it should be paid 15% per year of the value of the purchased software. Technical assistance services will cost about 7% per year.

Table 18 – Software Maintenance Cost Estimate

<table>
<thead>
<tr>
<th>Service</th>
<th>Percentage</th>
<th>Value of Purchased Software (EUR)</th>
<th>Total (EUR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Software upgrade</td>
<td>15%</td>
<td>144.507</td>
<td>21.680</td>
</tr>
<tr>
<td>Technical assistance</td>
<td>7%</td>
<td>144.507</td>
<td>10.120</td>
</tr>
<tr>
<td>TOTAL:</td>
<td></td>
<td></td>
<td>31.800</td>
</tr>
</tbody>
</table>

3.3.7. Conclusion of IS Maintenance Sub-project

Based on the above analysis, the project team believes that the maintenance should be organized as described herein. The MA should be a carefully chose company, preferably from Montenegro, with well-qualified staff and the logistics sufficient to facilitate prompt response throughout Montenegro.

It is necessary to standardize maintenance documentation and procedures, and the project team recommends that the software application described in this project be implemented by all means.

Since this is a very dynamic system that will grow from year to year, the respective maintenance tasks will impose a need upon the MA to organize a separate operating segment to be responsible for these tasks solely during the contract period and to provide ongoing additional training of its staff. Staff training is pointed out as a necessary condition for efficient operation and maintenance of the educational information system.

On the basis of the presented analysis of average annual expenses per a school, we believe that these expenses are not high and that they could become even smaller through the tender procedure.
4. COMPUTER EDUCATION FOR TEACHERS (CEFT) PROJECT

4.1.1. Introduction to CEFT Sub-project

"The Book of Changes" introduces a new conception of educational system that requires the introduction of ICT - information and communication technologies in the educational system in Montenegro. Computers have not been sufficiently used in Montenegrin education, particularly in primary and secondary schools and the pupils have not been offered adequate ways to manage IT skills, including the use of Internet. Teachers, with individual exceptions, also do not use modern ICT tools in their professional work. Teachers' college curricula do not include computer training.

The capacity of the Montenegrin educational system to incorporate ICT is highly dependant on professional skills of managing structures, teachers, administrative staff and other employees in schools in the use of computers. It is therefore necessary to design a modern and feasible training programme for teachers and IT staff in schools, which will be the subject of this study. A great number of potential trainees imposes the need for a comprehensive and constantly running training programme.

4.1.2. Selection of Methodology for Preparation of CEFT Project

In the preparation of the project of training for teachers and other staff in the use of ICT in the educational system of Montenegro (hereinafter: CEFT), methodologies and standards prescribed by ECDL (European Computer Driving License Foundation) and ICDL (International Computer Driving License) were used. These methodologies for preparation of IT education and testing programmes are applied with great success all over the world. They will be explained in more detail later.

The ECDL/ICDL methodology ensures the development of a modern, permanent IT training for teachers and IT staff in education. It is very important to stress that this methodology enables training independent of the choice of specific hardware or software solutions and supports all the strategic goals of the educational reform in Montenegro.

4.1.3. Institutional Organization of Montenegrin Educational System up to University Level

The educational network in Montenegro consists of about 240 institutions including:
- 20 preschool institutions,
- 169 primary schools,
- 45 vocational secondary schools and gymnasiums, and
- institutes, student dormitories and adult education centres.

Preschools, primary schools, secondary schools and special schools, which are organized as public institutions owned by the state, are managed by the school board, or the management board. The head of a preschool or school is the director (principal), as the professional, pedagogical leader and the operating, executive officer. The director is responsible for implementation of the curricula and thereby for the implementation of the ICT introduction strategy.

In some schools, director is assisted by one or more (usually two) assistant directors, who, together with the director and secretary of the school, constitute the school managing structure of the school.

4.1.4. MEIS Project

The need for introduction of ICT and EU standards in the educational system in Montenegro has been presented as part of the educational reform described in "The Book of Changes".
That is exactly the purpose of implementation of the MEIS Project. Under this project, primary and secondary schools in Montenegro will be equipped with needed computer equipment, provided with local computer networks and connected to Internet. The MEIS Project is divided in four stages. Stage 1 comprises the preparation of necessary project documentation. Stage 2 covers the provision of computer equipment for the first 30 focus schools. In Stage 3 additional 50 schools will be equipped and in Stage 4 the ICT will be introduced in another 50 schools.

Implementation of the MEIS Project is a precondition for the teacher training project, the so-called CEFT Project. With full implementation of both these projects, modern ICT would become and integral part of educational curricula in schools.

4.2. Definition of Requirements for the Development of CEFT

The “Strategy of ICT Introduction in the Montenegrin Educational System” states that ICT introduction will lead to higher quality of teaching, higher efficiency in the learning process, better didactic organization of individual subjects, as well as the adoption of general computer skills. On the other side, computers are today proven means of presentation of multimedia and virtual project, and they can be useful as an aid in teaching that enables part of classical lectures to be replaced by attractive presentations of material via computers. The system of IT education of teachers and staff covered by the CEFT Project is supposed to provide for efficient functioning of information systems in schools, which will pay off the investments made.

The system of comprehensive IT education in schools will be built up in accordance with the general plan of ICT implementation. Its gradual implementation by stages will be the basis for an economical and efficient implementation of the CEFT Project. In addition to that, the CEFT Project will be based on the following important assumptions:

- all schools will be included in a single Academic Computer Network - MEN using uniform methodologies and uniform programmes;
- schools will be connected to and compatible with the IT Centre of the University of Montenegro, which will facilitate the use of university resources such as: databases, library fund data, information about curricula of individual faculties, materials from individual subjects, etc.;
- all services offered by the global information network Internet, such as: WWW, electronic mail, exchange of information etc. will become accessible.

With the existence of these assumptions and successful implementation of the ICT and CEFT projects, it will be possible to integrate our schools in world information trends, with special stress on development in the area of education and application of state-of-the-art methodologies in the teaching process.

4.2.1. Objectives of CEFT Project

The objectives of the CEFT Project are reflected in the following:

1. Development of the educational system, by opening up possibilities for the use of computers in schools;
2. Support to the system for fully automated processing of statistical researches and records in education;
3. IT support and improvement of process of feeding current data for the purposes of statistical researches and records in education;
4. Taking over and forwarding relevant information in electronic form from and to the entities that possess automated education information systems;
5. IT support to the preparation of various educational publications and their presentation on Internet;
6. Application of generally accepted trends in the development of information systems in the world to the solutions verified in practice, in our environment. Globally looking, the main task of information system that will be installed in primary and secondary schools in Montenegro is to improve knowledge of pupils and teachers in the IT and use of computers. In addition, another task is to provide automation of various school records. The automation of records in schools means the collection, by means of computers, of relevant statistical information, their classification, control, summarizing and search by various criteria. Keeping diverse statistical records by classical methods requires a lot of time and effort, and the accuracy is not satisfactory. With the application of IS in schools and use of centralized database for the whole Republic, it is possible, simply and quickly, to obtain different statistical data, such as, e.g.: pupil’s accomplishment, records of teachers, etc.

But, in order to be able to use the IS advantages in the most efficient way, it is necessary to provide good training of teachers and other school staff in handling individual parts of the IS that are of interest to them as well as applications that bolster productivity and quality of the teaching process.

If the above tasks and objectives are achieved, particularly in primary and secondary schools, it would contribute to the following:

- Better, more rational and more efficient conduct of the teaching process, through faster resolution of problem situations;
- Creation of a better basis for making faster and informed decisions, management and improvement of teaching process;
- Better exploitation of existing teaching and technical staff in schools;
- More efficient support, monitoring and control of the educational process, with stress on timeliness and correctness of relevant data on its quality;
- Better cooperation of schools with the Ministry of Education and Science and other relevant entities in Montenegro, with respect to exchange and use of information,
- Increased flexibility of schools in accepting new educational programmes and modern teaching methodologies;
- More rational use of resources;
- Continuous insight into the elements of planning and development of IT education of pupils towards more efficient use of computer resource (hardware and software equipment, application programmes, etc.).

The set tasks and objectives may be accomplished, while respecting the standards and regulations, through the following steps:

- Defining the conception of recruit IT training,
- Designing the model of IT education in schools,
- Organizing training and testing centres, as mainstays of IT educations and
- Mass training of teachers and other staff in schools.

This may be carried out by defining and implementing a comprehensive project of IT education in schools.

### 4.2.2. CEFT Project Implementation Tasks

During the implementation of the CEFT Project, it is necessary to:

- Define the required types and level of courses for teachers,
- Define the number of it knowledgeable teachers and instructors who will support the ICT project in schools,
- Determine, in an objective way, training priorities based on the ICT requirements and available resources,
- Design training plan and define the method of its implementation,
- Define: material, financial, personnel and time resources needed for implementation of training,
- Define the training schedule and expenses,
- Carry out the planned IT training of teachers and other staff that will support the information system in schools.

It is therefore evident that this project should create a basis for: efficient resolution of the problem of IT training of teachers and IT staff, training implementation according to the plan, efficient monitoring and suggesting steps for further training when needed, efficient flow of information, direct aid in teaching, etc.

### 4.3. Current Level of Computer Use and Teachers' Computer Skills in Primary and Secondary Schools

ICT application has become a part of education in developed countries long time ago. The present level of use of computers and level of those skills of teachers in primary and secondary schools in Montenegro may be presented by means of data obtained from polls conducted in the schools.

#### 4.3.1. Current Level of IT Education in Primary and Secondary Schools in Montenegro

The polls conducted by the Ministry of Education and Science in April 2002 show that 10.8% teachers and 14.07% pupils in primary schools have been skilled in using computers. Only 11% of the schools are connected to Internet, and only 4% of them have websites. In secondary schools, 18.9% teachers and 29.2% pupils can use the computer, Internet is rarely used and only 11% of the schools have websites.

![Figure 30 - Current Level of Computer Use in Schools in Montenegro](image)

Computer classrooms exist in only 36 primary and 34 secondary schools in Montenegro, and the mean number of students per one computer is as high as 142. Similar data are obtained
for pupils and students dormitories. A separate problem is the outdatedness of that equipment.
The pupils training in the used of computers is mostly provided through the following subjects: Technical Education in grade 7 and grade 8 of primary schools and IT Education in grade 1 of secondary schools. In a couple of cases only, computers are used in English lessons and for organization of IT courses.

4.3.2. Problems in IT Training of Teachers and Students in Primary and Secondary Schools

Critical problems in IT education of teachers and students are the following:
- Lack of computer equipments and its outdatedness in some schools;
- Inability to use modern operating systems and modern software;
- Lack of modern equipment for multimedia presentations;
- Insufficient and unequal competence of teachers and administrative staff in schools;
- Lack of funds and non-existence of skilled staff for the maintenance of hardware and software in schools;
- Lack of connection to Internet and appropriate units in the Ministry of Education and Science;
- Absence or outdatedness of applications for keeping school records and taking care of economic and financial operations of schools;
- Absence of a single information system in the area of education;
- Absence of a conception and model of IT training of teachers and students;
- Incompliance of existing educational system with the one of EU, and thereby impossibility of meaningful presentation of data to foreign institutions and use of their experience in the system of education.

In addition, the problem is a fact that the existing curricula are not based on contemporary information and communication technologies so that they cannot use the advantages these may have in upgrading the quality of teaching.

An important aspect of application of ICT in education is also the possibility to use great quantity of information that may be acceded through Internet. By using Internet, as a global computer network, teachers may acquire supplemental material needed to improve the quality of instruction. On the other side, one of well-known favourable implications of Internet is that it inspires researching spirit and self-motivations of students, which is very important in the process of teaching.

A major deficiency in the application of IT in schools to date is poor or almost no use of Internet. The causes are many: poor computer infrastructure, absence of free Internet connections, poor awareness of possibilities and significance of Internet.

Application of computers as auxiliary aids in the instruction has become quite common in the developed countries. First of all, computer presentations can be prepared very simply and quickly and then they can be connected to numerous other documents kept in the computer. Computer presentations are very rarely used in our schools as a teaching aid. The reason is the lack of appropriate equipment, such as projector and SmartBoard etc., but also the fact that a very limited number of teachers know how to prepare such presentations.

4.3.3. Proposals for Overcoming Problems in IT Training of Teachers and Students in Primary and Secondary Schools

The existing problems in IT training of teachers and students in primary and secondary schools may be overcome by the following measures:
1. To equip the schools with modern ICT equipment as well as facilities for multimedia presentations,

2. To procure modern and licensed system software,

3. To connect schools in an overarching network - MEN,

4. To provide a system of maintenance of the installed equipment and enable free and unrestricted use of computers for students and teachers,

5. To carry out a comprehensive IT training of teachers and students, in controlled conditions and under the adopted standards,

6. To develop and use applications for schools records, accounting operations, records of inventories, school libraries, administrative operations etc.,

7. To ensure free access to Internet and all of its resources,

8. To make websites of schools.

The implementation of the IT training in educational institutions in Montenegro should rely on local expertise and proper applicative solutions. The local expertise here means the expertise found at the University of Montenegro and appropriate personnel in schools that may be trained for this job.

### 4.4. Organization of CEFT Project

The use and degree of exploitation of computers in schools may be low in comparison to their technical capacities and the reason for that is untimely and incomplete training of the needed staff. That is why it is critically important for an efficient and successful implementation of information technologies in the system of education to have teachers with adequate IT education and skills, who are interested in knowing and using the possibilities offered by information and communication technologies.

The CEFT Project is supposed to provide quality and permanent IT training for all the employees in schools. That will create a good basis for the subsequent mass training of students and wide popularisation of computers and IT in general.

#### 4.4.1. Categories of Users of CEFT Project

Users of CEFT Project will be teachers and administrative staff employed in primary and secondary schools, management and administrative staff in the Institute for Education, Ministry of Education and Science, Vocational Training Centre, Examination Centre, staff of IT department/centre of the Ministry of Education and Science and other educational institutions (preschools, private schools, adult education institutions, adult training centres). For more efficient and rational training, and considering the various levels, as well as areas, of knowledge and skills that will be needed in their work, it will be beneficial to divide users in distinctive categories.

Trainees, i.e. users of the CEFT Project, may be classified according to their position, role and tasks that they will have in the process of CEFT Project implementation into the following five categories, or profiles:

1. **Management** in schools, Institute for Education, sections of the Ministry, Vocational Training Centre, Examination Centre, Institute for Textbooks, etc.
2. **Administrative staff** in schools and institutions at the central level such as: librarians, accounting staff, staff in warehouses, workshops etc.

3. **Teachers-IT staff or ICT administrators** who are selected from the ranks of teaching or administrative staff and have the task to take care of the use and usability of computer equipment, proper functioning of the system and application software, and communication with the IT department of the Ministry and/or hardware and software maintenance providers. This category includes the staff employed in the IT department of the Ministry.

4. **Teachers-instructors** who attend and take examinations at appropriate instructor courses and obtain certificates to become instructors/trainers in local or regional training centres.

5. **Teachers** in primary and secondary schools.

---

**Figure 31. - Categories of Users of CEFT Project**

**4.4.2. Education and Testing Centres**

The complete organization and implementation of the CEFT Project should be carried on in **education and testing centres**. Education and training centres should assume the responsibility for implementation of the CEFT Project. These centres should satisfy certain standards and be capable to provide the planned training for teachers and IT staff in schools during the project.
4.4.2.1. Territorial Organization of Education and Testing Centres

Education and testing centres should be organized at three levels:

A. **Main Republican centre** in Podgorica, to educate the staff that will be main promoters of ICT implementation in schools. These are primarily principals and assistant principals, school secretaries, teachers-administrators, and teachers that will become instructors in local and regional centres in the second stage of the project. The main centre will provide training for employees of Institute for Education, sections and units of the Ministry, Vocational Training Centre, Examination Centre and Institute for Textbooks.

B. **Regional or city centres** would be formed in: Bar, Kotor, Bijelo Polje, Niksic, Berane, Ulcinj and Pljevlja. They will provide training for teachers and administrative staff of schools surrounding these centres.

C. **Local centres** would be formed, if needed, in particular larger schools and their courses would be attended by other teachers. Courses could be organized for students as well.

![Territorial Organization of Education and Training Centres](image-url)
4.4.2.2. Standards to Be Satisfied by Regional and Local Education and Training Centres

Training centres should, first of all, possess appropriate physical resource needed for their work, such as computer classrooms equipped with modern IT facilities for the conduct of IT training on computers. Minimum technical equipment of computer classrooms in regional and local centres should include the following:

- A classroom with 15+1 modern computers (one computer per each trainee);
- Licensed software (operating system, office tools, database management systems). It would be desirable to have two operating systems installed on computers: Linux and some of MS Windows operating system;
- LCD projector connected to the instructor’s computer;
- Network printer;
- Local computer network;
- Connection to Internet for each computer;
- Air-conditioned, spacious and properly lit working area.

The training centres must pass through strict control for satisfaction of certain quality standards and trainers must hold appropriate certificates. If the number of trainees per classroom exceeds 10, two trainers should be engaged. To ensure the quality system, the work of the centres will be periodically evaluated by the Project Council. In case that the prescribed standards are not fulfilled, license for further participation in the CEFT Project may be revoked to such training centre.

4.4.2.3. Selection of Regional and Local Training Centres

Education and training centres will be formed within schools or university units, subject to the approval of the Ministry of Education and Science. In exceptional cases, e.g., in cities in which the schools are not interested in this, training centres may be established by specialized organizations and forms properly licensed by the Ministry and recommended by the CEFT Project Council. A specialized organization or firm may become an Authorized Training Centre of the Ministry if it participates in the tender to be published the Ministry and meets both the general conditions and those described by ECDL standards.

If general conditions for constituting a centre have been fulfilled, the CEFT Project Council will determine an expert group that will examine the adequacy of premises foreseen for classes and tests, technical capacity, conditions for keeping testing materials, Internet connections etc. and will give its written proposal to the Project Council.

A regional or local centre must have at least two authorized instructors holding appropriate certificates and one coordinator for technical, administrative and financial tasks (preparation of data for diplomas, recording of test results, provision of the quality system, communication with the Project Council and the Ministry etc.) available. The coordination tasks may be performed by one of the instructors or the existing school administration.

The main Republican centre will organize training, testing and issuing certificates for trainers (instructors), testing the knowledge of candidates, administration work related to testing and the coordinator training (for administrative employees of training centres of lower level). After the passed courses, the main centre will issue certificates to authorized trainers (instructors). These certificates must be posted on a visible place during the work in the centre. The centre may hire trainers that are not employed in the school or university unit, if they possess appropriate certificates.

If an organization (faculty, school or firm) meets all the conditions, it will sign a contract with the Ministry and become licensed as Authorized Training Centre. It will receive and
safeguard a confidential database of examination questions for tests, testing instructions, marketing material, administrative system and guidelines for communication with the main Republican centre and the CEFT Project Council.

4.4.2.4. Certificates and Diplomas Issued by Training Centres

A certificate will be issued to the trainees that want to become trainers in training centres. The following is needed in order to obtain the certificate:

1. Obligatory attendance and active participation in classes for all the prescribed courses given in the column teachers-instructors, in Table 23. (Choice of courses for individual categories of trainees);
2. Passing an examination which will confirm that a certain level of practical and theoretical knowledge is achieved.

Examinations for obtaining certificates may be taken in the Main Education and Testing Centre only.

All other trainees that are passing through the basic computer training only (see Table 23) will obtain an appropriate diploma. There are two possibilities for obtaining diplomas:

1. Authorized education and testing centres will organize courses as preparation for taking examinations that are in conformity with ECDL program requirements. After the course classes are over, examination will be taken, consisting of a practical and a theoretical part. The passed examinations will be recorded.
2. Course attendance is not a condition for taking examinations. If a candidate has the necessary knowledge, he/she can apply for testing to any of the centres, and after the successful examination, he/she will get an appropriate diploma. All teachers in schools covered by the CEFT Project may take examination. The Project Council will determine the cost of the examination.

If a trainee attended the classes and participated actively in them, but has not taken or passed the examination, the education and testing centre may issue an appropriate certificate of the attended course. The attendance means that a trainee was present on at least 90% of the classes and completed all practical and other exercises during the course, which shall be decided by the trainer who performed training on that course. Diplomas issued by the education and training centres will contain:

- Name of course, i.e., or the area covered by the course,
- Stamp of the school or university unit that formed the education and testing centre,
- Signature of the authorized centre leader (school principal or faculty dean) and signature of one member of the CEFT Project Council.

4.4.2.5. Knowledge Testing for a Diploma or a Certificate

There are two testing systems: classical and automated (On Line) testing. In classical testing, examination is taken for every course. In automated testing (ATES- Automated Test Equipment Specification), special software is used, which sends to the candidate’s screen a test selected at random and registers the answers by adding up the points earned. If the number of the points is sufficient, after the last answer, the system informs the candidate of the successfully passed test and enters the score in the database. All the courses are intended for adoption of practical skills and abilities, and test questions are examples of practical usage. Such a system of testing would be mostly applied during the implementation of the CEFT Project, especially in the first phase, because of significant expenses of procuring programmes for ATES.

The testing procedure is such that an examiner takes a test chosen at random and gives it to a candidate together with the diskette holding other details about the test. When the centre
finishes the training, it must be ensured that the trainer who trained the candidates in a certain course would not examine or supervise them during the testing for that course. Such trainers may not evaluate their tests either. Education and testing centres, which also conduct training, should use the literature and materials approved by the competent councils, upon the proposal of the Project Council. These materials must satisfy the generally accepted ECDL standards.

4.4.2.6. Supervision of the Work of an Education and Testing Centre

In order to check whether the adopted procedures are followed, from time to time, but at least bimonthly, the work of the centre will be examined by the CEFT Project Council (Chapter 6.1) or the Ministry. The centre’s appearance, equipment, testing system, manner of candidate registration, possibility of testing candidates with special needs (if any), candidate recording administration system, prominence of posting the centre’s license and teachers’ certificates, testing documentation keeping, and other factors are examined. The examination is also performed during the testing of candidates, which includes determining the identity of candidates, materials used for testing, test duration, time of starting and ending the tests, candidates’ behaviour (leaving the room, taking out tests and other materials, copying of results, use of mobile phones, use of literature, asking help from other candidates or examiners, leaving the room without supervision, which is all not allowed), handing the testing materials to the examiner after the testing is completed, start of evaluation, time of entry of results in the administrative system, name of test evaluator, manner of keeping the test materials and scores safe, place of evaluation, keeping details of candidates safe, etc.

If a candidate breaks any testing rules, testing will be terminated for him/her. After the testing the examiner will choose 10 arbitrarily taken tests on the basis on which he/she will prepare a report analysing the time taken to do the test, the evaluation procedure and other facts, in order to determine the accuracy, fairness and methodology of the evaluation, and percentage of passing scores, which will be then classified as outstanding, acceptable or unacceptable.

If the results of the examination of the work of the centre are unsatisfactory, the Ministry of Education and Science, upon the proposal of the CEFT Project Council, may revoke license to such centre.

4.4.3. CEFT Implementation Support Staff

Success of the CEFT Project also depends on the selection, quality and devotion of the staff that will participate in its implementation. The staff required for the successful implementation of the CEFT Project and ICT projects in general may be divided in two groups:

- Instructors that will conduct training in training centres and
- Teachers, employed in schools, that will actively participate in the ICT implementation, and will practically be the beneficiaries of the training conducted in training centres.

4.4.3.1. Personnel in Education and Training Centres

Every education and training centre must have at least two licensed instructors. In addition to general requirements, an instructor must possess the following:

- General information knowledge – familiarity with methods and techniques of IS implementation, database features and operation principles, rules of
structural and modular programming, programming languages, operating systems;

- Computer technical skills – knowledge of principles of operation of computers and communications, trends of hardware and software development and their application;
- Human recourse knowledge and experience.

Manner of organization of staff support in education and training centres is in direct connection with the conception of the CEFT Project development and operation.

4.4.3.2. Staffing Structure in Schools

Teachers should be the operating core of the implementation of ICT in schools, which will together with other school staff form a complete and functional whole. Teachers themselves should record, process and distribute relevant information about the teaching process, as well as define additional requirements for new processing and participate in the development of new areas of application. *Users’ aspects of staffing support do not imply the need for extending the existing human resources but for introducing new methods, qualities and contents of the work of existing personnel in schools.*

The function of the staffing support to the implementation of information technologies in schools will be carried out by means of the existing teaching, administrative and managing staff that will receive appropriate IT training and undergo preparations in education and training centres. To that end, schools should assign a number of teachers to be more intensively engaged in ICT implementation. Their number will depend on the number of students in a school and may vary from school to school.

Depending on the role that the teachers will have in the ICT implementation in the educational system, and on the profile of their field of specialization, two groups of teachers may be discerned:

- **Teachers-IT specialists or ICT administrators** will take care of the functional correctness and usability of the information system, contacts with maintenance providers, IT centre of the Ministry and Telecom, etc. Their additional effort will be specially valuated by the Ministry. One, two or three *teachers-IT specialists* should be chosen from among the teachers in schools, depending on the size of the school, number of shifts etc. The principle of determining the number of teachers-IT specialists may be the following: in schools with up to 400 students, one teacher is to be trained to become an IT responsible, in schools with up to 1,000 students – two teachers-IT responsible, and in schools with over 1,000 students – three teachers-IT responsible;

- **Teachers-instructors** will, after the successfully passed tests and obtained trainer certificates, become professionally involved in the process of training in education and training centres. Their number will depend on the interest shown in particular schools, but should not be less than five, especially in the first phase of CEFT implementation, having in mind the subsequent mass training of teachers and students in schools. Teachers-IT specialists, if they posses appropriate certificates, may be lecturers in education and training centres.

Teachers-IT specialists and teachers-instructors, together with school managing structure, should assume the function of CEFT development and implementation. These persons must be active in the following tasks:

- Process of ICT education,
- Training planning and implementation,
- Exploitation of computer systems in schools in the planned manner,
• Ensuring constant functional correctness of the installed hardware, system and application software and communications,
• Organization of students’ groups and extracurricular activities aimed at increasing IT awareness and culture.

Having in mind that the efficiency of IS use and development in schools is directly correlated to the skills and competencies of teachers, particularly teachers-IT specialists (ICT administrators) and teachers-instructors (trainers in training centres), then they should be very carefully selected in order to be able to successfully apply the new systems. As part of the training of managing structures, these structures should be assisted in designating the best teams for the IS development, i.e., in selecting teachers-IT specialists and teachers-instructors from the ranks of teachers in their schools. The following is important:

- The timetable and required skill levels should be defined in such a way as not to depend on the school calendar and not to impact their professional engagement in the school;
- In designating the number of teachers involved in this process, certain substitute teachers should also be included;
- It is recommended that the teachers-IT specialists and teachers-instructors should be teachers who are in the first half of their working career.

4.4.4. Planning IT Training of Teachers

IT training of teachers in schools should be viewed as a continuing process, in other words, as the basic training and constant updating of the acquired knowledge. The training should be planned for each category of attendees separately, and the level of the training will depend on their prior individual knowledge and specialty. We recommend that training be implemented via education and training centres to be formed by the Ministry of Education and Science and controlled by the Project Council. The training should be planned and implemented in two levels:

A. Basic training,
B. Advanced training.

Basic training should cover the following categories: managing structure, administrative staff and teachers in schools. Advanced courses should be attended by: teachers-IT specialists (ICT administrators), employees of IT Centre of the Ministry and teachers-instructors, i.e., future trainers in education and testing centres.

A special problem in planning the training of teachers is the fact that the process must run parallel to their regular engagement in schools, including their obligatory presence in classrooms. In other words, the process of regular instruction in schools must not be interrupted because of IT training. Since an efficient computer training of teachers requires their presence on at least 30 to 50 classes, and the training centres are not located in the place of their residence or work, the planning and timing of the courses may pose a serious problem.

That is why it is proposed to adjust the timing of the courses to the regular teaching process in the following manner:

1. Teachers who attend courses in their place of residence (or work) would listen to the courses on working days, in the morning or afternoon hours, depending on the shift in which they work.
2. Teachers who must use intercity transport to come to the course would attend the classes on weekend days.

3. Teacher training could be also organized during the summer vacation.

In making plans for the training it should be taken into account that the training must be continuous, must cover as many beneficiaries (teachers) as possible and must be adjusted in form and contents to various levels of attendees in order to reach maximum effect. Special attention should be given to the training of management, because it is the main prerequisite for the success of the planned activities.

The acquisition of additional and specialized skills in the area of organization and use of broader possibilities of information and communication technologies is very desirable for all the categories of attendees, but that is not covered by this project.

4.5. Definition of Priorities

This chapter defines priorities in the system of educating teachers and necessary IT staff in the implementation of information and communication technologies in the Montenegrin educational system, organized in phases. Three implementation phases are foreseen. In accordance with the implementation of the general ICT project, education and training should be harmonized with those three phases of the ICT project, which are then further divided into a number of sub-phases. Some parts of the first and second phase, or the second and third phase may overlap in order to provide efficiency and rationality and reduce the total time needed for the training of teachers in the schools in Montenegro.

4.5.1. Criteria for Selection of Priorities in IT Education System Development

The criteria for the selection of priorities in the development of IT education are the following:

- **Potential benefits** – Potential direct and indirect benefits that may be expected after the introduction of individual functions.

- **Impact on improving the core activity of educational institutions** – Estimation of the number of schools and students that will use results of individual phases of IT education implementation and qualitative effects of those phases. Improvement of the core activity of educational institutions, primarily primary and secondary schools means the upgrading of the level of quality of the instruction and general education of students that may be achieved by active use of computers and Internet in schools. General IT culture of students will also improve.

- **Impact on administrative operations of schools** – Estimation of institutions and staff included in the system of education that will use the results of particular functions of IT education of teachers and other (support and administrative) staff in schools and qualitative effects of their training.

- **Likely successful implementation** – Estimation of how an observed function will be accepted, how technically complex it is and which preconditions for its implementation need to be met.

- **User requirements** – Degree of demand for a certain function by the users, i.e., by teachers in school. Estimation of what impact, in the opinion of teachers and management, a particular function may have on the achievement of the primary goal, i.e., broader IT education in schools, higher IT culture of teachers and students and their preparedness to use computers in their everyday life.
Demand for phased implementation of ICT in the Montenegrin educational system – as a consequence of efficient ICT implementation in Montenegrin schools.

4.5.2. Priorities in IT Education System Development

If the above criteria are given ratings from 1 to 10, the priorities in the development of IT education in schools may be shown as follows (Figure 33):

Based on the above graph, it can be concluded that the formation, or a proper selection, of the main education and testing centre has the highest priority. The level of computer equipment, quality of Internet connections and level of trainers in this centre are crucial for the further implementation of the Project.

Preparation of the detailed plan and fixing the specific timing for the training, due to lower priority, will be considered as part of regular activity of the main centre.

Further order of activities in the process of IT education in schools, considering the defined priorities, would be the following:

- Training of managing staff in schools, Institute for Education, departments, section and units in the Ministry of Education and Science, Vocational Training Centre, Examination Centre and Institute for Textbooks;

- Training of teachers-IT specialists (ICT administrators) and staff of the Ministry’s IT Centre;

- Training of teachers-instructors;

- Training of administrative and other support staff;
Training of other teachers in primary and secondary schools;
Training of students and setting up of IT groups in schools.

In accordance with the need for the phased implementation of the MEIS Project, IT education should be conducted in the following phases:
- In Phase 1 – training in focus schools (30 schools),
- In Phase 2 – training in additional 50 schools.

Phase 4 of the MEIS Project will be identical to Phase 3, from the aspect of training of teachers and IT staff in schools, so that it is not covered by the CEFT Project.

4.5.3. **Stages in IT Education System Development**

Table 19 shows the two phases in the development of IT education in schools, according to the defined priorities. Phase I is divided into four sub-phases and Phase II into three sub-phases. As mentioned, the CEFT Project refers to the first three phases of the MEIS Project only.

To eliminate any "idle time" in the work of education centres, certain phases should be planned in such a way to overlap in time. For example, sub-phase IV of the Phase I and sub-phase I of the Phase II.

**Table 19 - Division of IT Education in Phases**

<table>
<thead>
<tr>
<th>Subsystems</th>
<th>Phase I Focus schools</th>
<th>Phase I Additional 50 schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formation of the main education and testing centre</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Preparation of detailed plan and curricula for the training</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Training of managing staff in schools and central level institutions</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Training of teachers-IT specialists and staff of IT Centre</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Training of teachers-instructors and trainers in education centres</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Organization of network of regional and local education centres</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Training of administrative staff</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Mass training of teachers</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Training of students</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Detailed description of time schedule of computer training, by priorities specified in this chapter, is given in chapter 4.7. (Table 23 and Table 24).
4.6. Organization of Teacher IT Training Development Functions

Organization of the development functions of IT education of teachers consists of planning the activities in the education of teachers and IT staff, i.e., in the process of implementation of the CEFT Project.

Organization of IT education of teachers during the CEFT development will be analysed at the following levels:

- CEFT Project management;
- Operational education of teachers and IT staff.

4.6.1. Project Management

The basic methodological assumption for the successful implementation of the project, in accordance with the standard JUS ISO 12207 (point 4.1.1.2.2.), is the existence of two structures: controlling and operating (or executive). For better management of the Project and better control of its successful implementation, the following structures should be formed:

1. CEFT Project Council
2. Education and Testing Centres

The Project Council should consist of experts in ICT and computer science. The Council will be formed by the Ministry of Education and Science and will report to it.

The Project Council will provide constant control over the work of education and testing centres, as well as timely removal of any malfunctions in their work. The Project Council will have the task to adopt the results of the work of education and testing centres at control points that represent the finalization of individual phases in the Project implementation.

On the other side, if such a body exists, there is no need for a special supervisor of the Project, because the Project will be supervised and verified in that way at all phases of its implementation.

The Project Council does not have to have permanent composition. Depending on the contents to be verified, it can work with a smaller or a larger number of members. It is necessary to appoint a chairman or coordinator from among the council members, who will be contacted for direct assistance by education and testing centres or the organizations and firms that will be entrusted the task to conduct the training and form the centres in resolving disputable situations during the work – between control points.

The CEFT Project Council should have 2 to 3 members.

Education and Testing Centres shall be those to conduct the training. They will perform direct activities related to concrete implementation of the CEFT Project and form the documentation on the number and level of knowledge of attendees that will serve as a basis for verification and for the project implementation daily book. Final working activities will be completed when the planned number of teachers and pupils in primary and secondary schools in Montenegro becomes well trained for working with computers.

Local and regional education and testing centres will be formed by schools. As mentioned, the centres should have at least two trainers that are teachers in those or neighbouring schools who have passed the instructor courses. Coordinators, who may be one of the instructors, will lead the centres. The centre coordinator may also be the school director or assistant director. Figure 34 illustrates the structure of the CEFT Project.
4.6.2. Operational Training of Teachers and IT Staff

Operational training will make teachers and IT staff capable of implementing the ICT in the educational system. For purposes of the training methodology, standards described in ECDL specifications should be used.

4.6.2.1. Programme of IT Training

The programme of IT training of teachers within the CEFT Project is in conformity with the ECDL programme and is actually its broader variant.\(^2\)

---

\(^2\) ECDL Programme is a project of the CEPIS (Council of European Professional Informatics Societies) and is supported by a large number of national informatics societies in the world. The programme implementation is entrusted to the ECDL Foundation (European Computer Driving Licence Foundation, ECDL-F) with the head office in Dublin, Ireland.

ECDL diploma is an internationally recognized standard of IT literacy, which guarantees computer proficiency and necessary user skills. Due to its importance, ECDL Programme gained a role in the whole world.
The training programme for teachers and IT staff covered by the CEFT Project will include the following courses:

1. **Basic Concepts of Information Technology**
2. **Using the Computer and Managing Files**
3. **Word Processing**, e.g., Microsoft Word 2000
4. **Spreadsheets**, e.g., Microsoft Excel 2000
5. **Databases**, e.g., Microsoft Access 2000
6. **Presentation Software**, e.g., Microsoft PowerPoint 2000
7. **Information Network Services**, e.g., Internet, E-mail and World Wide Web
8. **Using the ICT Applications in the Montenegrin Educational System**
9. **Using the Computers in Teaching**

The first seven courses are in full conformity with ECDL programme modules. The additional two courses are relevant for the educational system in Montenegro. Special advantage of the training programme designed in this way and grounded on ECDL recommendations is its independence from manufacturers of computers, system software and programmes. The obtained diplomas this carry greater value and the schools, including the Ministry, will not be conditioned by a particular type of equipment and use of only one kind of system and application software.

4.6.2.2. **Choice of Courses and Levels of Training for Particular Attendee Categories**

Different categories of attendees may attend different courses and study different subjects. The choice of specific courses to be attended will depend on the level of knowledge and skills that the attendees will need to have in their work in schools. There will be five levels of obligatory training of teachers and IT staff in schools:

1. **Training of managing structures** – The managing staff in schools (principals, assistant principals, secretaries, psychologists and pedagogues), Institute for Education, sections of the Ministries of Finance, Professional Training Centre, Examination Centre and Institute for Textbooks will be the main bearers of the development of IT in the educational system and their IT knowledge should therefore receive special attention. They need to be aware of the purpose and significance of ICT introduction in schools and convey it to the remaining part of the school staff.

2. **Training of teachers-IT staff** – Teachers-IT specialized and staff of the IT Centre of the Ministry of Education and Science will have the professional responsibility for the maintenance of the educational information system, so that their IT knowledge needs

---

*There are about 12,000 testing centres for computer knowledge in the world today. So far, 12 million people, from 91 countries, passed the examinations and got the ECDL certificate. In March 2003 only, 2.75 million people in the work applied for an ECDL certificate.*

*The U.K. Department of Health, which employees 1.3 million people, started an ECDL programme for its employees, including both training and testing of them all, from cleaners to doctors.*

*The ECDL concept is supported by: European Commission, UNESCO, the World Bank, ministries of education of Australia, Austria, Netherlands, Hungary, Italy, Jordan and Poland.*
to be at a higher level. They should know all the details about potential problems with hardware, and system and application software. In addition to basic courses, they should also pass advanced levels of other courses.

3. **Training of teachers-instructors** – Teachers-instructors are potential trainers in education and testing centres. They should attend both basic and advanced training. Their knowledge and practical skills must be tested and then verified by appropriate certificates.

4. **Training of administrative staff** – Administrative staff in schools, beside basic courses, should attend courses for working with concrete applications.

5. **Training of teachers** – Training models and methods should be defined so as to cover as many teachers as possible and thereby accomplish the primary goal of the CEFT Project – broadening the IT culture. Majority teachers should attend the basic courses only as well as become familiar with the concrete application that refer to their work.

Training models should be uniform for whole Montenegro. Evaluation of the knowledge must be performed in a uniform manner, according to the accepted standards. In that way, the main objectives of the CEFT Project will be achieved, as follows:

- Efficient computer education of teachers and students;
- Use of computers in the teaching process;
- Much better and more efficient use of Internet;
- Use of a set of ICT applications in the system of education.

Recommendations for obligatory courses for certain categories of attendees are given in Table 23. Possible levels of courses are, depending on the chosen subject: **A** – basic and **B** - advanced. The designation **A** in the Table means that the attendees in that category are obliged to listen and take examinations in basic subjects of that course only. The designation **A+B** means obligatory attendance and taking examinations also of advanced or additional subjects in that area. Subject to the job requirements, the choice of courses and subjects may be extended.

The attendees should also undergo training in the use of ICT applications. Since their jobs are related to different parts of the information system, it is proposed that they take training only in those modules of the ICT applications that are relevant for their jobs. The applications used in educational institutions will contain the following sub-systems:

1. **Basic processes in education**, designation **O**, which encompasses the two sub-systems:
   - **Education**, designation **O.1** and
   - **Central level of educational institutions infrastructure**, designation **O.2**;
2. **Recourses**, designation **R**, main resources, libraries and staff records;
3. **Administrative operations**, designation **AP**, maintaining administrative books;
4. **Strategic management**, designation **SU**, assistance in strategic management (planning, organization, decision-making, etc.);
5. **IS administration**, designation **AIS**, records of codes, database administration, hardware and software maintenance management, problem reporting.
Table 20. Selection of Courses for Individual Trainee Categories

<table>
<thead>
<tr>
<th>Course</th>
<th>Management Structure</th>
<th>Teachers-IT Staff</th>
<th>Teachers-Instructors</th>
<th>Administrative Staff</th>
<th>Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Basic Concepts of IT</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>2. Using the Computers and Managing Files</td>
<td>A</td>
<td>A+B</td>
<td>A+B</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>3. Word Processing</td>
<td>A</td>
<td>A+B</td>
<td>A+B</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>4. Spreadsheet</td>
<td>A+B</td>
<td>A+B</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>5. Databases</td>
<td>A</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Presentation Software</td>
<td></td>
<td></td>
<td>A+B</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>7. Information Network Services and Internet</td>
<td>I+K</td>
<td>I+K</td>
<td>I+K</td>
<td>I+K</td>
<td>I</td>
</tr>
<tr>
<td>8. ICT Applications</td>
<td>O+SU</td>
<td>O.1+R.3+AP</td>
<td>O.1</td>
<td>AP or R or AIS</td>
<td>O.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+SU.1+AIS.2</td>
<td></td>
<td>(See Table 22)</td>
<td></td>
</tr>
<tr>
<td>9. Using Computers in Teaching</td>
<td></td>
<td></td>
<td>A</td>
<td>A</td>
<td></td>
</tr>
</tbody>
</table>

For easier reference, courses will have designations. The designations will consist of a number identifying the course and the letter showing the level of the course. The following table (Table 21) shows this method of designation and the duration and tentative cost of individual courses.

Table 21. Duration and Cost of Individual Courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Course Level or Module</th>
<th>Course Code</th>
<th>Number of Classes</th>
<th>Cost per Trainee [€]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Concepts of IT</td>
<td>A</td>
<td>1A</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Using the Computer and Managing Files</td>
<td>A</td>
<td>2A</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>2B</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Office tools</td>
<td>Word Processing (e.g. MS Word)</td>
<td>A</td>
<td>3A</td>
<td>10</td>
</tr>
</tbody>
</table>
### 4.6.2.3. Software Platforms for Implementation of Training

Thanking to the use of ECDL standards, the training in education centres may be performed on various software platforms. The next table gives examples of two possible software platforms that may be used in education centres.

**Table 22. Examples of Possible Software Platforms**

<table>
<thead>
<tr>
<th>Software Type</th>
<th>Software</th>
<th>Operating System</th>
<th>Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICT Applications</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spreadsheets (e.g. MS Excel)</td>
<td>A 4A</td>
<td>7</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>B 4B</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>Databases (e.g. MS Access)</td>
<td>A 5A</td>
<td>6</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>B 5B</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>Presentation Software (e.g. MS PowerPoint and FrontPage)</td>
<td>A 6A</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>B 6B</td>
<td>6</td>
<td>18</td>
</tr>
<tr>
<td>Information Network Services and Internet (e.g. Internet Explorer and MS Outlook)</td>
<td>I 7I</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>K 7K</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Using Computers in Teaching</td>
<td>A 10A</td>
<td>4</td>
<td>12</td>
</tr>
</tbody>
</table>
### 4.6.2.4. Project Implementation Daily Book

The education and testing centres will have databases of the process and results of the training. The databases will contain daily books registering the attendance of trainees, their activities during the courses and success shown at the examination, separately for each school.

Education centres are obliged to keep records of issued diplomas and certificates, which must be strictly controlled and done according to the standards, and which will include:

- Attendance records,
- Records of exercises and case studies done,
- Examination records.

On the basis of documentation from all education and testing centres, the main book of the project implementation will be made, to serve to the Project Council as the foundation for making decisions about further project activities and their success.

### 4.6.3. Trend of Further Development of IT Training in the Montenegrin Educational System

The activities of the educational system of Montenegro, including its information system, should be in the line with the world standardization trends, regarding both obligatory postulates and recommendations.

The educational system described in the CEFT Project, when implemented, will represent a full and thorough basis for conducting such system of work in the educational system and for reaching the European standards. In accordance with these guidelines, the CEFT Project should keep up and be compatible with current IT developments and achievements of technological progress.

Computer training of teachers in schools should be viewed as a continuing process, which includes the starting basic training and on-going advancement of knowledge. Efforts should be made to provide permanent computer education of teachers that will also continue after the CEFT Project has been formally concluded.
4.6.4. Training Materials

Training materials for the courses held according to ECDL standards, i.e., Syllabus courses, may be found on the following website: http://www.ecdlmanual.org/index.cgi

1. Basic courses:
   Training Manual for ECDL Syllabus 4
   link: http://www.ecdlmanual.org/index.cgi?page=tmfes4

2. Advanced courses:
   Advanced Word Processing for ECDL
   link: http://www.ecdlmanual.org/index.cgi?page=awpfe
   Advanced Spreadsheets for ECDL
   link: http://www.ecdlmanual.org/index.cgi?page=asfe

3. Guidelines for the use of ICT applications.

4. Popular and technical literature and magazines in our language in this area.

4.7. Definition of IT Education System Development Plan

The plan of development of IT education in the educational system of Montenegro includes:

- Time schedule of training of teachers and other staff;
- Definition of needed hardware, system software, personnel and qualification structure of personnel needed for the Main Republican Education and Testing Centre;
- Costs of CEFT implementation by phases.

4.7.1. Provision of Preconditions for Starting the Project

Preconditions to be met before the project can be started are the following:

1. Approval of the Ministry of Education and Science;
2. Provision of funds for the project implementation;
3. Constitution of the Project Council;
4. Start of implementation of the ICT introduction project phase II, that includes:
   - Supplying the focus schools with necessary computer equipment,
   - Installation of local networks and Internet connections for focus schools;
   - Selection of an organization, firm or university institution that will be given the responsibility to form the Main Republican Education and Testing Centre.
### Table 23 - Time Schedule of CEFT Project Phase I

<table>
<thead>
<tr>
<th>Key Events</th>
<th>Sub-Phase I</th>
<th>Sub-Phase II</th>
<th>Sub-Phase III</th>
<th>Sub-Phase IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Providing preconditions for the start of Project Phase One⁵</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Formation of Main Centre</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preparation of detailed training plan and curricula⁴</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training of management structure in schools⁷</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training of management structure in central institutions¹⁰</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training of teachers – IT staff¹⁰</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training of staff of IT Centre of the Ministry¹⁰</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training of teachers – instructors¹⁰</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organization of network of education centres</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training of administrative staff in central institutions¹⁰</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training of administrative staff in schools</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training of accounting staff</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass training of teachers⁶</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student training</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

⁵ Precondition for the start of Phase II is the provision of computer equipment for focus schools in max. 30 days.

⁴ In planning the training, account should be taken to conduct the training in groups, from 10 to 12 lessons per week. Size of groups depends on the capacity of classrooms. The training of trainees from Podgorica should be planned on weekdays, from 2 to 3 lessons per day. Trainees outside Podgorica would attend training on weekends (Saturday and Sunday), from 5 to 6 lessons per day. In that way the training would be adjusted to the school calendar and accommodation expenses in Podgorica would be reduced.

¹⁰ This training is conducted in the Main Education and Testing Centre in Podgorica.

⁶ This training is conducted in the trainees' place of residence or neighbouring place. It should be planned to last 2 or 3 hours a day on weekdays or weekend.
Table 24 - Time Schedule of CEFT Project Phase II

<table>
<thead>
<tr>
<th>Key Events</th>
<th>Sub-Phase I</th>
<th>Sub-Phase II</th>
<th>Sub-Phase III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Providing preconditions for the start of Project Phase Two(^7)</td>
<td>Preparation of detailed training plan and curricula</td>
<td>Training of teachers – IT staff(^{13})</td>
<td>Training of administrative staff in schools</td>
</tr>
<tr>
<td></td>
<td>Training of management structure in schools(^8)</td>
<td>Training of teachers – instructors(^7)</td>
<td>Training of accounting staff</td>
</tr>
<tr>
<td></td>
<td>Organization of network of education centres</td>
<td></td>
<td>Mass training of teachers(^9)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Student training</td>
</tr>
</tbody>
</table>

\(^7\) Precondition for the start of Phase II is the provision of computer equipment for additional 50 schools in max. 30 days.

\(^8\) This training is conducted in the Main Education and Testing Centre in Podgorica.

\(^9\) This training is conducted in the trainees’ place of residence or neighbouring place. It should be planned to last 2 or 3 hours a day on weekdays or weekend.
4.7.2. Definition of Necessary Resources for the Main Education and Testing Centre

The proposed concept of the CEFT education system can be carried out only by forming the appropriate centres for education and testing. The Main Republican Education and Testing Centre should have the following infrastructure:

1. At least 3 computer classrooms (Figure 6) equipped with:
   - 20 + 1 modern computers (e.g. Pentium IV, CPU 2.4 GHz, DDRAM 512 MB, Hard disk 60 GB, 17” monitor CD/DVD drive, LAN)
   - one printer,
   - one scanner,
   - a video-projector and a smart-board.

2. Classrooms must be spacious, with proper lights and air conditions.

3. At least 8 available teachers.

4. Manager of the centre who can be a professional or one of the teachers.

5. One administrative worker – a secretary of the centre with secondary school qualifications whose job would be to:
   - communicate with schools, course attendees and teachers,
   - keep the entire records of the Centre,
   - take care of the implementation of the defined timetable of courses,
   - take care of the provision of testing material,
   - keep accounting records.

![Figure 35 - A Computer Classroom in the Main Education and Testing Centre](image-url)
4.7.3. CEFT Implementation Costs by Phases

The estimate of required funds for implementation of the CEFT Project (Table 25) is given separately for the first and the second variant of the Main Education and Testing Centre. The estimate does not include travel expenses, daily spending and hotel accommodation for teachers who will attend the courses away from their place of residence, as with an appropriate timetable of courses these expenses can be reduced to minimum.

<table>
<thead>
<tr>
<th>Implementation Cost of Project Phase 1 (additional 50 schools)</th>
<th>Number of Attendees</th>
<th>Number of Lessons</th>
<th>Amount [€]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financing the Project Council (2 members)</td>
<td></td>
<td></td>
<td>4,200</td>
</tr>
<tr>
<td>Costs of financing the Main Centre</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lease of 2 classrooms of 80 m² (each)</td>
<td></td>
<td>19,200</td>
<td></td>
</tr>
<tr>
<td>ISDN Internet connection</td>
<td></td>
<td>3,600</td>
<td></td>
</tr>
<tr>
<td>Equipment and classrooms maintenance</td>
<td></td>
<td>3,600</td>
<td></td>
</tr>
<tr>
<td>Centre manager’s salary</td>
<td></td>
<td>12,000</td>
<td></td>
</tr>
<tr>
<td>Centre secretary’s salary</td>
<td></td>
<td>7,200</td>
<td></td>
</tr>
<tr>
<td>Training and testing of schools’ management</td>
<td>200</td>
<td>48</td>
<td>28,800</td>
</tr>
<tr>
<td>Training and testing of IT teachers</td>
<td>100</td>
<td>90</td>
<td>27,000</td>
</tr>
<tr>
<td>Training and testing of teachers - instructors</td>
<td>200</td>
<td>78</td>
<td>46,800</td>
</tr>
<tr>
<td>Training of administrative personnel</td>
<td>200</td>
<td>44</td>
<td>17,600</td>
</tr>
<tr>
<td>Mass training of teachers</td>
<td>1,250</td>
<td>52</td>
<td>130,000</td>
</tr>
<tr>
<td><strong>TOTAL for Phase 2:</strong></td>
<td><strong>2,000</strong></td>
<td><strong>300,000</strong></td>
<td></td>
</tr>
</tbody>
</table>

Recapitulation of the cost estimate for CEFT project (variant 1) | Amount [€] |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PHASE 1</strong></td>
<td>370,896</td>
</tr>
<tr>
<td><strong>PHASE 2</strong></td>
<td>300,000</td>
</tr>
<tr>
<td><strong>Total for CEFT Project:</strong></td>
<td><strong>670,896</strong></td>
</tr>
</tbody>
</table>

*Table 25 Cost of the CEFT Project Implementation*
**Organization of MEIS Development Functions**

<table>
<thead>
<tr>
<th>central level institutions</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Training and testing of IT teachers and employees of the IT Centre of the Ministry</td>
<td>69</td>
</tr>
<tr>
<td>Training and testing of teachers - instructors</td>
<td>150</td>
</tr>
<tr>
<td>Training of administrative personnel</td>
<td>83</td>
</tr>
<tr>
<td>Mass training of teachers</td>
<td>1,060</td>
</tr>
</tbody>
</table>

**TOTAL for Phase 1:**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1,502</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Implementation Cost of Project Phase 2 (additional 50 schools)</th>
<th>Number of Attendees</th>
<th>Number of Lessons</th>
<th>Amount [€]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financing the Project Council (2 members)</td>
<td></td>
<td></td>
<td>2,400</td>
</tr>
<tr>
<td>Costs of financing the Main Centre</td>
<td>Centre manager's fee</td>
<td>3,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Administrative worker's fee</td>
<td>1,800</td>
<td></td>
</tr>
<tr>
<td>Training and testing of schools’ management</td>
<td>200</td>
<td>48</td>
<td>28,800</td>
</tr>
<tr>
<td>Training and testing of IT teachers</td>
<td>100</td>
<td>90</td>
<td>27,000</td>
</tr>
<tr>
<td>Training and testing of teachers - instructors</td>
<td>200</td>
<td>78</td>
<td>46,800</td>
</tr>
<tr>
<td>Training of administrative personnel</td>
<td>200</td>
<td>44</td>
<td>17,600</td>
</tr>
<tr>
<td>Mass training of teachers</td>
<td>1,250</td>
<td>52</td>
<td>130,000</td>
</tr>
</tbody>
</table>

**TOTAL for Phase 2:**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2,000</td>
</tr>
</tbody>
</table>

**Recapitulation of the cost estimate for CEFT project (variant 2)**

<table>
<thead>
<tr>
<th></th>
<th>Amount [€]</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHASE 1</td>
<td></td>
</tr>
<tr>
<td>PHASE 2</td>
<td></td>
</tr>
<tr>
<td>Total for CEFT Project:</td>
<td>491,146</td>
</tr>
</tbody>
</table>
4.8. Course Programme

Elementary Computer Courses (A)

1A. Basic Concepts of IT

The concept of information technology provides the course attendees with the knowledge of some of the main IT characteristics. When they complete the course, the candidates are required to show basic knowledge of computers – general characteristics of hardware and software, concept of information technologies’ functioning in the sense of entering and saving data and programs. Additionally, they should understand the functioning of information networks and the use of computers in everyday life.

2A. Use of Computers and File Management

This module requires the candidates to demonstrate the knowledge and the skills in the use of usual functions of a personal computer and its operating system. A candidate should be able to make the main adjustments on a computer. A computer user should work efficiently in the desktop environment and deal with icons and windows. In addition, he/she should be able to manage files and directories/folders. An attendee should demonstrate the capability to use the simplest tool for printer management.

3A. Word Processing

The attendees are required to learn how to use the application for word processing. After this course they should be able to perform independently everyday tasks related to creating, formatting and correcting documents and preparing them for distribution. Furthermore, the attendees are required to handle the technique of copying contents within one or between different documents. In addition, creating and manipulating tables, as well as working with graphical elements of a document are the mandatory knowledge.

4A. Spreadsheets

The aim of this training is for attendees to grasp the concept of spreadsheet processing and learn how to use the application for spreadsheet processing on a computer. After the training completion, the attendees should be able to carry out the tasks related to creating, formatting, modifying and use of spreadsheets and worksheets of limited volumes ready for distribution. Additionally, they should master the use of mathematical formulas by using standard formulas and functions, as well as creating and formatting graphical elements.

5A. Databases

The aim of this part of training is for attendees to understand some of the main concepts of databases and to demonstrate the ability to manage databases on a computer. The attendees should be trained to create and modify tables, queries, forms and reports, and to prepare the last-mentioned for distribution. They should also be able to make relationships between tables, obtain data and manipulate them by using tools for queries and tools for sorting available in the package.
6A. Presentation Software

The aim of this part of training is for attendees to learn how to use presentation applications on a computer. After the training, the attendees should be able to perform independently the tasks such as: creating, formatting, modifying, and preparing presentations by using different organization of slides on the screen or in printed form. In addition, they should be able to duplicate or move texts, slides, and graphs within a presentation or between presentations. Furthermore, it is important for them to learn how to manipulate pictures, graphs, and drawings, as well as to handle different effects related to the presentation and slide show.

7. Use of Network Services and Internet

This course is divided in two sections. The first one is called Information and requires the attendees to understand some concepts and terms related to the Internet, as well as to answer some questions regarding data security in the network. They should also be able to do some simple network search by using Web browser application and available search tools. Knowledge of site bookmarking, site printing, and printing of search results is also required. Besides the aforementioned, an attendee must also learn the navigation through forms within a Web page. The second section, Communications, implies acquiring knowledge of the use of electronic mail (e-mail) and security issues related to this service. It is essential to learn how to use applications for receiving and sending e-mails, and the procedure for attaching files to a message (attachment), as well as the methods for organizing messages in files/directories.

Advanced Computer Courses (B)

2B. Use of Computers and File Management – Advanced Level

Attendees of this course are required to demonstrate the knowledge and skill in the use of advanced functions of a personal computer and its operating system. A candidate should be able to make main adjustments on a computer and to handle the situations when an application does not respond to usual commands. A computer user should be able to efficiently compress and decompress files. The attendees should learn what computer viruses are and how to use antivirus software. They should demonstrate the ability to use simpler tools for editing and printer management.

3B. Word Processing – Advanced Level

This advanced level enables a user to utilize word processing applications more efficiently than on the elementary level, which implies the following: generating different text forms by using more advanced formatting techniques, illustration of sophisticated topographies, formatting and presentation of schemes, working with tables, forms and graphs, mail merge – text patterns.

4B. Spreadsheets – Advanced Level

The advanced course on applications for spreadsheets should teach a user to utilize these applications with a much thorough knowledge of some of their features. Candidates on this level are taught to edit and correct numerical, textual and graphic data on a higher level, and to sort, prepare queries and connect data. In addition, they should learn advanced formatting
techniques, as well as adding presentation features to graphs. Furthermore, this training comprises the use of functions for logical, mathematical and statistical operations, as well as running and recording simple macros.

5B. Databases – Advanced Level
This course should provide attendees with much better knowledge of the use of application for a database so they could make a better use of its advantages. An attendee should use the base for organizing, obtaining and reviewing of data, and for creating reports. A special emphasis should be placed on different methods for presentation of data. Besides that, an attendee should learn how to create and use macros, as well as the methods of importing, exporting, and connecting data.

6B. Presentation Software – Advanced Level
The advanced level programs for making computer presentations includes acquiring the knowledge and comprehension of the principles for planning and designing presentations. An attendee should make a better use of the application for preparing presentations and to create them by using advanced features of the application, such as advanced formatting, arranging techniques, and use of multimedia in presentations. The attendees should also learn advanced techniques of the utilization of graphs in presentations, as well as the tools for creating and modifying drawings. Mastering the creation and use of macros is preferable.

Set ICT Application

O. Main Education Processes

O.1 Education

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Description</th>
<th>Responsibility of</th>
<th>Numbrer of Lessons</th>
<th>Place</th>
</tr>
</thead>
<tbody>
<tr>
<td>O.1.1 Schools</td>
<td>Keeping main records of schools as legal entities</td>
<td>Administration employee</td>
<td>5</td>
<td>The Ministry</td>
</tr>
<tr>
<td>O.1.1.1 Parent schools</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O.1.1.2 Regional units</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O.1.2 Lessons</td>
<td>Keeping records of curricula and syllabus</td>
<td></td>
<td>15</td>
<td>The Institute and the Centre for Professional Education</td>
</tr>
<tr>
<td>O.1.2.1 Curricula</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O.1.2.2 Syllabus</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O.1.3 Classes</td>
<td>Keeping records of classes</td>
<td>Management O.3.1 and O.3.2, teacher on duty O.3.3</td>
<td></td>
<td>School</td>
</tr>
<tr>
<td>O.1.3.1 Class forming</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O.1.3.2 Timetables</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O.1.3.3 Lessons frequency</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Organization of MEIS Development Functions

#### O.1.4 Students
- **O.1.4.1** Basic information on students
- **O.1.4.2** Students’ accomplishments and grades
- **O.1.4.3** Discipline and absence
- **O.1.4.4** Prizes
- **O.1.4.5** Supplemental exams
- **O.1.4.6** Makeup exams
- **O.1.4.7** Other relevant data on students’ accomplishments (competitions, foreign languages…)
- **O.1.4.8** More complex health problems

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Description</th>
<th>Responsibility of</th>
<th>Number of lessons</th>
<th>Place of processing</th>
</tr>
</thead>
<tbody>
<tr>
<td>O.1.4.4</td>
<td>Keeping complete records of students</td>
<td>Class teacher, or a teacher, and a psychologist for O.4.8 (psychological problems)</td>
<td>School</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>O.1.5</strong> School competitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keeping records of school competitions organized by the institutions in Montenegro</td>
</tr>
<tr>
<td>Administration employee</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>The Institute and the Centre for Professional Education</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>O.1.6 Teachers</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Attended courses</td>
</tr>
<tr>
<td>Knowledge of languages</td>
</tr>
<tr>
<td>Published papers</td>
</tr>
<tr>
<td>Keeping records of teachers (promotions)</td>
</tr>
<tr>
<td>Administration employee</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>The Institute and the Centre for Professional Education</td>
</tr>
</tbody>
</table>

### O.2 Central level of the infrastructure of educational institutions

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Description</th>
<th>Responsibility of</th>
<th>Number of lessons</th>
<th>Place of processing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>O.2 Central level of educational institutions infrastructure</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>O.2.1</strong> The Ministry, Institute of Education, Exam Centre IC, Inspectorate, Centre for Professional Education</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Processes specific for these institutions would be automated here</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Administration employee</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stated institutions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>O.2.6</strong> Institute for Textbooks</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## R. Resources

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Description</th>
<th>Responsibility of</th>
<th>Number of Lessons</th>
<th>Place</th>
</tr>
</thead>
<tbody>
<tr>
<td>R.1 Personnel</td>
<td>keeping records of basic data on personnel</td>
<td>Legal department employee</td>
<td></td>
<td>The Ministry</td>
</tr>
<tr>
<td>R.2 Equipment</td>
<td>Description: Keeping basic records of fixed assets and library</td>
<td>Employer designated for keeping records for R.2.1; For R.2.2.1 a local operator; For R.2.3 librarian</td>
<td></td>
<td>The Institute and the Centre for Professional Education</td>
</tr>
<tr>
<td>R.2 Buildings</td>
<td>R.2.2.1 Records on computer equipment and its maintenance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R.3 Material</td>
<td>Records of consumables (e.g. oil for heating)</td>
<td>Accountant</td>
<td>6</td>
<td>School</td>
</tr>
<tr>
<td>R.4 Accounting operations</td>
<td>Covers overall accountancy department operations in accordance with the legislation</td>
<td>Accountant</td>
<td>6</td>
<td>Administrative worker</td>
</tr>
<tr>
<td>R.4.1 General ledger</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R.4.2 Fixed assets ledger</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R.4.3 Salaries</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R.4.4 Authors’ fees</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## AP. Administrative Operations

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Description</th>
<th>Responsibility of</th>
<th>Number of Lessons</th>
<th>Place</th>
</tr>
</thead>
<tbody>
<tr>
<td>AP.1 Administrative operations</td>
<td>Administrative bookkeeping</td>
<td>Legal department employee</td>
<td>12</td>
<td>All the institutions</td>
</tr>
</tbody>
</table>

## SU. Systems Management

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Description</th>
<th>Responsibility of</th>
<th>Number of Lessons</th>
<th>Place</th>
</tr>
</thead>
<tbody>
<tr>
<td>SU.1 Subsystem as a part of schools</td>
<td>This is primarily use of reports on different levels</td>
<td>Management</td>
<td>8</td>
<td>All the institutions</td>
</tr>
<tr>
<td>SU.2 Subsystem as a part of the central level</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
AIS. Administration of IS

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Description</th>
<th>Responsibility of</th>
<th>Number of Lessons</th>
<th>Place</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIS.1 Central level</td>
<td>Registering of codebook</td>
<td>AIS.1 IT Centre worker</td>
<td>3x6</td>
<td>IT Centre of the Ministry of Education and Science</td>
</tr>
<tr>
<td>AIS.1.1 Database administration</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AIS.1.2 Hardware and software maintenance management</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AIS.2 Local level</td>
<td>Minimum hardware and software maintenance</td>
<td>AIS.2 Local operator</td>
<td></td>
<td>All the institutions</td>
</tr>
<tr>
<td>AIS.2.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AIS.2.2 Malfunction reporting</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The previous table shows the structures that should be trained for using a set of ICT applications and the subsystems these structures should be trained for. In the first phase, the training should be conducted for 30 focus schools and central institutions. IT teacher or IS administrator in schools is, in fact, a local operator from AIS.2. Review of training for the set of ICT applications is divided in 8 basic categories (Table 26). Manual for Users will be printed for this training.

Table 26 Detailed Training Schedule for the Set of ICT Applications

<table>
<thead>
<tr>
<th>Attendees</th>
<th>Subsystem</th>
<th>Number of Attendees</th>
<th>Number of Lessons</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Employees of the IT Centre of the Ministry</td>
<td>Complete set of ICT applications</td>
<td>4</td>
<td>40</td>
<td>Two workers with university degree in Informatics and two operators</td>
</tr>
<tr>
<td>2 IS administrators in schools (IT teachers)</td>
<td>Complete set of applications, except SU.2 and AIS.1</td>
<td>60</td>
<td>35</td>
<td>Two per school</td>
</tr>
<tr>
<td>3 School managements and teachers</td>
<td>Classes and students, i.e. O.1.3 and O.1.4</td>
<td>around 1400</td>
<td>15</td>
<td>Elementary training for teachers</td>
</tr>
<tr>
<td>4 Administrative workers in the Institute and the Centre for Professional Education</td>
<td>The Institute and the Centre for Professional Education operations O.1.2, O.1.5 and O.1.6</td>
<td>7</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>5 Administrative workers in the central level institutions</td>
<td>The Ministry, the Test Centre and the Institute for Textbooks operations</td>
<td></td>
<td></td>
<td>Specific operations in central level institutions</td>
</tr>
<tr>
<td></td>
<td>The Ministry AIS.1.1 for O.1.1</td>
<td>1</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Test Centre AIS.1.2</td>
<td>3</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Institute for Textbooks AIS.1.3</td>
<td>1</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>6 Administrative workers in administrative operations</td>
<td>Administrative operations</td>
<td>35</td>
<td>12</td>
<td>30 focus schools and 5 central level</td>
</tr>
</tbody>
</table>
**Organization of MEIS Development Functions**

<table>
<thead>
<tr>
<th>Schools and Central Level Institutions</th>
<th>Institutions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Employees in Accountancy Department</strong></td>
<td>Resources R.3 and R.4</td>
</tr>
<tr>
<td><strong>School Management</strong></td>
<td>Subsystem for assistance in strategic management in schools SU.1</td>
</tr>
<tr>
<td><strong>Central Institutions</strong></td>
<td>Subsystem for assistance in strategic management on central level SU.2</td>
</tr>
</tbody>
</table>

**Note:** Additional courses on database administration (30 lessons) should be organized for employees in the IT Centre.
5. ORGANIZATION OF MEIS DEVELOPMENT FUNCTIONS

This chapter deals with planned operative preparation of Information System, that is, the MEIS project. Organization of MEIS development is analysed on the following levels:

1. MEIS project management,
2. Operative preparation of MEIS,
3. MEIS maintenance.

5.1. IS Implementation Entities

The main methodological presumption for a successful project implementation, which is in accordance with JUS ISO 12207 (point 4.1.1.2.2.), is the existence of two structures – operative and control, and those are:

1. Project Council (control)
2. Project management (control and operative)
3. Implementation teams (operative)
4. IT Centre (operative)
5. Coordinators (operative)

Management structures are defined as a part of the Strategy. Volume of the management structure has been reduced, and some of the structures, such as the ICT committee, have been cancelled.

5.1.1. Project Council

The Project Council should consist of experts in the fields of information technology and education.

The main task of the Project Council is the strategic guidance of the project, control and verification of implementation teams’ and project management’s results. The Project Council function provides a constant project control with a timely elimination of potential flaws in its implementation. Detailed description of the Council’s tasks is given in the Strategy, of which we single out the following:

- Prepares and adopts general framework of the strategy for MEIS implementation in the education system of the Republic of Montenegro;
- Investigates and analyses problems in the general and special ICT usage policy, its interaction in the general education policy, i.e. reform;
- Enacts decisions on establishment of the project management and the structure of coordinators in schools and other education institutions;
- Adopts the plan and the dynamics, and adjusts the development of MEIS in accordance with the project management reports;
- Considers proposals of new curricula and gives opinions and suggestions;
- Performs evaluations during and at the end of the project phases (milestones);
- Proposes organization of seminars and other forms of education of the project participants;
- Adopts the project management financial reports;
However, with the existence of this body there is no need for a separate project supervisor because the project will be controlled and verified in all the implementation phases.

**Composition of the Council:** The Ministry of Education and Science forms the ICT Council. The Project Council does not have to be of a permanent composition. Depending on the phase that is verified, it can be of broader or narrower composition. It is necessary to name the president - coordinator from the Council structure to whom an operating team or project management will turn to when seeking for immediate assistance in settling disputable situations during their work.

The Council shall consist of 12 members. It is preferable for them to be from the Ministry of Education and Science, educational institutions, the University of Montenegro, the Secretariat for Development, and other domestic and foreign donor organizations and associations that support the project financially or in some other way. The narrower composition of the Council should count 6 members.

### 5.1.2. Project Management

Management of the project is a constant control body, i.e. supervision, and at the same time it is the leading body for the project implementation. Since numerous teams participate in the implementation of this project (team for the application preparation, team for the network creation, team for hardware and software installation, team for training, and so on), it is necessary for the project management to coordinate and supervise them. Moreover, management of the project represents the bond between the Council and implementation teams. It is preferable for members of the management to be from implementation teams so they could be directly involved in the project implementation. The ICT committee's tasks specified in the Strategy are taken over by the project management. In addition to the aforementioned duties, the project management should:

- Harmonize the work of ICT coordinators for the purpose of the realization of planned activities;
- Initiate partnerships on a local level with a view to providing infrastructure and participation in financing the required ICT capacities and multimedia educational projects, pilot projects, and so on;
- Prepare drafts of strategic recommendations for the modernization of education and the system of training for teachers and other ICT users in cooperation with the implementation participants and other partners;
- Coordinate the work of different levels of education and partners, local and regional authorities, focus schools, companies, administrative authorities and associations;
- Organize workshops, seminars, bulletins, interviews and press conferences with a view to informing the general public and training of the participants in the project implementation;
- Submit reports to the ICT Council every three months;
- Approve use of funds in accordance with the defined financial plan;
- Fulfil other tasks imposed by the ICT Council, as well as the activities in the function of the project improvement.

**Composition of the project management:** The project management should consist of 7 members. Since forming of the IT Centre is anticipated in the future, we believe that it would be best if 2 members of the management were to be workers of the future IT Centre. The Ministry of Education and Science elects the project management. One of the members has to be the project manager with a rich experience in the ICT field. As the number of carried out work increases, the number of the project management members reduces in time.

The project manager is the most responsible person for the project implementation, and his duties are:
• Operative planning and the project supervision;
• Coordination of the project management operations;
• Supervision of the ICT implementation and some of its phases;
• Supervision of project implementers;
• Coordination of different levels and partners;
• Project promotion; preparation and organization of workshops, seminars, and so on;
• Preparation and submission of reports to the Council (at least on quarterly basis);
• Taking care of expenses in accordance with the financial plan;
• Fulfilling of other tasks imposed by the Council.

5.1.3. Implementation Teams

Implementation teams are bearers of direct implementation of the MEIS project. Team leaders lead teams. Implementation teams are formed when necessary. For example, team for creation of computer network, team for application implementation, and so on.

5.1.4. IT Centre

At the beginning, MEIS management would be entrusted to the project management, and as the implementation of MEIS advances it would be taken over by IT CENTRE. The management shall be cancelled after MEIS is put in operation. Therefore, in about three years, the main leader of MEIS development, management and maintenance will be IT Centre.

5.1.5. Coordinators

The job of a coordinator is primarily to support the exploitation of MEIS. Two levels of coordinators should be formed: regional and local. We suggest some of the local coordinators to be regional coordinators as well.

5.1.5.1. Regional Coordinator

The job of a regional coordinator is to:

• coordinate the local coordinators` work;
• carry out tasks imposed by the project management;
• ensure that development plan of a school or an institution is in accordance with the ICT project;
• cooperate with a local community;
• submit two-month reports to the management of the project.

5.1.5.2. Local Coordinators (in Focus Schools or an Institution)

The job of a coordinator in a school or an institution is to:

• monitor the activities on the introduction of ICT in schools and institutions;
• propose participants in some of the activities in the implementation process;
• prepare appropriate procedures for implementation of the ICT policy of a school, as well as for the review and evaluation of the ICT effects on the process of teaching and studying;
• give advice to teachers and other ICT users about the content, and training of designated levels which are in accordance with curricula and development plans;
• mediate in maintenance and purchase of ICT equipment;
• cooperate closely with management, teachers, students, or other partners;
• ensure the quality of premises and other conditions to remain on a high level;
• report to regional coordinators on current activities;
• cooperate with parents;
• perform other tasks imposed by the project management or a regional coordinator.

5.2. Personnel of IT Centre

Bearing in mind the volume and the complexity of MEIS, it is necessary to form the IT Centre. All servers would be located there. At the beginning, MEIS management would be entrusted to the project management, and as the implementation of MEIS advances it would be taken over by the IT Centre. We propose the following job positions within the IT Centre:

1. IT CENTRE MANAGER
2. DATABASE ADMINISTRATOR
3. SYSTEM ENGINEER
4. SYSTEM OPERATOR

The first phase anticipates one person for each of the aforementioned jobs. IT Centre organization chart and job descriptions are given below.

![IT Centre Organizational Chart](image-url)
### 5.3. Time Schedule of Main Project Implementation Phases 1 and 2

<table>
<thead>
<tr>
<th>Key Events</th>
<th>Start Date</th>
<th>End Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Application</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Invitation to bid for the applications</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Selection of contractor and contract signing</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Preparation of application</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Application installation and testing</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Import of data</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Application maintenance</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Phase 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Networks and Hardware</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Invitation to bid for network and hardware creation</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Selection of contractor and signing contract on network and hardware</td>
<td>110</td>
<td>110</td>
</tr>
<tr>
<td>Creation of network and installation of hardware and software</td>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td>Network and hardware maintenance</td>
<td>130</td>
<td>130</td>
</tr>
<tr>
<td>Training</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preparation of training plan and selection of teachers</td>
<td>140</td>
<td>140</td>
</tr>
<tr>
<td>Training of staff on basic MS tools</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td>Training of staff for working with application</td>
<td>160</td>
<td>160</td>
</tr>
<tr>
<td>Training of students</td>
<td>170</td>
<td>170</td>
</tr>
</tbody>
</table>
5.4. Total Expenses of MEIS Introduction and Maintenance for Phases 2 and 3

<table>
<thead>
<tr>
<th>Subproject</th>
<th>Phase 2</th>
<th>Phase 3</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I-MEIS (implementation of IS, i.e. preparation of application)</td>
<td>180,000</td>
<td></td>
<td>180,000</td>
</tr>
<tr>
<td>2. PA-MEIS (Implementation of physical infrastructure of IS)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.2. MEN (Computer network)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.2.1. Implementation of MEN</td>
<td>227,600</td>
<td>380,000</td>
<td>607,600</td>
</tr>
<tr>
<td>2.2.2. Link lease for a year with com. equipment</td>
<td>144,000</td>
<td>240,000€</td>
<td>384,000€</td>
</tr>
<tr>
<td>2.3. Hardware and software</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.3.1. Hardware installation</td>
<td>1.178,900</td>
<td>1.862,500</td>
<td>3.041,400</td>
</tr>
<tr>
<td>2.3.2. Software installation</td>
<td>164,900</td>
<td>33,350</td>
<td>198,250</td>
</tr>
<tr>
<td>3. CEFT implementation (computer training of staff)</td>
<td>233,750</td>
<td>257,400</td>
<td>491,150</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td>2,129,150€</td>
<td>2,773,250€</td>
<td>4,902,400€</td>
</tr>
</tbody>
</table>
### Cost of MEIS Project Maintenance (Phases 2 and 3) for a Three-Year Period

<table>
<thead>
<tr>
<th>COST DESCRIPTION</th>
<th>YEAR 1</th>
<th>YEAR 2</th>
<th>YEAR 3</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HARDWARE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PHASE ONE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardware replacement</td>
<td>82,950</td>
<td>82,950</td>
<td>71,750</td>
<td>237,650</td>
</tr>
<tr>
<td>Contracted annual maintenance</td>
<td>84,000</td>
<td>84,000</td>
<td>84,000</td>
<td>252,000</td>
</tr>
<tr>
<td>Maintenance at call</td>
<td>12,000</td>
<td>5,000</td>
<td>5,000</td>
<td>22,000</td>
</tr>
<tr>
<td><strong>TOTAL for Phase One</strong></td>
<td>178,950</td>
<td>171,950</td>
<td>160,750</td>
<td>511,650</td>
</tr>
<tr>
<td><strong>PHASE TWO</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardware replacement</td>
<td></td>
<td>138,250</td>
<td>119,583</td>
<td>257,833</td>
</tr>
<tr>
<td>Contracted annual maintenance</td>
<td></td>
<td>140,000</td>
<td>140,000</td>
<td>280,000</td>
</tr>
<tr>
<td>Maintenance at call</td>
<td></td>
<td>8,333</td>
<td>8,333</td>
<td>16,666,67</td>
</tr>
<tr>
<td><strong>TOTAL for Phase Two</strong></td>
<td></td>
<td>286,583</td>
<td>267,916</td>
<td>554,500</td>
</tr>
<tr>
<td><strong>TOTAL for HARDWARE</strong></td>
<td>178,950</td>
<td>458,533,33</td>
<td>428,666,67</td>
<td>1,066,150</td>
</tr>
<tr>
<td><strong>LINK LEASE</strong></td>
<td></td>
<td>144,000</td>
<td>384,000</td>
<td>528,000</td>
</tr>
<tr>
<td><strong>SOFTWARE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oracle software upgrade 15 %</td>
<td></td>
<td></td>
<td></td>
<td>21,680</td>
</tr>
<tr>
<td>Oracle technical assistance 7%</td>
<td></td>
<td></td>
<td></td>
<td>10,120</td>
</tr>
<tr>
<td>MEIS application maintenance</td>
<td></td>
<td></td>
<td></td>
<td>36,000</td>
</tr>
<tr>
<td><strong>TOTAL for SOFTWARE</strong></td>
<td></td>
<td></td>
<td></td>
<td>57,680</td>
</tr>
<tr>
<td><strong>COST OF COUNCIL AND PROJECT MANAGEMENT</strong></td>
<td>40,000</td>
<td>30,000</td>
<td>10,000</td>
<td>80,000</td>
</tr>
<tr>
<td><strong>TOTAL for MAINTENANCE</strong></td>
<td>218,950</td>
<td>660,653</td>
<td>862,346</td>
<td>1,731,830</td>
</tr>
</tbody>
</table>
5.5. Key Problems in MEIS Implementation and Proposed Solutions

When speaking of IS automation, practice in the world shows that only 19% of them are carried out correctly. We have similar problems, maybe even more obvious. The following table presents potential problems in the implementation of MEIS and proposed solutions.

Table 27- Potential Problems in MEIS Implementation and Proposed Solutions

<table>
<thead>
<tr>
<th>PROBLEMS</th>
<th>PROPOSED SOLUTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>The practice proves that IS automations are often not completed in full, or they wind up on partial solutions.</td>
<td>It should be insisted on putting all MEIS details in full function.</td>
</tr>
<tr>
<td>Resistance by a community or a user towards ICT.</td>
<td>Animate employees to use ICT. Evaluate the knowledge of ICT and employees’ engagement and reward employees accordingly. Introduce the ICT knowledge to be one of the factors influencing promotions.</td>
</tr>
<tr>
<td>Legislation in the process of enactment.</td>
<td>Project and implement the application to be as flexible as possible. Conclude a contract with a performer of work in the application implementation project underlying the problem and binding the performer to honour any legal changes during the implementation.</td>
</tr>
<tr>
<td>Not updated and untimely keeping of databases by employees.</td>
<td>Make a strategy of working with database and specify the consequences in the case of inadequate updating.</td>
</tr>
<tr>
<td>Inadequate or no didactic software for some areas, i.e. subjects.</td>
<td>We believe that the experts from the Institute of Education and the Centre for Professional Education (responsible for certain subjects) should be the ones to explore and find didactic software perfect for teaching. Additionally, they should work out and control the use of didactic software. Another solution is to engage people from the teaching staff (proposed by the Institute or the Centre) who are interested in exploring didactic software by searching on the Internet or contacting colleagues, students, and so on.</td>
</tr>
<tr>
<td>At the beginning, we will have a variety of institutions connected to the integral IS and institutions on the waiting list for connection. In that case we will not have the actual review of the complete education. For example, we will not have the total number of students in database, but only the number of students from schools which are stored in database. Additionally, we will not have an update on certain levels of students monitoring. For example, a student is in a school which is not connected to database, but he/she won some school competition – the student will be filed as a contestant, but with incomplete data (e.g. without</td>
<td>The best solution is to integrate all schools in MEIS as soon as possible. However, if that is impossible, we propose the interim solution where data on a school without the implemented IS will be entered in a nearby school with the implemented IS. Not all data have to be entered, just those relevant from the global reports aspect. These interim solutions should be implemented in the application. Entering of these data could also be organized in IT Centre where several operators would be temporarily engaged at the beginning.</td>
</tr>
<tr>
<td><strong>official registration number</strong>). When IS starts working in his/her school, indirect connection of the student’s personal data and his/her contestant data will have to be made.</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td></td>
</tr>
<tr>
<td><strong>Bad codebook keeping in database resulting in bad quality reports.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Centralized codebook keeping with the request procedure to IT Centre for codes updating. This work method is implemented in the Logical Architecture project.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Data unprotected from an unauthorized use.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>All the levels of security from an unauthorized working in database are specified and designed in the Logical Architecture project.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Poor IS maintenance.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Maintenance project specifies the procedures for IS maintenance. Additionally, logical architecture defines the system for IS monitoring and maintenance.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Bad selection of staff, primarily MEIS coordinators. Negligence and non-engagement by coordinators or their changing of job.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>In order for someone to become a coordinator, he/she has to pass the exams with best grades. He/she has to be stimulated financially or with reduced number of lessons. We also have to have backup solutions for coordinators.</strong></td>
<td></td>
</tr>
</tbody>
</table>