ITHEA

International Journal

INFORMATION CONTENT & PROCESSING

2018 Volume 5 Number 3

International Journal
INFORMATION CONTENT & PROCESSING
Volume 5 / 2018, Number 3

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International Journal "INFORMATION CONTENT AND PROCESSING" Volume 5, Number 3, 2018

Edited by the **Institute of Information Theories and Applications FOI ITHEA**, Bulgaria,
in collaboration with: University of Telecommunications and Posts, Bulgaria,
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Publisher: **ITHEA®** Sofia, 1000, P.O.B. 775, Bulgaria. www.ithea.org , e-mail: office@ithea.org
Technical editor: **Ina Markova**
Printed in Bulgaria

ISSN 2367-5128 (printed) **ISSN 2367-5152 (online)**

A MULTI-LAYER APPROACH OF VIEW MODELS DESIGNING

Olena Chebanyuk, Olexandr Palahin

Abstract: *Interface prototyping is a progressive approach of requirement analysis. Interface models allow setting a dialog between stakeholders and customer. Involving this approach to model-driven development will get a chance to precise initial development information, namely CIM models, by means of tracing them to interface components. From the other hand, defining components events allows to get a set of initial information about architectural solutions designing.*

Paper proposes an approach of interface designing based on matching data flow parts to events of view model components. Paper contains case study.

Keywords*: BPMN diagram, Use Case, User Interface, MockFlow.*

ACM Classification Keywords*: D.2 Software Engineering; D.2.2 Design Tools and Techniques*

Introduction

One of the reasons of growing development costs is necessity to design the same interface for range of devices, technology platforms and communication channels.

This leads to the fact that front-end development is an expensive and inefficient process. Manual designing of user interface components with the aim of the reuse is difficult task.

In order to solve this task component-based engineering is involved. Central idea of component-based engineering is implementing reuse procedure in the level of component, scaling software system.

The idea of software components has been present since the very beginnings of software engineering. It was inspired by other areas of engineering, such as electronics, in which systems are assembled from pre-existing, standardized parts – components [Stefan P, 2014].

Component-based engineering brings scalability since systems are defined as compositions of components that may in turn be further composed to form hierarchical system descriptions. Furthermore, components can be reused across many systems to minimize development efforts, thereby reducing project schedules and budgets.

To correctly identify composite components for view, it is needed to make the prototype of program's interface and correctly identify the use case.

For this purpose, it will be most expedient to use Interaction Flow Modeling Language (IFML, 2016).

IFML is a standardized modeling language in the field of software engineering. IFML includes a set of graphic notations to create visual models of user interactions and front-end behavior in software systems (IFML, 2016).

The Interaction Flow Modeling Language was developed in 2012 and 2013 under the lead of WebRatio (Acerbis, R. et. al., 2004) and was inspired by the WebML (Moreno N. et. el., 2007) notation, as well as by a few other experiences in the Web modeling field.

It was adopted as a standard by the Object Management Group (OMG) in March 2013 (IFML, 2016).

IFML supports the platform independent description of graphical user interfaces for applications accessed or deployed on such systems as desktop computers, laptop computers, PDAs, mobile phones, and tablets. The focus of the description is on the structure and behavior of the application as perceived by the end user (Marco Brambilla and Pietro Fraternali, 2015).

Related papers

Paper [Lu, Xudong, and Jiancheng Wan., 2007] proposes a model driven development approach of complex user interface designing. The approach captures the process data in user interfaces. User interfaces depicted as objects, components and their cooperative relations in an Interaction Model. These objects are merged with the aim to compose a view model for common user interface. Such models are composed from the different types of UI templates.

There are many researches reflecting achievements in model-based user interface approaches. They are Drive (Mitchell K. et. al, 1996), MOBI-D (Angel Puerta and Jacob Eisenstein, 1999), Wisdom (Nunes, N.J. at. el., 2005), Teresa (Mori G. et. al., 2004), Teallach (Griffiths, Tonya, Barclay and Peter J, Teallach, 2001), JUST-UI (Pedro J. Molina et. al., 2002), SUPPLE (Krzysztof Gajos and Daniel S. Weld, 2004), etc. Many approaches for UI design and model-based user interface development environments (MB-UIDEs) have been proposed. Such approach do not consider totally complexity of UI controls as grid, graph and tree, sharing presentation space that can overlapping many present units so can show different content in different context, and their operational relations [Lu, Xudong, and Jiancheng Wan., 2007].

Paper (Karagkasidis A., 2008) proposes the pattern-based approach defining user-interface in modern architectural design patterns as MVC and HMVC (Hieratical Model-View-Controller) design patterns. Authors consider a problem of defining the best component for implementing the user scenario pointing that one task can be solved by different user interface components that have different relations to business logic and controller layers. They describe such problem by example: “Let’s consider a typical usage scenario of a graphical user interface (GUI) application: A user wants to accomplish some (business) task. He/she selects the corresponding menu item, and an input dialog is displayed. The user types some data in and submits the dialog. The data is processed by the application, and results are displayed to the user (Karagkasidis A., 2008).

In order to catch events of User Interface components the Observer pattern is used. The views and controllers register themselves with the model. Upon state changes, the model notifies all the registered components, which then retrieve the required data from the model. The input data is passed to the application logic objects and processed there. The results are then returned to the GUI part, and the visual state of the presentation objects is updated.

Library of components gathers user interface components in the widget-level allowing to select a widget, namely, a view is a visual component from the toolkit. More precisely, each toolkit widget in the GUI is considered as a view and controller levels in an MVC-based framework.

In a large application, with dozens of usage scenarios, the system design may contain hundreds of classes with intensive interaction among objects at runtime. The more features a GUI application provides, the tighter the relationships among objects are. This makes the developing of GUI applications a rather difficult task (Karagkasidis A., 2008).

There are researches devoted designing of user interface and matching functionality to its components from the other side, namely, paying attention to composition of user interface components. Interface itself is designed by using XML techniques of user screen representation, combining XML mark-up ((Lepreux, S. and Vanderdonckt, J., 2007), the ServFace project (Patern` O. F. et. al., 2011), Alias (Joffroy, C. et. al., 2011) and Transparent Interface (Ginzburg, J. et. al., 2007).) or reuse interface widgets from companies repositories (Compose (Gabillon Y. et. al., 2011), COTS-UI (Criado, J. et. al., 2010), CRUISe (Pietschmann, S. at. el., 2009), WinCuts (Tan, D. S. at. el., 2004) and on-the-fly mashup composition (Zhao, Q. at. el, 2008)). Functionality of user interface components is based on supporting collaboration of services using specific collaboration patterns.

To contribute to better support the composition process, it was propose a new composition model and a prototype of a component assembler, the so-called OntoCompo, which implements the model. The model describes applications in terms of Task, UI and software components. The prototype allows a composition mainly driven by the direct manipulation of UI elements, the other

components being hidden, but still being linked to the UI elements (Christian Brel et. al, 2014)

The approach is applied to the application composition driven by UI manipulation. Thus, starting from a selected part of the UI, corresponding software components are identified. The connections between models are exploited in a process of selection, composition by substitution and layout reorganization.

In the paper (Christian Brel et. al, 2014) were presented approach of application composition based on three application descriptions or models, namely the UI, Task and Software Components descriptions or models. OntoCompo is the prototype applying approach to an application composition driven by manipulation of UI graphical elements only.

The user testing it was performed with OntoCompo highlighted that this restricted manipulation was not enough to achieve an appropriate composition. The most realistic of our working hypotheses was the weak hypothesis, namely: to perform their composition task, developers need to manipulate the three kinds of models together, but to different degrees; developers must have the control of the three models; they need to visualize and manipulate these models when needed.

However, to achieve the composition, developers did not need to manipulate the code of the resulting application.

Proposed approach

1) Prepare detailed requirement specification.
2) Design a Use Case diagrams.
3) Transform them into the BPMN diagrams.
4) Match constituents of BPMN diagrams with mock-up of UI components.
5) Define events of UI components and match them for code.
6) Organize UI components into composite ones.
7) Trace containers and events on BPMN diagram.

Case study

It is proposed to design an interface with script libraries supporting functionalities of analyzing content obtained from different segments of search content. Requirement specification for the designed application is given below.

Req. code	Req. description
F1	Support search from different google regional sub-domains
F1.1	Support search from Bulgarian area
F 1.2	Support search in Dutch area
F 1.3	Support search from Espanol area
F2	Contain lists of references for content in different sub-domains that are pointing to different content
F3	Possibility to organize search history and calculate common numbers of references that are the same for searching by specific keywords in different sub-domains
F4	Allow users to choose a background

The result of specification analysis is BPMN diagram designed after Use Case diagram transformation. This diagram is represented in the Figure 1.

Activities of this diagram are matched to components of interface for creating user screen allowing solving task of analysis internet content in different sub-domains. The interface of the proposed specification is represented on the Figure 2. It is created by means of MockFlow online utility. Every component has a set of standard events according to MVC architectural style.

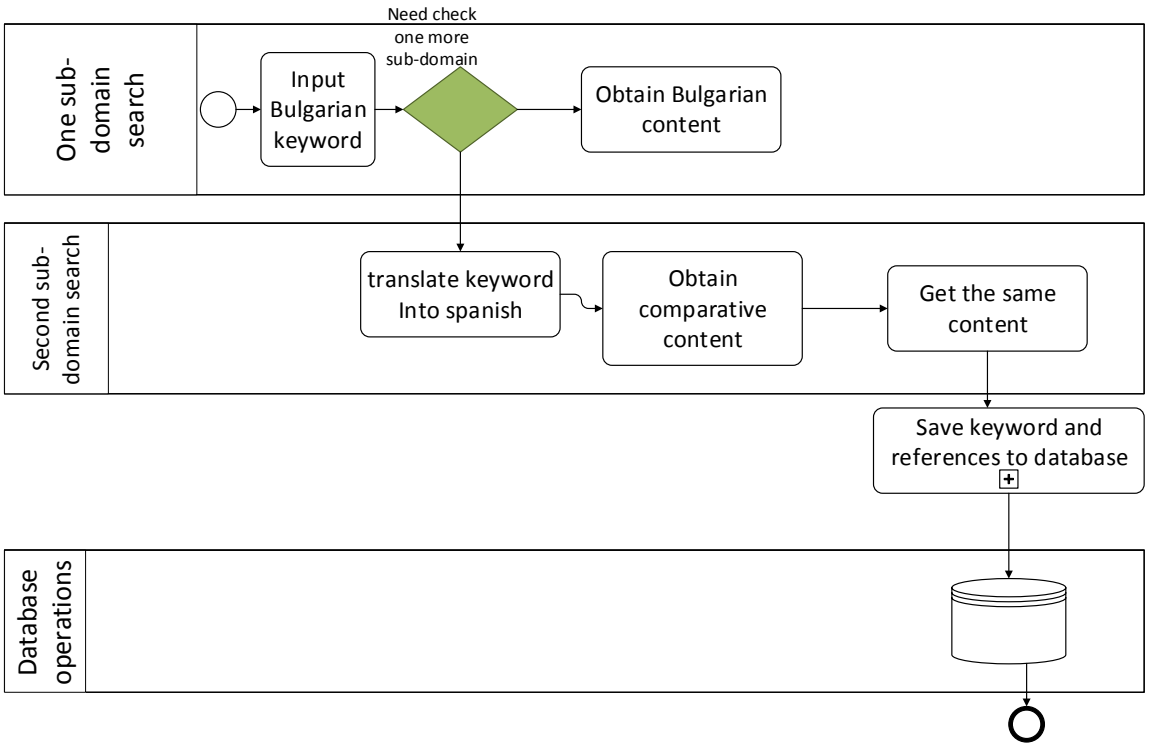

Figure 1. BPMN diagram of the process “Analysis of sub-domain content”

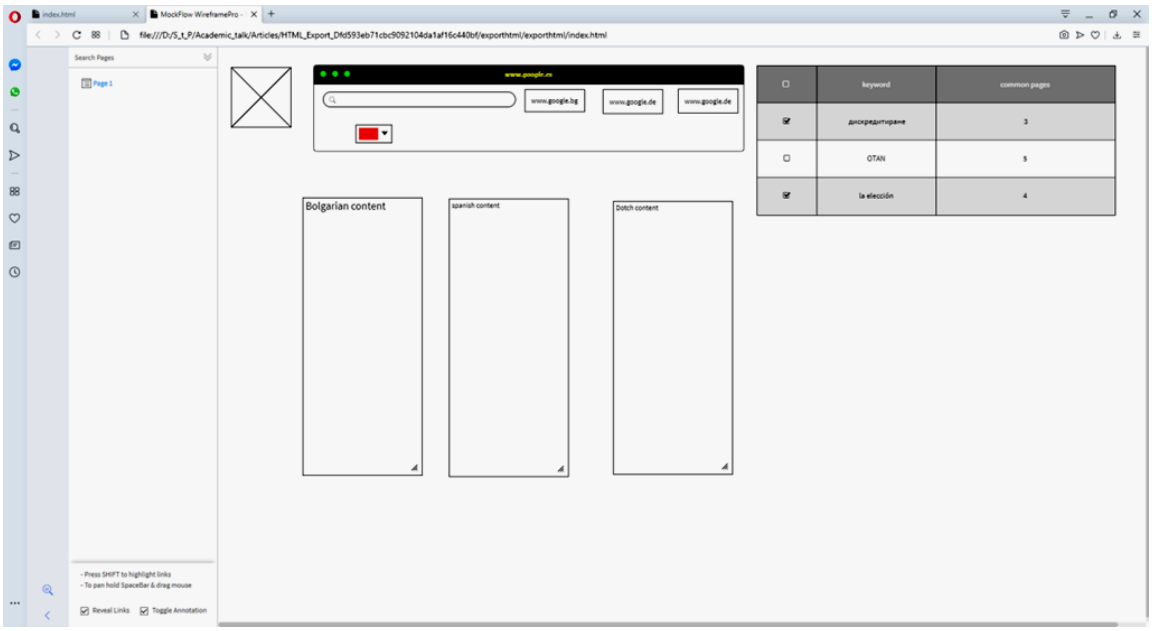

Figure 2. Designed interface on the basic of BPMN diagram

Designed *.html of the created interface is represented below.

```
<!DOCTYPE html>
	<head>

	<base href="">

	<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
	<meta name="google" content="notranslate" />
	<title>MockFlow WireframePro - Viewer</title>

<!-- external css files -->
<link
href="https://wireframepro.mockflow.com/css/external/bootstrap3/bootstrap-editor-min.css" rel="stylesheet" type="text/css" />
		<link
href="https://wireframepro.mockflow.com/css/external/bootstrap3/bootstrap-theme.css" rel="stylesheet" type="text/css" />

		<link href="https://wireframepro.mockflow.com/css/external/jquery-ui-1.11.4.custom.min.css" rel="stylesheet" type="text/css" />
		<link
href="https://wireframepro.mockflow.com/css/external/styles/kendo.common.min.css" rel="stylesheet" type="text/css" />
		<link
href="https://wireframepro.mockflow.com/css/external/styles/kendo.custom.metro.css" rel="stylesheet" type="text/css" />
		<link
href="https://wireframepro.mockflow.com/css/external/bootstrap-toggle-buttons.css" rel="stylesheet" type="text/css" />
		<link href="css/external/fontawesome/css/font-awesome.css"
rel="stylesheet" type="text/css" />

		<link
href="https://fonts.googleapis.com/css?family=Source+Sans+Pro:300,300italic,regular,italic,600,700,700italic" rel="stylesheet">

<link href="css/internal/icons/style.css" rel="stylesheet" type="text/css" />
		 <!-- internal css files -->
		<link href="css/internal/editor-min.css?v=2019_12_20_16_22_10"
rel="stylesheet" type="text/css">
```

```
		<!-- external js files -->
		<!-- mfexternal-min.js -->

		<script type="text/javascript" src="data/data.js"></script>
		<script type="text/javascript"
src="https://d20hhedk3h2l88.cloudfront.net/apps/wireframepro/external/js/webfont.js"></script>

<script
src="https://ajax.googleapis.com/ajax/libs/jquery/2.1.4/jquery.min.js"></script>
<!-- <script type="text/javascript" src="js/external/jquery-2.1.4.min.js"></script>-->
		<script type="text/javascript"
src="https://d20hhedk3h2l88.cloudfront.net/apps/wireframepro/external/js/jquery-ui-1.11.4.custom.min.js"></script>
		<script type="text/javascript"
src="https://d20hhedk3h2l88.cloudfront.net/apps/wireframepro/external/js/jquery-migrate-1.2.1.min.js"></script>
		<script type="text/javascript"
src="https://d20hhedk3h2l88.cloudfront.net/apps/wireframepro/external/js/kendo.custom.min.js"></script>
		<script type="text/javascript"
src="https://d20hhedk3h2l88.cloudfront.net/apps/wireframepro/external/js/bootstrap3.min.js"></script>
		<script type="text/javascript"
src="https://d20hhedk3h2l88.cloudfront.net/apps/external/js/jquery.textchange.min.js"></script>
		<script type="text/javascript"
src="https://d20hhedk3h2l88.cloudfront.net/apps/external/js/jquery.event.drag-2.2.min.js"></script>
		<script type="text/javascript"
src="https://d20hhedk3h2l88.cloudfront.net/apps/external/js/arraycollection.min.js"></script>
		<script type="text/javascript"
src="https://d20hhedk3h2l88.cloudfront.net/apps/wireframepro/external/js/spin.min.js"></script>
		<script type="text/javascript"
src="https://d20hhedk3h2l88.cloudfront.net/apps/wireframepro/external/js/multiline.min.js"></script>
		<script type="text/javascript"
src="https://d20hhedk3h2l88.cloudfront.net/apps/wireframepro/external/js/jquery.address-1.5.min.js"></script>

		<!-- internal js files -->
		<script type="text/javascript" src="js/internal/mf_wireframepro-min.js?v=2019_12_20_16_22_10"></script>
```

Represented listing of an *.html shows that user Interface components functionality is provided by third party resources https://d20hhedk3h2l88.cloudfront.net/apps/wireframepro/external/js/

supporting JQuery libraries.

Conclusion

Modern user interfaces are highly dynamic and interactive. They often compose in various ways user interface components. Thus, there is a need to understand what can be composed in user interfaces and how.

The technologies for the development of UI evolve very rapidly like any other relatable field in web development. The way technologies are evolving in the front end frameworks has been changing the logic and methodologies used in the development process.

There are various numbers of technologies, environments and approaches for composite component designing. Each of these methods has advantages and disadvantages.

Implementation of the proposed approach will increase the development speed by means of shrinking time for testing and development. Other advantage of the proposed approach is the next: matching BPMN diagrams from previous and current project, one can reuse interface components that are combined into containers, and even whole user screens can be prepared for reuse.

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A QUICK METHOD OF SOLVING THE INVERSE PROBLEM OF ELECTROMETRY IN OIL AND GAS WELLS

Mykyta Myrontsov

Abstract*: The effective iterative method for the inverse problem of oil and gas wells electrometry rapid solution was considered. Author proposed to use a high-effective full currents method to solve the direct problem of electrical and induction logging at each step of the inverse problem iterative solution. It was demonstrated that when structure model changes, only the coefficients in the equations of system of linear algebraic equations change too. In this connection, their number is not change. The possibility of taking into account the quantative measure of each sonde influence to overall result was used to increase the efficiency of the inverse problem solution. That opportunity allows taking into account firstly the sondes which are the most sensitive to selected section model parameters changing, with minimizing of discrepancy. That attitude significantly accelerates the speed and accuracy of the inverse problem solution. This article is a generalization of long-term work for development of highly effective algorithms to solve direct and inverse problems of well logging.*

Keywords*: Numerical modeling, electrometry in wells, direct problem, inverse problem*

ACM Classification Keywords*: G1.8. Partial Differential Equations, J.2 Physical Sciences and Engineering*

Introduction

Unless and until the only way to extract oil and gas will be drilling of wells, until then the well logging (WL) will not lose its relevance both from scientific and practical points of view. Among the number of methods, WL-electrometry takes the main place because it gives the answer to the key question: “Where is the useful fluid, how much it can be extracted totally and per day?” [Pirson, 1996;

Anderson, 2001]. The answer to these questions is not hidden among measured averaged values of the apparent resistivity (AR), but among the values of section model geoelectrical parameters. This model describes the spatial distribution of differential value of specific resistivity (SR). Such parameters can be determined in solving the inverse problem of electrical logging (IL) of induction logging (EL). However, it should be understood the necessity of direct problem solving (Fig. 1).

Also, as a lot of geophysical problems, answer to these questions requires a numerical solution of complex and unstable Hadamard mathematical inverse problem [Strahov, 1967; Tikhonov etc., 1979; Tikhonov etc., 1990].

Note that in addition to volatility naturally factored in a lot of geophysical inverse problems, electrometry inverse problem solution is often enhanced by complex start conditions.

In practice, geoelectrical parameters of researched objects (reservoir beds) are often comparable with equipment spatial and/or measurement resolution value.

A lot of researches are on the problem of creating the effective method to solve direct problem (and its using in the iterative solution of the inverse problem). However, there are still no method with no possibility of improving. Therefore, the purpose of this research was to develop a method of solving the direct and inverse problems which have an advantage over existing methods in implementation simplicity and calculation speed, other factors being equal. In this paper quantitative assessment of the calculation speed using the proposed methods in comparison with widely used other was realized.

Direct problem

What do we mean under EL [Ilinsky, 1971] direct problem or IL [Kaufman, 1965; Plyusnin, 1968] direct problem?

Firstly, we mean some way of value obtaining which corresponds to a measurement of value by a particular sonde, of specific physical measurement principle, for the particular well section.

We need to formalize some concepts to describe the improving of this method.

In this method, the measurement is the physical law, its mathematical description and their possibility of modelling in convenient way.

From a mathematical point of view, we need to solve the equation of divergence in the area with no current sources, and with variable coefficients:

$$div\vec{j} = div\left(\sigma\vec{E}\right) = 0\,. \tag{1}$$

In terms of modeling, it means to improve the numerical solution of such equation in any convenient way, but without error, which can exceed the predetermined (preferably small enough) value. For example, finite difference or finite element methods can be used [Samarsky, 1971; Samarsky etc., 1989; Bakhova etc., 1999].

In this research, we will use the method of integral currents [Myrontsov, 2012e; 2019a]. To do it, we replace the structure with a discrete model, which describes by a non-uniform system of linear algebraistic equations (SLAE). This SLAE describes the "electrical integrator" [Alpin, 1953; 1962; Myrontsov, 2007b; 2009b].

In each node we record the Second Kirchhoff law. It is the integral analogy of current density vector equation of continuity (1):

$$\frac{U_i^{j+1}-U_i^j}{R_{j,i}^{j+1,i}} - \frac{U_i^j-U_i^{j-1}}{R_{j-1,i}^{j,i}} + \frac{U_{i+1}^j-U_i^j}{R_{j,i}^{j,i+1}} - \frac{U_i^j-U_{i-1}^j}{R_{j,i-1}^{j,i}} = 0\,,\ i=\overline{1,n},\ j=\overline{1,m}\,, \tag{2}$$

where U_i^j – potential in the node j,i; n – nodes number on z-direction; m – nodes number on r-direction; $R_{j,i}^{j+1,i}$, $R_{j,i}^{j,i+1}$ – resistances between nodes $(j+1,i)$, (j,i) and $(j,i+1)$, (j,i) appropriate (for nodes on z-direction we need to make a change to the appropriate step change to the denominator):

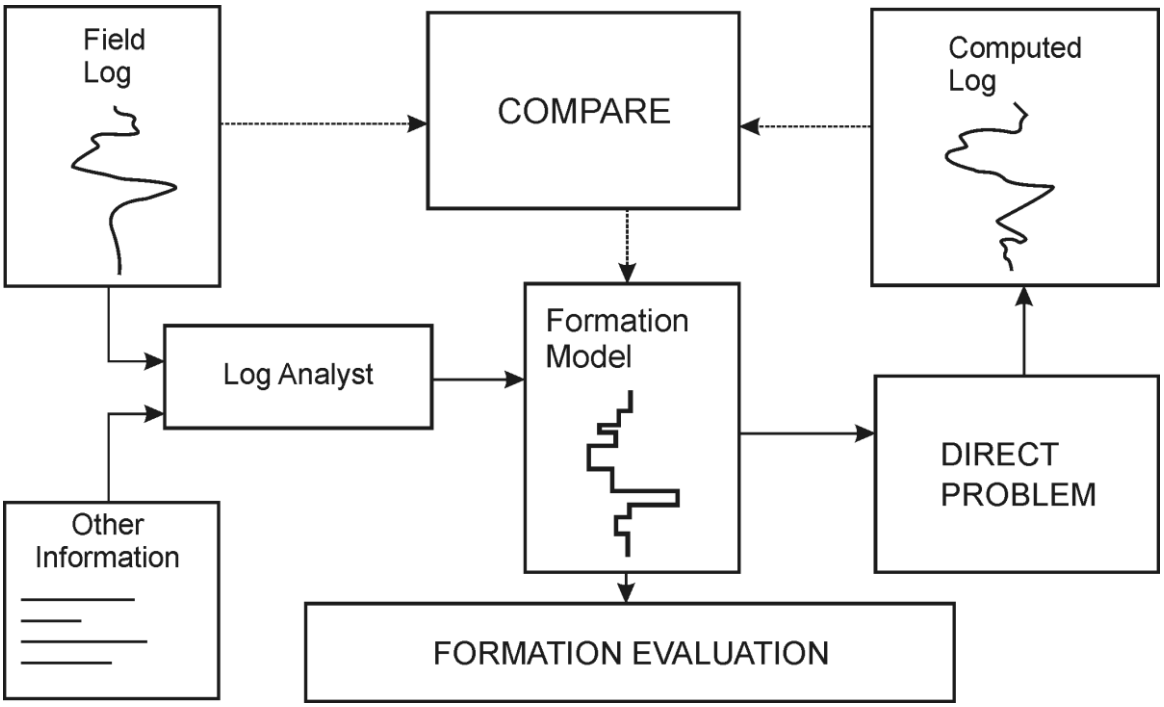

Figure 1. Scheme of the inverse problem effective solution

$$R_{j,i}^{j+1,i} = \int_{\Delta r} \rho \frac{dr}{2\pi\Delta z\left(r_0 + (j-0.5)\Delta r\right)}, \tag{3.1}$$

$$R_{j,i}^{j,i+1} = \int_{\Delta Z} \rho \frac{dz}{\pi\left[\left(r_0 + (i+0.5)\Delta r\right)^2 - \left(r_0 + (i-0.5)\Delta r\right)^2\right]}. \tag{3.2}$$

In (3.1), (3.2) – approximation step in the coordinates r, z appropriate, r_0 – sonde radius.

We note that the system (2) will not change (type and number of equations) for any number and any location of coaxial boundaries with coordinates $i \cdot \Delta r$ or for boundaries which are normal to the well axis with coordinates $j \cdot \Delta z$ in the model with plane-parallel arrangement. Only (3.1) and (3.2) will change, because change in the model will only result in the calculation of the corresponding integrals (coefficients of the system).

The variant when $\rho = \rho(z,r)$ a change with its derivative continuously also does not require changes of number or equations of system type.

That's why, solving of EL direct problem is that:

– the problem of rectangular grid (discrete model of structure);

– system (2) solution for homogenous structure with SR, equal to 1 for sonde (or sondes) coefficient calculating;

– coefficient (3.1), (3.2) calculation for system (2) and it solution for a given model of structure.

Boundary conditions for the derivative functions (Neumann condition) on the infinity and on insulator surfaces of the device are performing automatically. Grid is limited, that's why the current cannot spread in the direction with absent grid.

The non-zero boundary conditions on the electrodes surfaces are performing by adding to the equations (2) right side the magnitude of the current flowing from the electrode.

By this means, we have a non-homogenous SLAE with a single solution. This solution also can be expressed through the determinant of the system (according to Kramer formula). Therefore, for a given geometry of the sonde (specified boundary conditions), the direct problem solution for any 2D-spatial distribution of SR does not require changes in system of equations, but only changes of coefficients.

System without generality limitation accepts the use of grid with an irregular pitch.

Now let substantiate the proposed method for EL direct problem solving. Transition from the differential equation (1) to its integral analogue (2) by choice (3.1) and (3.2) is proved. Transition from integral form to a differential transforms the system (2) into a finite difference system with orthographic grid. It allows to use all the theorems about convergence and stability of the method (in a homogenous structure).

Relation (2) and (1) follows from equation of continuity, which has that form in cylindrical coordinate system (CCS):

$$\frac{j_r}{r} + \frac{\partial j_r}{\partial r} + \frac{\partial j_z}{\partial z} = 0 .$$

Elements I_r , I_z of the full current are related with its density:

$$I_r = j_n \cdot r \cdot 2\pi \cdot \Delta z ,$$

$$I_z = j_z \cdot ((r + \Delta r/2)^2 - (r - \Delta r/2)^2) \cdot \pi \cdot \Delta r = j_z \cdot r \cdot \Delta r \cdot 2\pi .$$

Then let's use the transformation:

$$\frac{j_r}{r} + \frac{\partial j_r}{\partial r} = \frac{I_r}{r^2 \cdot 2\pi \cdot \Delta z} + \frac{\partial I_r}{\partial r} \cdot \frac{1}{r \cdot 2\pi \cdot \Delta z} - \frac{I_r}{r^2 \cdot 2\pi \cdot \Delta z} = \frac{\partial I_r}{\partial r} \cdot \frac{1}{r \cdot 2\pi \cdot \Delta z} ,$$

$$\frac{\partial j_z}{\partial z} = \frac{\partial I_z}{\partial z} \cdot \frac{1}{r \cdot \Delta r \cdot 2\pi} .$$

And finally will get:

$$\frac{j_r}{r} + \frac{\partial j_r}{\partial r} + \frac{\partial j_z}{\partial z} = \frac{1}{\Delta r} \cdot \left(\frac{\partial I_r}{\partial r} + \frac{\partial I_z}{\partial z} \right) = 0 ,$$

or:

$$\frac{\partial I_r}{\partial r} + \frac{\partial I_z}{\partial z} = 0 ,$$

which is equivalent to the equation (2) that describe our discrete model.

To verify the numerical method for EL direct problem solving, we can compare the calculated values of the sondes coefficients with calculated ones by analysis [Myrontsov, 2003].

There are a number of numerical methods for exact solution of IL direct problem. For example, author proposed and implemented method [Myrontsov, 2004, 2007a, 2009], which is based on structure performance as an integration of elementary rings under additional conditions:

- considering coils contours as elementary rings, with taking into account their geometric (diameter, cross section etc.) and physical (conductivity) features;
- taking into account currents interaction as a mutual induction of all elementary rings in the system.

In general form, change of current in generator coil k: $I = I^k_{\text{Re}} e^{i\omega t} + i I^k_{\text{Im}} e^{i\omega t}$, (where I^k_{Re}, I^k_{Im} – active and reactive components) is provided by applied electromotive force (EMF):

$$\varepsilon = \varepsilon^k_{\text{Re}} e^{i\omega t} + i\varepsilon^k_{\text{Im}} e^{i\omega t},$$

where

$$\varepsilon^k_{\text{Re}} = A^k = const,$$

$$\varepsilon^S_{\text{Im}} = B^k = const.$$

Let's see the principle of mutual induction: on change of current I^j in the elementary ring j EMF ε^{ij} emerges in elementary ring i:

$$\varepsilon^{ij} = -M_{ij} \frac{dI^j}{dt},$$

where M_{ij} – coefficient of mutual induction.

Full EMF ε^i emerges in elementary ring i, and is sum of EMF, which induced in other rings by separate currents:

$$\varepsilon^i = \sum_j \varepsilon^{ij} = -\sum_j M_{ij} \frac{dI^j}{dt}.$$

To obtain the final systems of equations, we use:

1. Ohm's law in integral form:

$$\varepsilon^i = I^i R_i,$$

where R_i – resistivity of elementary ring. Because of axial symmetry: $R_i = \oint_{C_i} \langle \rho \rangle \frac{dl_i}{dS_i}$ ($\langle \rho \rangle$ – is SR, which averaged on the section of the elementary ring;

2. The formula for derivative in time of constant frequency alternating current:

$$\frac{dI^i}{dt} = i\omega I^i_{\text{Re}} e^{i\omega t} - i\omega I^i_{\text{Im}} e^{i\omega t}.$$

3. So that:

$$M_{ij} = M_{ji}.$$

Finally we obtain:

$$I^i_{\text{Re}} R_i - \omega \sum_j M_{ij} I^j_{\text{Im}} = 0, \quad (4.1)$$

$$I^i_{\text{Im}} R_i + \omega \sum_j M_{ij} I^j_{\text{Re}} = 0. \quad (4.2)$$

These equations corresponds to changes in active and reactive components of generator coils EMF A^k or B^k. By adding to right parts of these equations right parts of equations (4.1) and (4.2), we will obtain a non-homogenous and regular SLAE with number of variables N and number of equations equality.

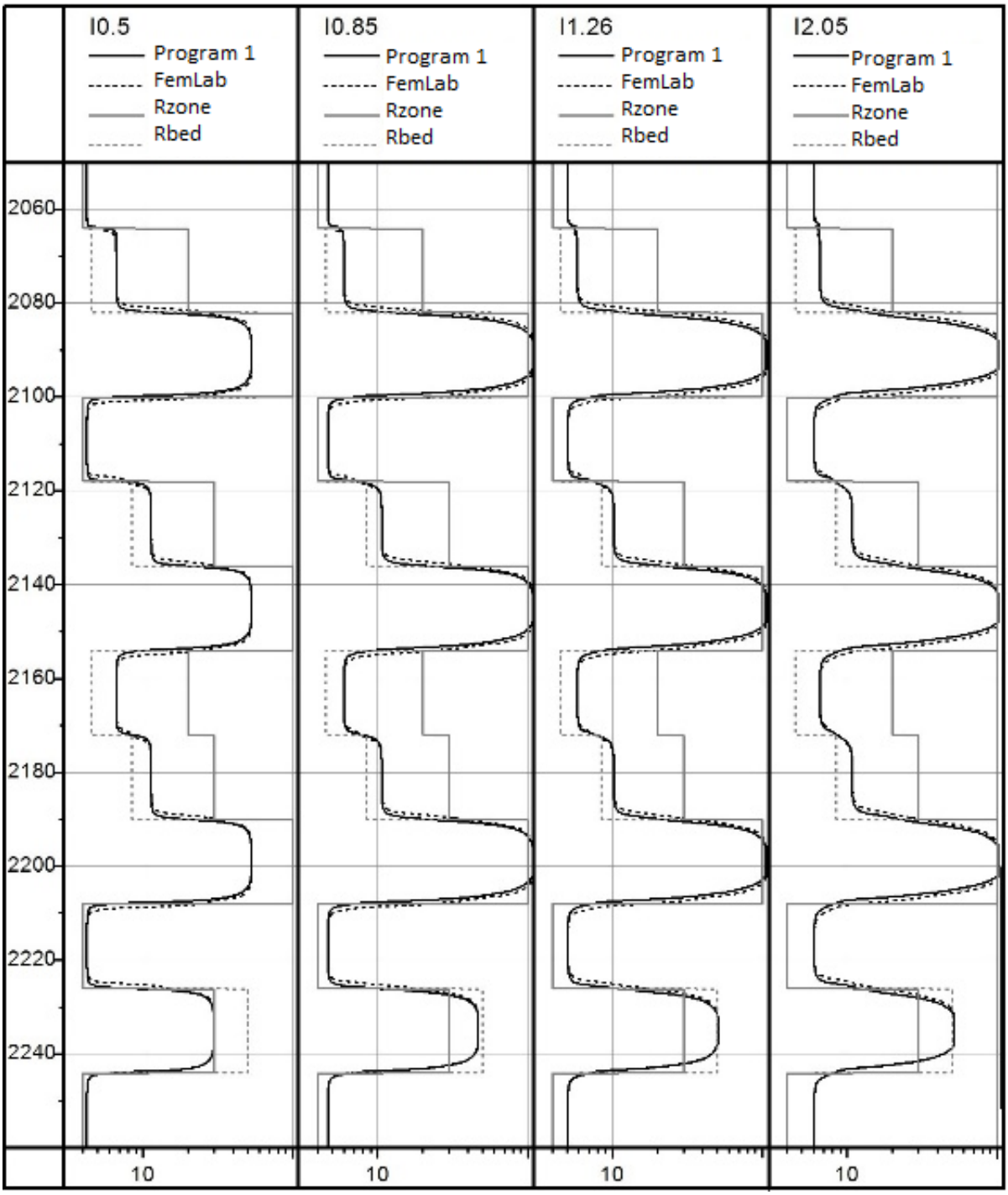

Figure 2. An example of comparing IL direct method solving results with different software

Comparison of various methods accuracy and speed for direct problem solving

Let's make comparison with other methods to evaluate the effectiveness and accuracy of the proposed solution.

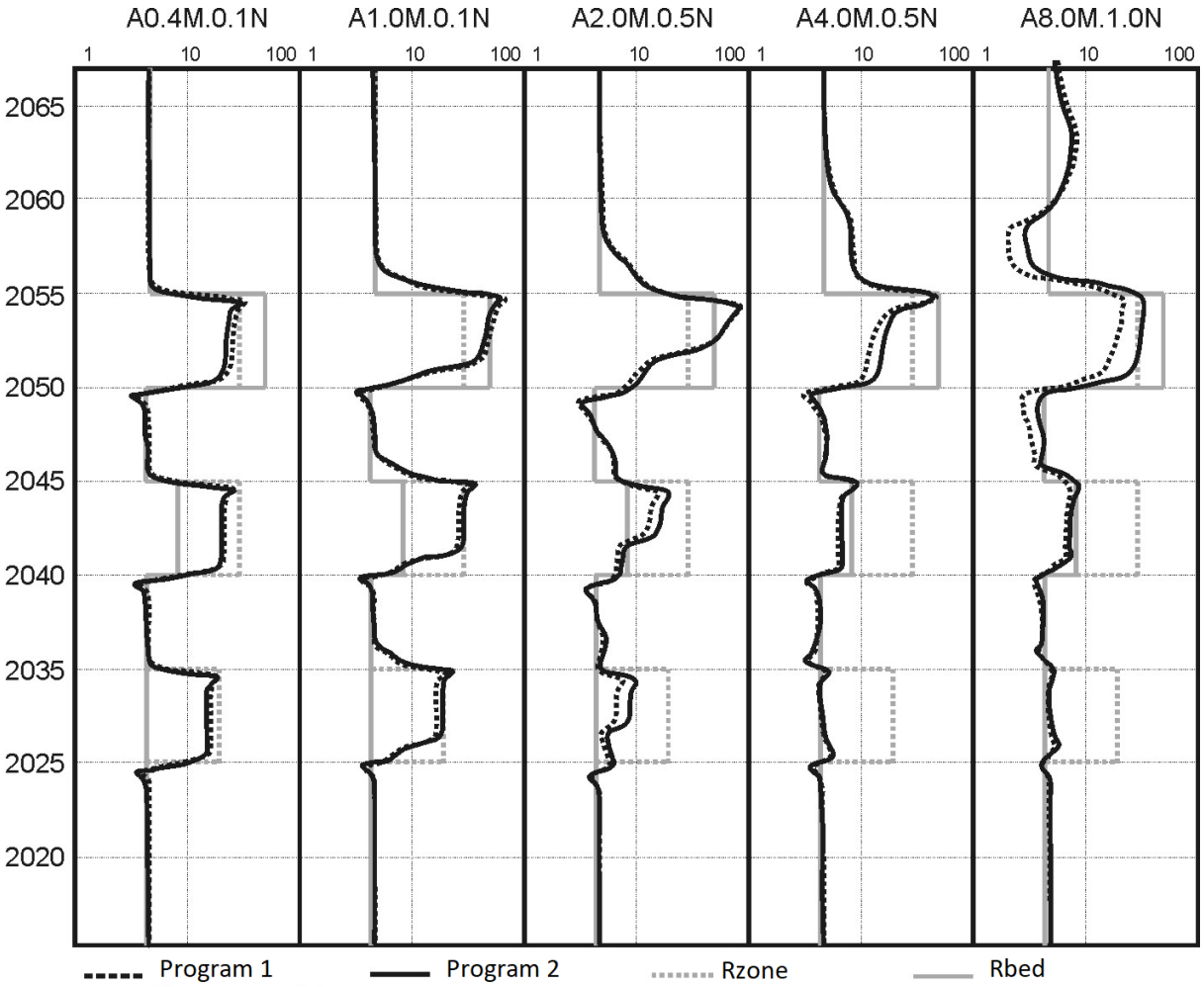

Figure 3. An example of comparing direct 2D problem by different software for the section with three-layer horizons (ρ_C = 2 ohm·m; r_C =0.1 m)

Firstly, let's compare IL direct problem solution for IL four-probe equipment using the proposed method with the result of modelling by FemLab software (University of Florida).

Fig. 2 shows the log graphs 4IL [Myrontsov, 2012e; 2019a] complex for a bench. It contains different models of the horizons in different sequence which corresponds to water-saturated, petroleum-saturated, gas-saturated, clay and consolidated. Log graphs were obtained using proposed method (codenamed as “program 1”) and using FemLab (codenamed as “FemLab”). The agreement of results is obvious, but solution using proposed method was almost 20 times less than FemLab (University of Florida) program.

Let’s assess the effectiveness of the proposed method for EL [Technical…, 2002] direct problem solving (“program 1” in Fig. 3) by comparing its results with results of software developed in Trofimuk Institute of Petroleum Geology and Geophysics, Siberian Branch of the Russian Academy of Sciences (“program 2” in Fig. 3) for side logging sound equipment [Myrontsov2019a].

In addition to the results agreement, proposed method solves the problem almost 100 times faster than software of colleagues from Novosibirsk. Unfortunately, author cannot name neither software authors nor its name without allowance.

During the discussion about comparison results, it was establishing the facts that some differences may occur due to different representations during reversed current electrode modelling. In author’s software it is presented not as point electrode but as conducting braid of a logging cable as a finite distance from the direct electrode. Other divergences are the results of the approximation in any numerical calculation, they are objectively reflecting values of real error. Author leaves visual assessment of results convergence behind the reader.

Inverse problem

The answer to the question about location and amount of useful fluid, about possible daily amount of its extraction is not in the area of measured AR (or apparent conductivity (AC) imaginary quantities. It is in the area of geoelecrtrical parameters of a model describing the spatial distribution of SR or specific conductivity (SC).

Therefore, geophysical characteristics of the equipment are the ability of particular algorithm (and its implementation) to solve the inverse problem: to allocate certain objects and to recognize their geoelectrical parameters with define accuracy.

Consequently, from the WL point of view, equipment with more accurate measurement is less good than equipment with more precise inverse problem solution. The effectiveness of any inverse problem solving method depends on such factors: way to determine the sondes measurement data for the define structure parameters; choice of "proximity" of sonde and real indications parameter; choosing for model parameters selecting for selected proximity parameter.

These questions can be paraphrased as:

- choice of direct problem solution method (finite difference, finite elements, full currents, semi-linear solution etc.);
- choice of a functional which will be minimized during inverse problem solving;
- choice of iteration process method for inverse problem solving.

We can consider minimization of the functional as a criterion for proximity of the solution with desired true value:

$$F\left(\rho_1^T,...,\rho_n^T\right)=\frac{1}{n}\sqrt{\sum_{i=1}^{n}\left(\frac{\rho_i^T-\rho_i^E}{\rho_i^T}\right)^2}\,, \tag{5}$$

where n – number of sondes; ρ_i^T – AR calculated values for model; ρ_i^E – AR obtained values.

There are some variations of functional representation, which will be minimized during inverse problem solving.

For example, as:

$$F\left(\rho_1^T,...,\rho_n^T\right)=\frac{1}{n}\sqrt{\sum_{i=1}^{n}\left(\frac{\rho_i^T-\rho_i^E}{\delta_i\rho_i^T}\right)^2}\,, \tag{6}$$

where δ_i – relative error for sonde i.

Or:

$$F\left(\rho_1^T,...,\rho_n^T\right)=\frac{1}{n}\sqrt{\sum_{i=1}^{n}\left(\frac{\rho_i^T-\rho_i^E}{\delta_i\rho_i^T+\chi_i}\right)^2}\,, \tag{7}$$

where χ_i – absolute error for sonde i.

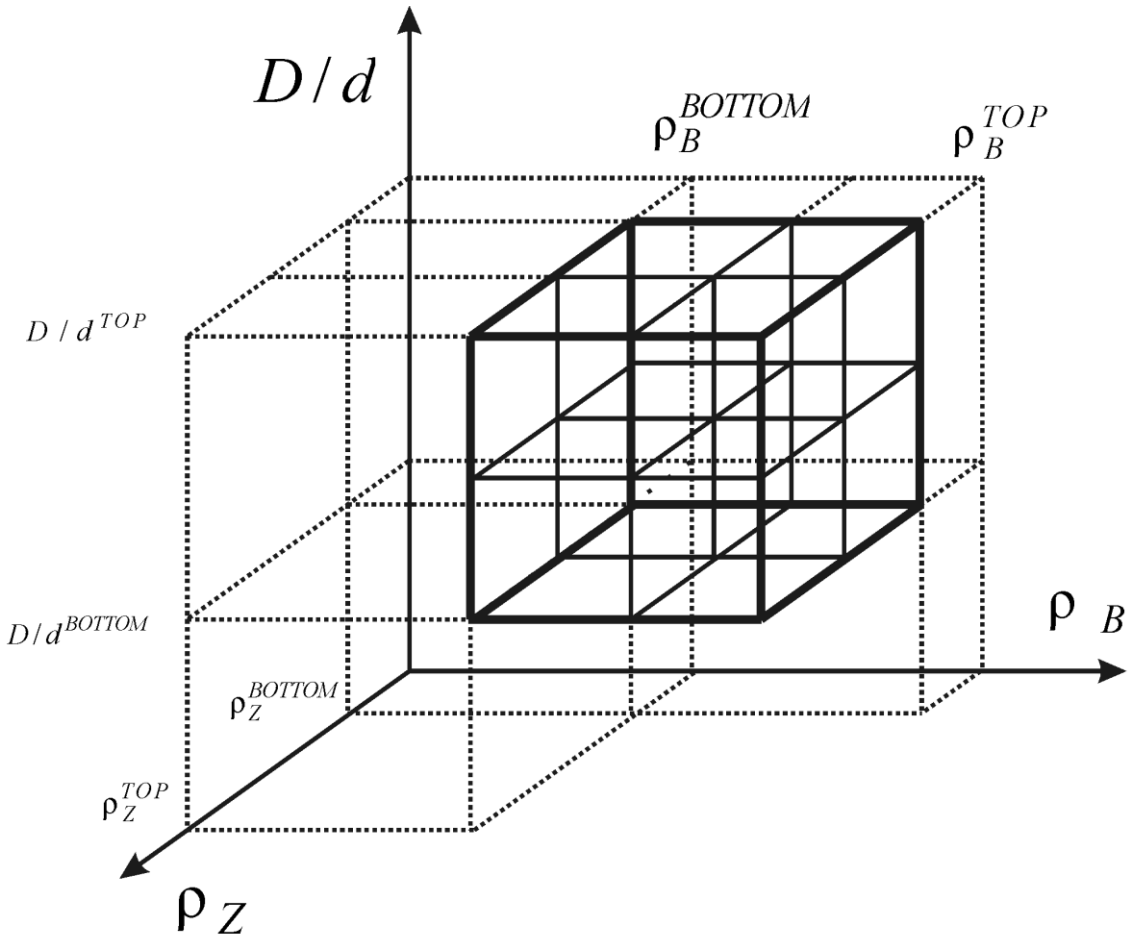

Figure 4. Illustration of reservoir parameters shredding. For allocated points direct problem was solved on the n+1-step of iteration

Let's consider such type of functional:

$$F\left(\rho_1^T,...,\rho_n^T\right)=\sqrt{\sum_{i=1}^{n}K_i\left(\frac{\rho_i^T-\rho_i^E}{\rho_i^T}\right)^2}\,, \tag{8}$$

where K_i are weight coefficients of each sonde of the complex which can be changed by the interpreter.

During calculation of functional (5)-(8) we can take both values ρ_i^T and ρ_i^E in denominator. Values ρ_i^E, at which minimum is achieved, do not depend on this. But this may depend on the functional minimizing speed which may be important during real inverse task solving. Different speed of minimization (depending on chosen method) can be explained by different form of the dependence of expression under radical sign and the denominator (argument or constant number).

The first step of inverse problem solving is formalization of requirements to the correspondent algorithm.

The requirement of accuracy is clear. Its ability to be executed depends on the accuracy of the available algorithm

of direct problem solving. Let's assume that accuracy is not in doubt, then focus on another requirement, which is the speed of calculation process. Practically, this is the speed of non-compliance functional minimization (8).

Let's consider the three-layer model as the model of reservoir-collector [Myrontsov, 2013]: well (SR of drilling mud – ρ_W, well diameter – d) + zones encircling the borehole flushed by the borehole mud (invaded zone) (SR of zone – ρ_Z, zone diameter – D) + uninvaded zone of bed (SR – ρ_B).

To begin, let's construct a table that associates the values of vectors components in the area of geoelectrical model parameters with vectors components from the measurement data area.

In the case of three-layer model, the associate table ρ_Z/ρ_W, D/d, ρ_B/ρ_W with number of AR ρ_i/ρ_W, $i=\overline{1,n}$, where n – quantity of sondes in the complex (for convenience and without generality limitation $\rho_W = 1$ ohm·m). Practically, the construction of each row in the table:

$$\rho_Z^j,\ (D/d)^j,\ \rho_B^j,\ \rho_{A0.4M0.1M}^j,\ldots,\ \rho_1^j,\ \rho_2^j,\ \ldots\rho_n^j.$$

requires to solve at least one direct problem.

Usually, table has to be made in bi-logarithmic scale. After making a table, it is actually possible to implement the algorithm of simplest solution of inverse problem.

During row of the table selecting, we choose the one for which the AR of selected logging complex is most closely identical with measured. Parameters $\rho_Z^j, (D/d)^j$, ρ_B^j from that row will be selected as the required model parameters. Search can be realized automatically, criterion of "the most accurate coincidence" will look like minimizing the functional (8).

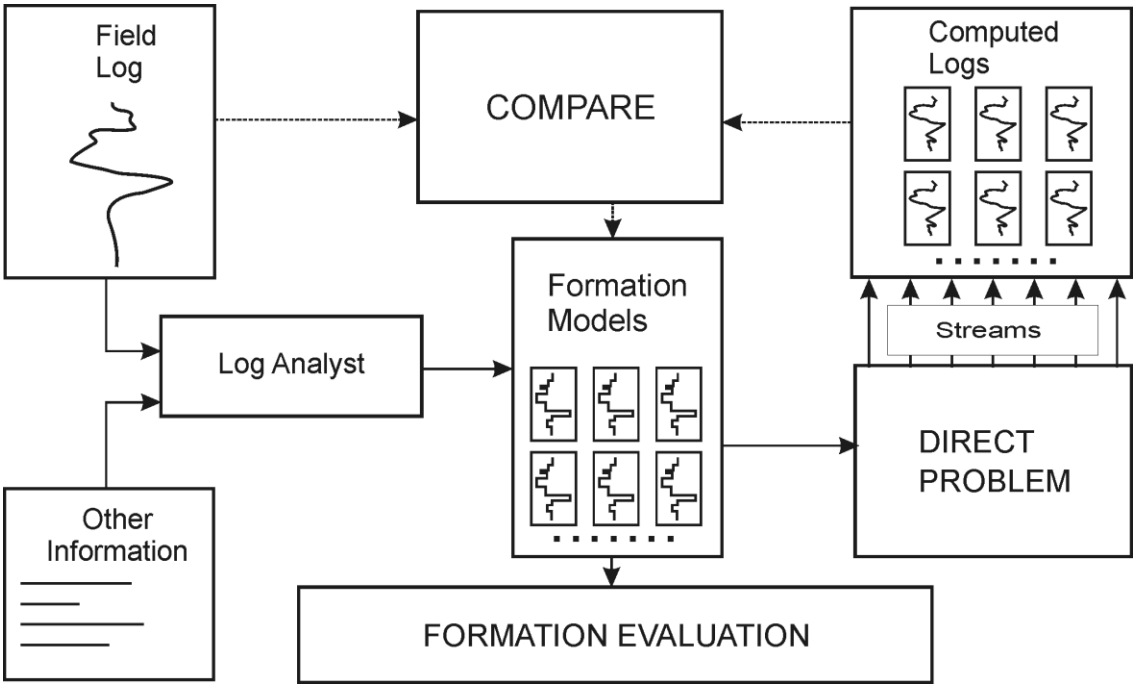

Figure 5. Scheme of inverse problem solving

That method is implemented in a lot of software for electrometer data interpretation. With a dense filling of the table, it shows a good results with error comparable with error of logging.

Modern development of hardware technologies and presence of pre-calculated table make possible solve inverse problem for interval of 1000 m along well axis in the split second. However, such algorithm has several drawbacks.

First: its accuracy is limited by the step of sweeping the parameters ρ_Z, D/d, ρ_B. Second: a large size of the table requires significant computing resources and prolongs the time of solving.

For three parameters, during the sweeping ρ_Z, ρ_B in 1000 values, and D/d – twenty, we will have 20000000 rows in the table. This can be considered for three-layer model, but this method are irrational and too difficult in implementation for four-layer model.

However, we will use such table. Even a table with 5 values for D/d and in 50 for ρ_Z, ρ_B (1250 rows in table) can simplify and accelerate further solution (for a four-layer model, with number of possible variations of washed zone parameters (5 for diameter and 50 for its SR) we will have a table with only 312500 lines).

This table will necessary to build the first approximation in the subsequent iteration minimization (8).

For iteration we will select the first approximation of the required parameters in the form of range [Myrontsov, 2019b]:

$$\rho_Z^{BOTTOM} < \rho_Z < \rho_Z^{TOP}, \tag{9.1}$$

$$D/d^{BOTTOM} < D/d < D/d^{TOP}, \tag{9.2}$$

$$\rho_B^{BOTTOM} < \rho_B < \rho_B^{TOP}. \tag{9.3}$$

On the next step, we divide the area (9.1)-(9.3) into flats (Fig. 4):

$$\rho_Z = \rho_z^{BOTTOM} + 0.5 \cdot (\rho_z^{TOP} - \rho_z^{BOTTOM}), \tag{10.1}$$

$$D/d = D/d^{BOTTOM} + 0.5 \cdot (D/d^{TOP} - D/d^{BOTTOM}), \tag{10.2}$$

$$\rho_B = \rho_B^{BOTTOM} + 0.5 \cdot (\rho_B^{TOP} - \rho_B^{BOTTOM}), \tag{10.3}$$

on eight areas. Now we solve the direct problems in the vertices of formed parallelepiped (9.1)-(9.3); at the points of flats intersection (10.1)-(10.3) only 13 of the points on the sides of parallelepiped. At one point we have a solution from the previous iteration.

Each of the eight areas creates a monotone area in the value space $\tilde{\rho}_i^T$. We select the one the value $\tilde{\rho}_i^E$ belongs to. Next step is to select the vertices of the area as the boundaries of intervals (9.1)-(9.3) of the next iteration: ρ_Z^{BOTTOM}, ρ_Z^{TOP}, D/d^{BOTTOM}, D/d^{TOP}, ρ_B^{BOTOM}, ρ_B^{TOP}.

We need to continue this process until satisfaction the condition for the pre-determined value of the misfit ε:

$$F\left(\rho_1^T,...,\rho_n^T\right)=\sqrt{\sum_{i=1}^{n}K_i\left(\frac{\rho_i^T-\rho_i^E}{\rho_i^T}\right)^2}<\varepsilon,$$

or if the value of the functional does not stop decreasing. Decreasing is possible because the minimum of functional does not necessarily equal zero during task redefining.

For the first iteration we construct area (9.1)-(9.3) from our pre-calculated table, taking the closest but not equal model parameters from rows with smallest values as boundary values (8).

For solving such a number of direct problems, it is appropriate to use so-called streams (for example with TThread object in Delphi). Possibility of solving several mathematical problems simultaneously is widely available now. Use of streams leads to solve several direct problems instead one (Fig. 5) in the same time. Number of direct problems depends, of course, from parameters of hardware.

Author uses know-how, which allows to significantly reducing the number of points in which direct task solved.

It should be said about another possible method to increase the accuracy of inverse problem solution. The described method can be effectively applied to

measured values of layers AR. The values of layers AR are not influence by the value of shoulder beds SR. So, before using described method of solving the inverse problem for each bed, we need to exclude the influence of shoulder beds to measurement.

In the case of EL inverse problem is non-linear. Then it is proposed to reduce the influence of shoulder beds to measurement using equipment with high vertically (along the axis z) spatial resolution [Myrontsov, 2010a; 2010d; 2010e; 2018a; 2018b].

Such equipment proved to be more effective in such complicated geological conditions in which the complex used in Ukraine is not effective [Yegurnova etc., 2005; Myrontsov, 2012a; 2012b; 2012c; 2012d].

In the case of IL, inverse problem is linear. In this context an effective factorization method developed and implemented by author can be used to exclude the influence of shoulder beds [Myrontsov, 2009a; 2010b]. This method also can be used for pulsed IL [Myrontsov, 2010c].

Conclusion

It was being shown that the use of integral currents method for EL and IL direct problem solving has such advantages over the use of the finite difference or finite element method:

- unlike the finite difference or finite element method, it is not necessary to change the number or type of SLAE during model around well environment changing. It is only necessary to change the values of system coefficients;
- implementation of the proposed method gives the preference to the calculation speed (for IL almost 20 times, for EL almost 100 times in comparison with finite element method).

It was being shown that the inverse problem solution based on the method of desired parameters space half-separating (by analogy with bisection method or half-partition division method for non-linear equations solution) has higher accuracy in comparison with calculated table-based methods. It connects the

values of horizon with values of measurement. Obviously, this follows inaccuracy of method based on such table using due to discreteness of the possible solution values in the table.

In addition, the proposed method of inverse problem solving has one more advantage. It is ability to change the weight number values for each probe of the complex. Thus, user has an opportunity to exclude unserviceable probes or amplify an effect of probes with better geophysical parameters for selected model of the cut to solve the inverse problem.

Proposed and implemented method of solving inverse problems of EL and IL is currently on the technical tests by industrial geophysical companies of Ukraine.

Author plans to continue theoretical researches firstly in the scientific area of equivalent solutions for inverse problem with measurement error [Myrontsov, 2012f; 2019c].

Author would like to thank PhD V.O. Okhariev for his assistance in translating the article.

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LEARNING MANAGEMENT SYSTEM WITH SCHEDULING FUNCTIONS

Zainab Saadi Hussein Al-Hilali, Volodymyr Shevchenko

Abstract: *In this paper, we investigated the problem of scheduling for the School Management System (Learning Management System, LMS) and proposed our solution to solve it. We articulated that change management is also an essential part of the system. The comparative analysis of standards for LMS, courses learning materials representation and well-known LMS was done and presented in this research. IEEE LTSC, AICC, IMS, ADL, SCORM, ARIADNE and other standards were inspected with regard to the systems where they are implemented. The conclusions were made based on the gathered and presented material. The new system developed and implemented in a number of educational institutions was presented in this work. The research is illustrated with the images of particular systems as well as the comparison table and brief information blocks to systemize the material representation.*

Keywords: *e-learning, learning management system, IEEE, LTSC, AICC, IMS, ADL, SCORM, ARIADNE, LMS, CMS, SMS, MOODLE, Claroline, Dokeos, ATutor, ILIAS.*

ITHEA Keywords: *J.1 Computer Applications - ADMINISTRATIVE DATA PROCESSING - Education, K.3.1 Computing Milieux - COMPUTERS AND EDUCATION - Computer Uses in Education, H.4.1 Information Systems - INFORMATION SYSTEMS APPLICATIONS - Office Automation - Time management (e.g., calendars, schedules)*

Introduction

Learning Management Systems (LMS) and its variants emerged as further development of Content Management System (CMS), a kind of specialized systems, in particular for learning management.

In the literature, one can find the following abbreviation for learning management systems:

- LMS - Learning Management System,

- CMS - Course Management System,

- LCMS - Learning Content Management System,

- MLE - Managed Learning Environment training),

- LSS - Learning Support System,

- LP - Learning Platform,

- VLE - Virtual Learning Environments.

The most common are LMS and CMS (not to be confused with the content management system).

Learning Management Systems (LMS) are very popular today, also known as e-Learning systems. They really cover many functions of the study process and its organization.

Here we will look through the most popular Learning Management Systems and argue the new development with relatively new important functions omitted in other systems.

A Brief History of E-Learning Development.

The LMS is defined as a software application designed to administer, monitor, document, provide educational content, and control e-learning and training courses. These systems are popular in colleges and universities but can also be used by businesses and other organizations.

In schools, LMS is often used as a supplementary online education or supplementary classroom resource. These software solutions can also be sought after by businesses as tools for corporate training, certification and accounting.

Every LMS, a learning management system, has its own unique set of features. This is what differentiates each product. At the same time, although the features may differ, there is a certain standard set of features and settings that are most common and present in virtually any LMS. This set typically solves basic learning tasks such as enrollment, educational achievement monitoring, planning, content management, communication, and teamwork. Some systems offer other attractive features, such as mobile access and e-commerce.

The effective use of information technology in education significantly improves the effectiveness of learning and reduces its costs.

The research conducted in this area most often compares group and individual training. In this regard, the following features were observed:

- on average, group has about 0.1 questions per hour per student [LTSC];

- in individual study the student can ask or answer 120 questions per hour [LTSC];

- for 98% of students, the efficiency of individual work is higher by 50% than in the group [LTSC].

There are many official LMS standards available today, so the product selection decision is up to the users and/or their companies to maximize their satisfaction. What works great for some organizations may not work for others at all. Let's go into details.

Review of standards.

A standard is a format approved by a recognized standardization institution or accepted by industry (or the majority of interested representatives) as a de facto sample.

There are standards for programming languages, operating systems, presentation formats, communication protocols, electronic interfaces, etc. Having standards is important for any IT user, as it is through standardization. The availability of standards is important for any IT user, because it is through standardization that each user can combine the equipment and programs of different manufacturers according to their individual needs. If there is no single standard, then the user should be limited to devices and applications from only one manufacturer. Both hardware and software, in particular, e-learning applications, are subject to standardization.

The most common standards in e-learning include:

- IEEE - Institute of Electrical and Electronic Engineers (LTSC - Learning Technology Standards Committee) (http://ltsc.ieee.org/) [LTSC]
- AICC - Airline Industry Computer Based Training Committee (Http://www.aicc.org) [AICC]
- IMS - Instructional Management Systems, World Education Consortium - IMS Specification - XML-based standard describes the course structure. (http://www.imsproject.org) [IMS]

- ADL/SCORM - Advanced Distributed Learning and the ADL SCORM standard - Sharable Content Object Reference Model (http://www.adlnet.org/) [ADL SCORM, SCORM]
- ARIADNE - Alliance of Remote Instructional Authoring & Distribution Networks for Europe (http://www.ariadne-eu.org/) standardizing the exchange of educational content for the European Union.
- PROMETEUS http: //www.prometeus.org/
- The Dublin Core Metadata Initiative http://dublincore.org/

SCORM - Sharable Content Object Reference Model.

The creation of the SCORM standard [ADL SCORM] was the first step in the development of the ADL [ADL] concept. This standard defines the structure of the training materials and the runtime interface, whereby training objects can be used in various electronic distant education systems.

In SCORM, this technical structure is described using some basic principles, standards and specifications based on the work of other already established specifications and standards for e-learning and distance education. Organizations that have established the relevant standards continue to work with ADL, developing and improving their own e-distance and eLearning specifications and standards, and helping to build and improve SCORM.

ADL has created SCORM to integrate different standards and specifications (such as LOM, IMS CP) into a single content model. SCORM is a technical infrastructure that allows you to share objects in a distributed learning environment. An exemplary Sharable Content Object Reference Model (SCORM) defines a model for content aggregation and a work environment for web-based learning objects.

Initially, it was a set of manuals and technical descriptions. Subsequently, a number of organizations joined the process and the project became more versatile (including, for example, the use of CDs, interactive multimedia, etc.).

SCORM uses the results of a number of projects and organizations such as: IMS Global Learning Consortium, Inc., the Aviation Industry CBT (Computer-Based Training) Committee (AICC), the Alliance of Remote Instructional Authoring & Distribution Networks for Europe (ARIADNE) and the IEEE Learning Technology Standards Committee (LTSC).

Version 1.2 of SCORM introduces the concept of content packaging and contains updated metadata for describing training content based on specifications created by the IMS Global Learning Consortium and IEEE LTSC.

SCORM is widely recognized among all e-learning standardization products. This model is used to create training systems that rely on Internet resources.

The standard SCORM model consists of three parts:

- the introduction or the overview (the Overview);
- a description of the content integration model (the Content Aggregate Model);
- a description of the workspace or the RunTime Environment (RTE).

The first part describes the ADL standards and provides a rationale for creating a reference model. The second part provides practical tips for identifying resources and transforming them into structured learning material. The last part gives practical tips for communicating with the web environment and tracking its content. In an ideal SCORM-compliant situation, all curriculum elements are functionally compatible with all LMS systems and VLE environments. Any standard training computer program can be introduced into an existing training organization / virtual environment and data will be shared between them.

Rather, SCORM is not a standard, but a benchmark to test the effectiveness and practical applicability of a set of individual specifications and standards. This benchmark is used by standards developers such as IEEE and IMS to integrate the specifications they have created.

The main features of e-learning solutions

When choosing software for training systems, the following characteristics can be considered:

- reliability in operation,
- security,
- compatibility (including compliance with standards),
- ease of use and administration,
- modularity,
- access providing,
- the cost of software, maintenance and hardware needed.

It is important to note that many of them overlap. However, examining them individually helps to understand the technical requirements for training systems.

Reliability in operation

This parameter characterizes the ease of administration and ease of updating content using existing templates. When choosing software, make sure that the content of the training course and the site structure are separated so that you cannot accidentally delete important menu items when updating content. Check the help system and make sure it is really helpful.

It is advisable that you do not depend on the mercy to the seller when operating.

If it is difficult to add new users to the system, exclude old users, add content, have problems updating the site, etc. teachers quickly refuse to use it.

Compatibility

The prosper system must be compatible with other e-learning solutions. Although a "universal" software solution that fits all possible, there are no universal and all-needs-covering standards, but you can still choose a system that supports at least one widespread standard. Otherwise you will be connected with developers of the system from the time of its installation until the end of life.

When compatibility may be required:

- Sharing (moving) content from one learning management system to another.
- Use of developed courses.
- New employees (non-standard systems require trainings).

One way to ensure compatibility is to look for software that supports industry-specific standards. Ideally, it should allow the use of the same training materials in different learning management and content management systems. Compatibility is the ability to take the same training material and, without making changes, use it in different learning management systems. Currently, standards are just a general direction for achieving compatibility. It should not be assumed in advance that a SCORM-compliant training course can be automatically used in a SCORM-based learning management system.

Ease of use and administration

When choosing a new system, it is necessary to ensure its convenient usage. This is an important parameter as potential students will never use technology that seems cumbersome or difficult to navigate. Teaching technology should be intuitive. The training course should be simple to find the help menu, easy to navigate from one section to another and communicate with the teacher.

Teachers, in turn, are not inclined to read a thick guide to using the courseware or to spend time figuring out how to create a test. The software should be simple and better open sourced.

Modularity

Modern systems of additional training often use small interchangeable objects of knowledge - small elements of educational content. These are small, self-contained information blocks that can be reused for educational purposes. They are often compared to the elements of the Lego game. Knowledge objects can simply be transferred from one course or lesson to another, completely different from it. The purpose of creating these objects is to reduce the development time of courses, because by creating one object, it can be reused again and again.

Such blocks can be joined, separated and arranged in different order, regardless of their size or color.

If you intend to use such "cubes", it is necessary for the system of your choice to support this kind of functionality, that is, to allow you to identify the objects of knowledge and to allow the course organizer to associate the objects of knowledge with the learning objectives.

Providing the access

There are two aspects to this question. The first is that those who are taught should have no barriers to accessing the curriculum. For example, it should be compatible with screen readers, programs that can read words on the screen for those who have low vision.

The second aspect is to make sure that the technology you purchase is suitable for all potential users. For example, if some of the students do not have the

latest version of Macromedia Flash, they will not see the animation you created with the technology.

Purchased software should be tested with those browsers that will be used by those who are being trained. In order to make sure that the training program runs on the platform on which it is required, several scenarios must be tested. Test on multiple computers with different browsers and programs, or you need to give rigid hardware configuration recommendations.

Cost of software, maintenance and hardware

An important aspect is the price.

When calculating the price one should take into account the following:

- Cost of all software including: the system itself; operating system; DBMS; anti-virus programs; security software etc.
- Support. It should be borne in mind that different software requires different levels of skill and salary. It all should be calculated.
- The cost of the hardware, including server; power consumption; data backup system; network and channel facilities; redundancy for hot and cold replacement of equipment in case of failure.

Overview of learning management systems

MOODLE

MOODLE [MOODLE] is one of the most widely used LMS. MOODLE allows you to create a private online learning space filled with exciting activities and materials. You will always have full control over all your data and the way your

employees, students and clients are on board. MOODLE design and development are guided by a particular teaching philosophy, which can be briefly called "social constructionist pedagogy" (**Fig. 1**).

MOODLE: Brief information

MOODLE - Modular Object-Oriented Dynamic Learning Environment.

Current Version: 3.8.1

Official site: https://moodle.com/lms/

Support: IMS / SCORM specifications

Platform: PHP, MySQL, PostgreSQL

License: GNU General Public License (GPL)

Supports many languages

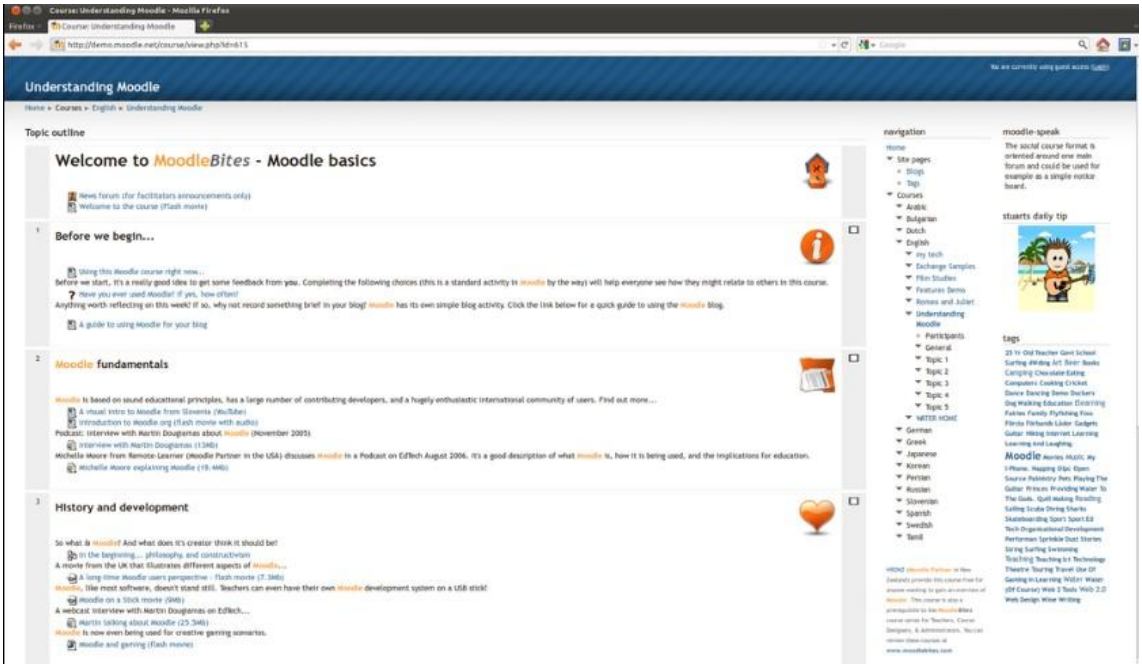

Fig. 1. MOODLE

Claroline

Claroline [Claroline] is a collaborative e-learning and e-work platform, licensed under the open source GPL. The application was created in Belgium at the Institute of Pedagogy and Multimedia of the Catholic University of Louvain. The Claroline Connect project aims to be a technology-driven project. Meeting the actual standards imposed by web giants such as Google, Facebook, and more.

So, today Claroline is being developed in React and Symfony. Claroline LMS is available in 35 languages and is currently used in more than one hundred different countries by organizations, universities, or schools to manage their e-learning resources.

Claroline offers a number of tools and features that allow the teacher to manage their courses and students. They can download files in various formats, such as PDF, HTML, or video, which will complement the course description, create exercises and timetables **(Fig. 2**). Other features include managing your students by creating user groups and checking attendance and exercise statistics.

Claroline: Brief information
Official site: www.claroline.net
Current Version: 12.0.1
Support: IMS / SCORM
Operating System: Windows, macOS, Linux
Specifications Application languages: PHP, JAVA, React and Symfony
License: GNU General Public License (GPL)
Language: English, French, Spanish

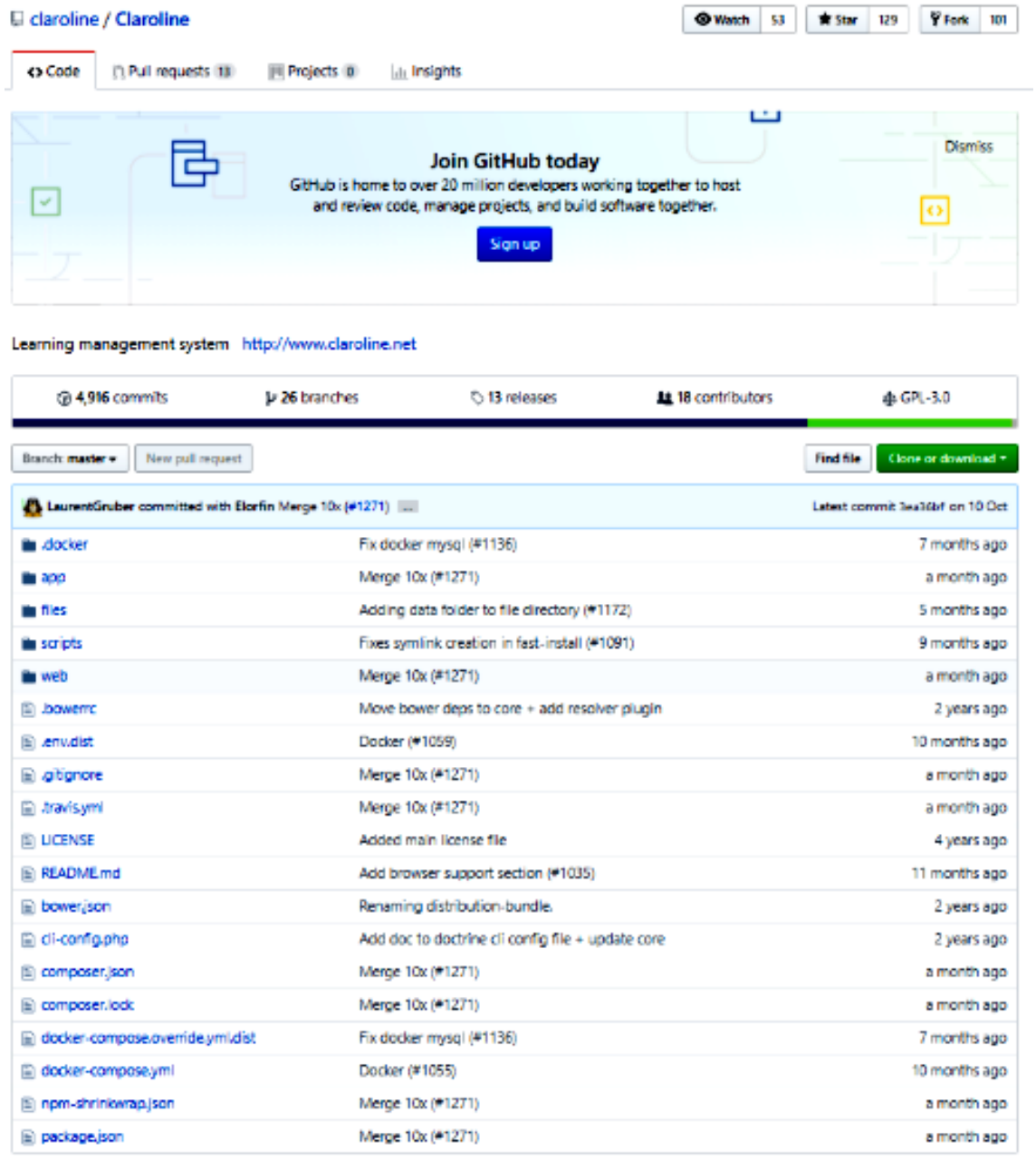

Fig. 2. Claroline

Dokeos

Dokeos [Dokeos]. A distance learning platform for Claroline branch fork (version 1.4.2.). A branch is a clone of a freely distributed software product designed to change an original application in one direction or another.

Dokeos is the result of the work of some members of the original Claroline development team who conceived change the orientation of the application. Now it is more appropriate for organizations than for universities.

The fact is that Claroline is perfectly adapted to the university environment, which is expressed in support of a large number of students and courses. Dokeos, we think, is more focused on a professional clientele, for example, company staff.

Developers wanted to organize (rather to put up for sale) a set of additional services for the platform. The name Dokeos refers to both the application and the company that offers a range of different services to the platform: hosting, content integration, development of additional modules, those. support etc.

Dokeos is free because the Claroline License (GNU / GPL) stipulates that branches are subject to the same license. Since the branch was recently highlighted, both applications are now relatively similar to each other, although some differences in ergonomics, interface design and functionality are already beginning to emerge.

An example of Dokeos implementation is the Ghent University.

Dokeos: Brief information
Official site: www.dokeos.com
Support: IMS / SCORM
Platform: PHP, MySQL
License: GNU General Public License (GPL)
Ukrainian language support: yes
Demo site: http://demo.opensourcecms.com/dokeos/

ATutor

ATutor [ATutor] is also a web-based LMS. The software is easy to install, configure, and support for system administrators. Teachers (instructors) can easily create and upload tutorials and run their online courses. Since the system is modular, and it consists of separate functional units - modules, then it is open for modernization and expansion of the functionality.

The system was created by Canadian developers. Includes all the necessary e-learning tools. There is a Ukrainian version also.

ATutor: Brief information
Official site: www.atutor.ca
Support: IMS / SCORM
Current Version: 2.2.1
Program languages: PHP, JAVA
DBMS: MySQL
License: GNU General Public License (GPL)
Ukrainian language support: yes
Demo site: http://www.atutor.ca/atutor/demo/login.php

ILIAS

ILIAS [ILIAS] is a free LMS to support the learning process. The system is widespread in universities, especially in Germany. ILIAS stands for Integrated Learning, Information and Work Cooperation System. The idea behind ILIAS is

to offer a flexible environment for learning and working online with integrated tools. ILIAS goes far beyond the idea of learning being confined to courses as a lot of other LMS do. ILIAS can rather be seen as a type of library providing learning and working materials and contents at any location of the repository. This offers the possibility to run ILIAS not as a locked warehouse but as an open knowledge platform where content might be made available for non-registered users too.

ILIAS: Brief information

Official site: www.ilias.de/ios/index-e.html#ilias

Support: SCORM

Minutes: CAS, SOAP, RADIUS, LDAP, Shiboleth authentication

Current Version: 5.3.10

Application languages: Apache, PHP, MySQL, XML.

License: GNU General Public License (GPL)

Multilingualism, support for the Ukrainian language

Comparison table and the need for new LMS software with scheduling function.

Now let's summarize the information about major open-source systems in the **Table 1**.

Table 1.

LMS comparison

	MOODLE	Claroline	Dokeos	ATutor	ILIAS
SCORM	yes	yes	yes	yes	yes
IMS	yes	yes	yes	yes	no
Application language	PHP	PHP,JAVA, React Symfony	PHP	PHP	PHP
License	GNU/GPL	GNU/GPL	GNU/GPL	GNU/GPL	GNU/GPL
Multilingualism	> 54	36	38	> 50	43
DBMS	MySQL	MySQL	MySQL	MySQL	MySQL
Knowledge testing system	Tests, tasks, seminars	Tests, exercises	Tests	Tests	Tests
Mobile app	yes	yes	yes	no	
Analytics and tracking	yes	yes			
Scheduling / Schedule	no	no	no	no	no

So, we can conclude, that different systems have different drawbacks but no one system provides the Scheduling functions which are required from the schools and universities very much.

So, we developed the new LMS software with the scheduling function (will be described in separate work).

The main modules of the developed system are:

- scheduler,
- schedule viewer for different roles: teacher, class timetable, classroom load,
- change management support subsystem,
- API for integration with external content management system (LMS),
- API for data exchange (inputs, outputs).

Hence, the module for the schedule could be also integrated into other LMSes.

At **Fig. 3** – **Fig. 8** one can see the examples of the interface of the new proposed LMS with the scheduling functions.

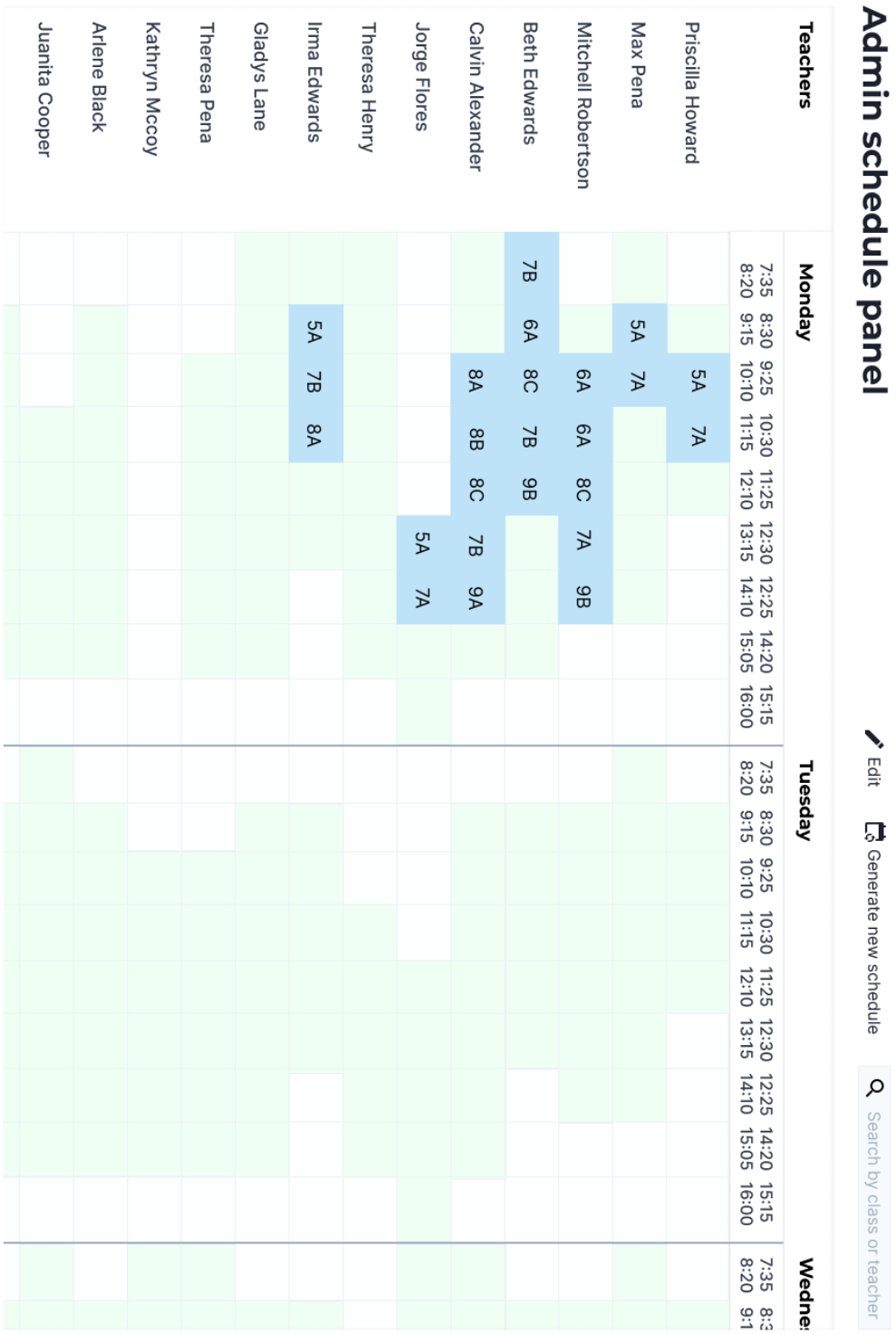

Fig. 3. Schedule example (administrator's view).

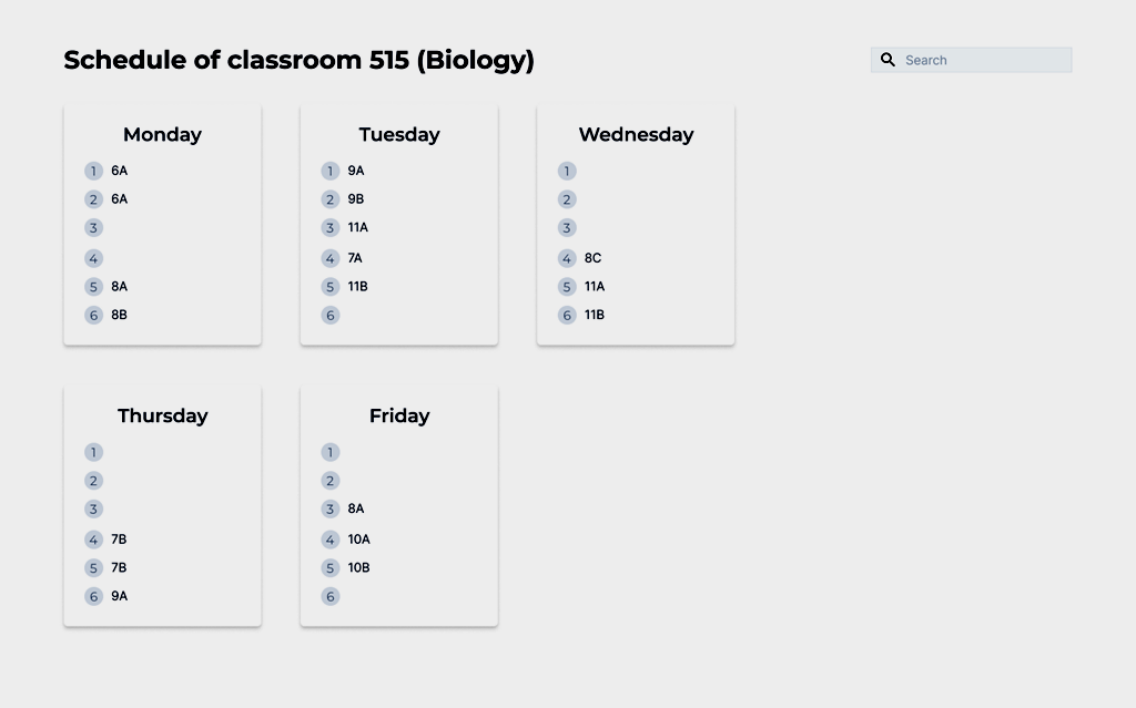

Fig. 4. Schedule view by rooms.

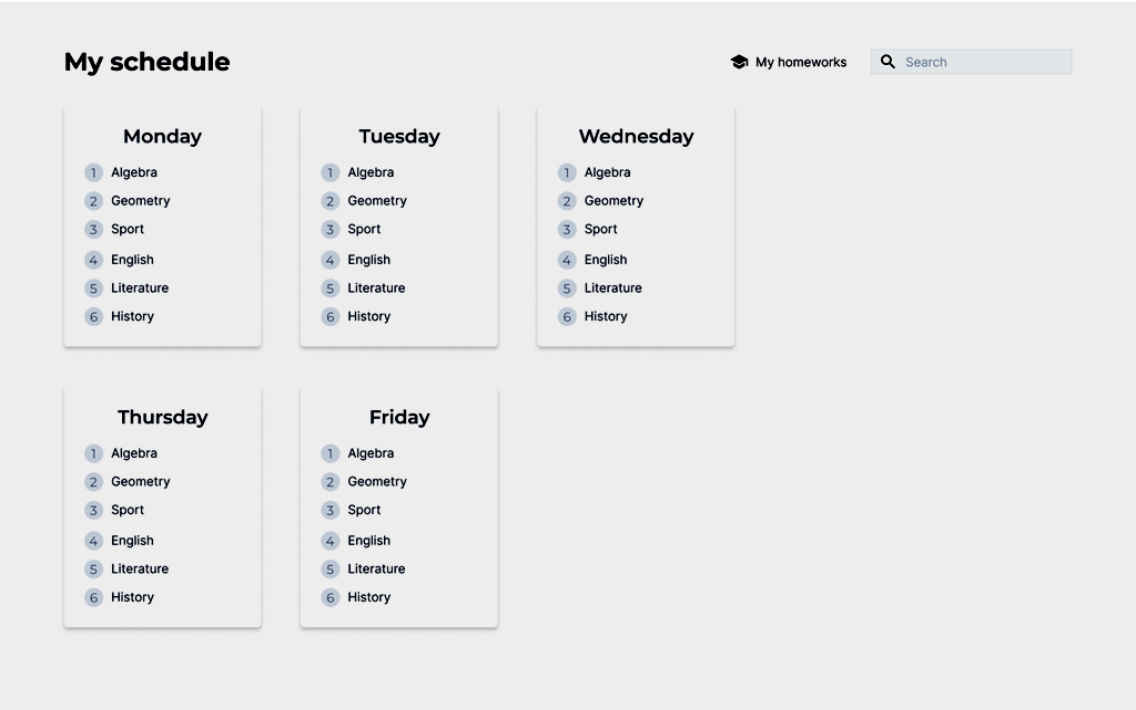

Fig. 5. Scheduler view (weekly, for the groups).

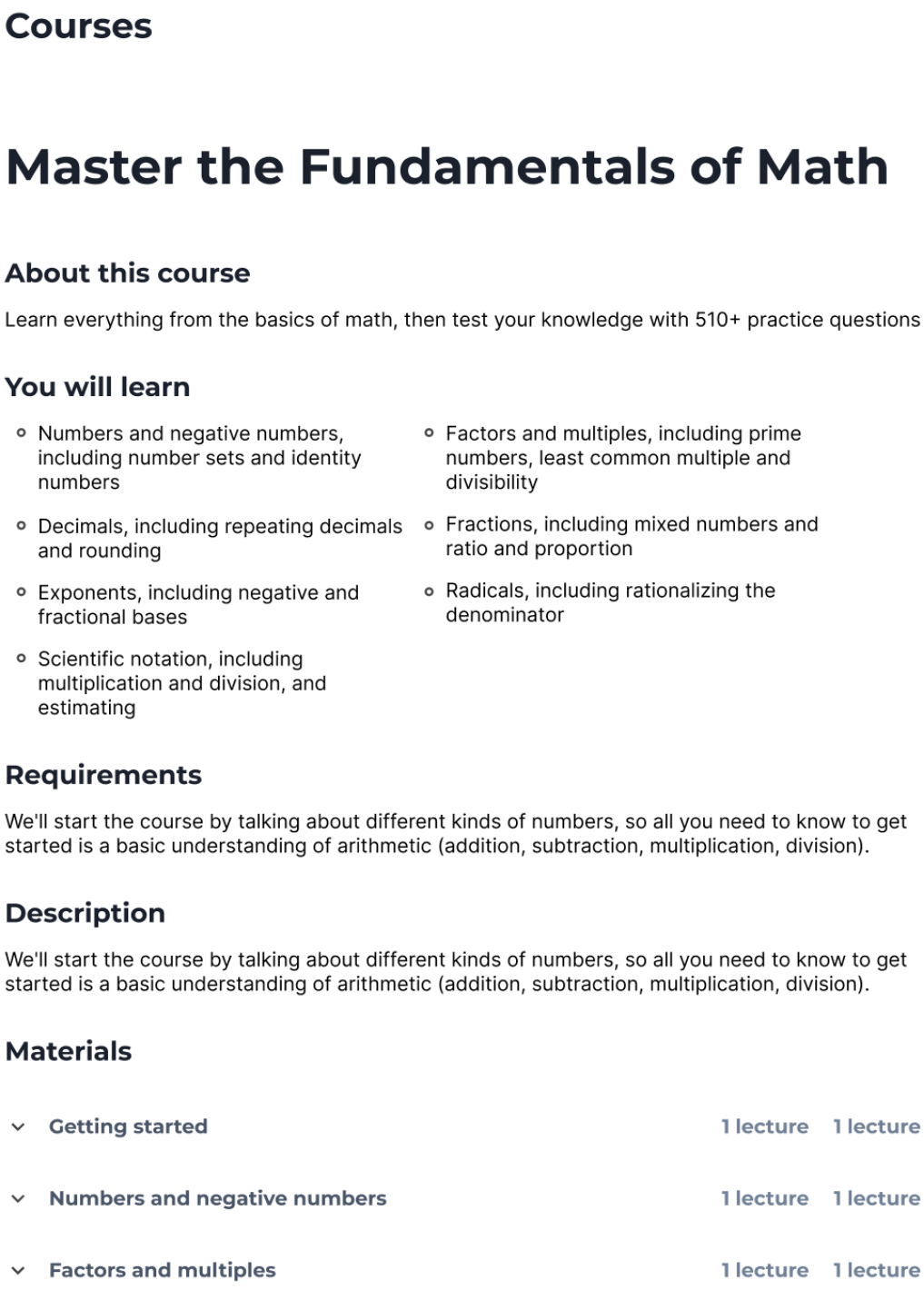

Fig. 6. Course syllabus example.

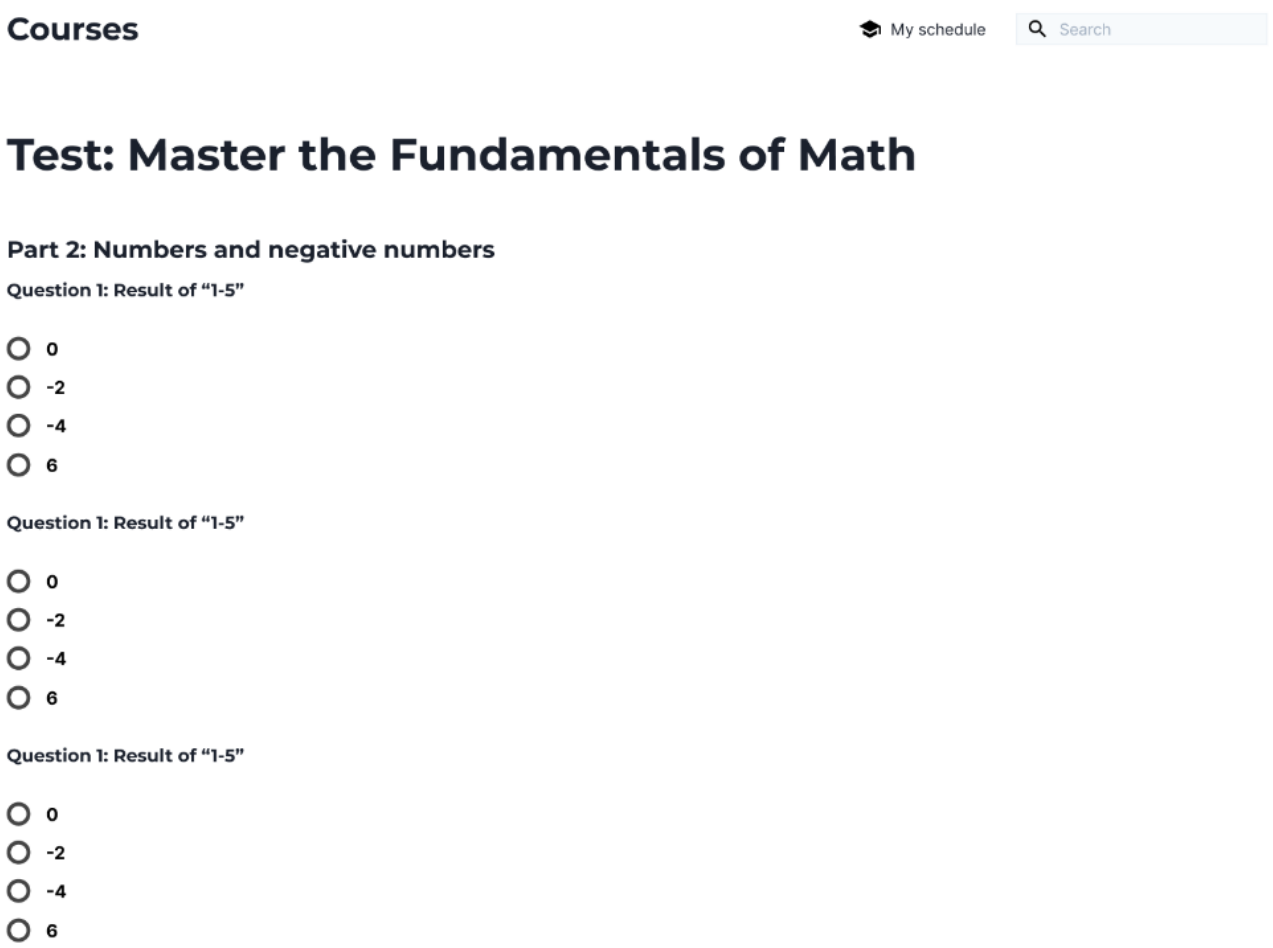

Fig. 7. Course test example view.

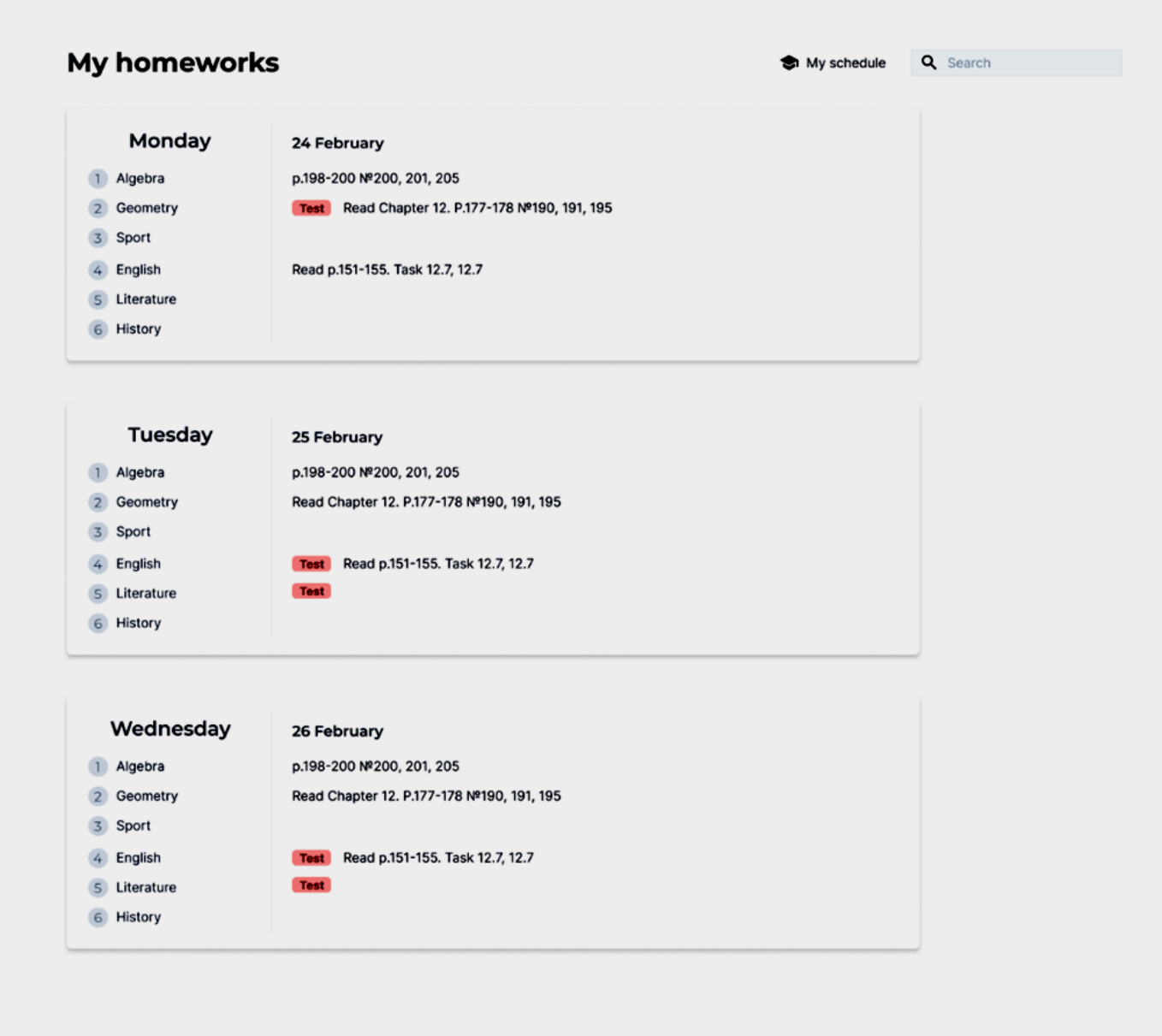

Fig. 8. Homework including scheduled tests during courses studying.

The details of this LMS will be featured in a separate paper.

Conclusion

We examined the most widely used Learning Management Systems [LTSC, AICC, IMS, ADL SCORM, ADL, MOODLE, Claroline, Dokeos, ATutor, ILIAS, SAKAI, LAMS, OLAT, OpenACS, LRN, COSE, LON-CAPA, ELEDGE, Colloquia, OpenLMS, Manhattan, DodeboLMS, Acollab], and we conducted the

comparative analysis and summarized the results in the appropriate table. Then we concluded that the scheduling functionality is omitted in all the systems, and we shed some light to the LMS developed to cope this lack. Also, we showed the pictures of the developed system, yet the system itself as well as the scheduling algorithm and the approach applied are the subject of a separate paper.

To summarize the comparison done here, main disadvantages of many systems are:

- absence in many systems of the Ukrainian higher education specifics of the organization of the educational process, that is, the document circulation between the management of the university, the deans of faculties, departments,

- lack of support for the Ukrainian language,

- inability to schedule classes.

The scheduling task is significant as it takes much time for manual work and has substantial practical importance. So, we are evaluating the results by experiments.

Unfortunately, the developers are not very concerned about the lack of timetable, although this will give a significant impetus to improve the organization of full-time as well as distant learning. Here are some benefits:

- it is convenient for the teacher to draw up a syllabus,

- the teacher can plan the lesson in advance (indicate instructional resources, methods, tasks) without spending time during the lesson,

- curriculum development would no longer take much time for the teacher,

- an automatic schedule would allow to import the curriculum of your colleagues at one click.

- gives the administration of the educational institution the possibility of convenient management and effective control.

In the future, it may be necessary to switch to another system, but most importantly, the skills of working with such systems will remain, that is, the infrastructure for supporting such systems will be created. And if the systems meet the standards, then the data will not be difficult to transfer.

Now we can conclude that we have 3 positive feedbacks from the schools and universities implemented our developed and proposed solution, so we do the features required development and also going to do the detailed poll of users of the system to analyze user experience in numbers.

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THE "CHURCH OF BULGARIA" IN MEDIEVAL EPIRUS, THESSALY AND DARDANIA: TWO HYPOTHESES

Jordan Tabov

Abstract: *The paper offers for discussion the problems of Christian tradition and Church organization in medieval Epirus, Thessaly and Dardania. Two hypotheses are made. The first is that the name "Ecclesia Bulgariae" ("Church of Bulgaria") was in use, from at least the ninth century, to denote continuous Church organization in this region, with different degrees of independence at different periods of time. The second is that the "Church of Bulgaria" has always followed the basic teachings of the Apostle Paul, found in specific traditions of early Christians in this region. The arguments in favour of these two hypotheses are presented.*

§ 0. Introduction: the question of the mediaeval "Ecclesia Bulgariae"

As is well known, the Byzantine Emperor Basil I invited representatives of the Christian world to his palace immediately after the Eighth Ecumenical Council, held at Constantinople on March 4, 870. "In fact, this meeting became an extraordinary meeting of the now-dissolved Church Council" (Bozhilov, Gyuzelev 1999 p. 184). It was here that the Bulgarian delegate Peter "raised for general consideration the issue of jurisdiction over the Bulgarian church, i.e. whether it should be subordinate to Rome or to Constantinople" (Bozhilov, Gyuzelev 1999 p. 184).

The representatives of the Pope argued that the "Bulgarian church" ought to be under the jurisdiction of Rome. The reason given was that the territories of the

former province of East Illyricum (Epirus, Thessaly, Dardania) had by ancient tradition been under Papal control.

The delegates of Rome and of the Eastern churches continued to dispute the matter. The Eastern delegates formulated their position about the status of the „Bulgarian church" as follows:

"... We decide that Bulgaria, which we know was recently under the rule of the Greeks and had Greek clergy, should now revert in Christendom to the Holy See of Constantinople" (Anastasius Bibliothecarius 1960 p. 192).

The statement that the country of the Bulgarians recently was under the rule of the Greeks implies that ***"the country of the Bulgarians"*** – the subject of the dispute – ***did not include the northeastern part of the Balkan Peninsula.***

The statement that „the country of the Bulgarians" had been under the rule of the Greeks and had had Greek priests means that the ***population was Christian before its conquest by the State of Boris***, therefore was not baptized by him or his representatives. This agrees with Koev and Bakalov's verdict regarding the mid ninth century: *„Today it is impossible to accurately determine the degree of the christianization of the Slavic tribes in the Balkans, but in any case in Thrace and Macedonia it was significant."* (Koev, Bakalov 1992 p. 152).

This analysis makes it probable that by "Bulgaria" the participants of the Eighth Ecumenical Council understood the region of Epirus, Thessaly, and Dardania (including the territory of ancient Macedonia). When did this idea become widespread, and where? Can it be linked with "Ecclesia Bulgariae" - the "Church of Bulgaria"?

§ 1. Two maps, Bulgaria and Zagora

Fig. 1. Fragment of the map “South Eastern Europe c. 1000” (Bury 1903).

At the end of the tenth century and during the eleventh, the name „Bulgaria” was widely used for the region discussed at the Eighth Ecumenical Council: Epirus, Thessaly, and Dardania. This can be seen on a number of historical maps. In **Fig. 1** there is a segment of one such map. Here the territory east of Bulgaria – the eastern part of the Balkans – is presented as Byzantine (Some authors call it by such names as Paristrion and Misia).

On the mid fifteenth century map of Fra Mauro (**Fig. 2**) we can see the name Bulgaria used for approximately the same area as in **Fig. 1.** This map is south-oriented; in other words South is at the top. In this segment the Danube is at the bottom and the Black Sea to the left. In this segment, the Danube-Black Sea region, corresponding to what is now northeastern Bulgaria, is labelled „Zagora". Further to the west, extending from around Sofia and Vidin to (approximately) the river Morava, is „Bolgaria" – Bulgaria. Her western neighbour is „Seruia" – Serbia.

Fig. 2. Fragment of the Fra Mauro World Map (c. 1450) (Fra Mauro 1450).

It is important to note the use, found in other documents as well, of the name “Zagora” for a country (or territories) “around Tarnovo” and for the eastern part of the Balkan Peninsula generally. According to some leading Bulgarian historians “Zagora” is synonymous with “Bulgaria”: (Ishirkov 1925), (Koledarov 1973), Bozhilov in the notes to (Muntaner 1994 p. 105) (Gyuzelev 1995 p. 12), and others. This view is summarized by Gyuzelev as follows: “... by the end of the XIIth century, Bulgaria and the revived Bulgarian state were starting to be called Zagora, originally by Byzantine writers and afterwards by Western writers ... a name, which was widespread mainly in XIII – XV c.” (Gyuzelev 1995 p. 12). This would fix the appearance of the name “Zagora” at around the turn of the twelfth century. However the name is found much earlier, in a Bulgarian history from the time of Tervel, who was granted by the Byzantine emperor Justinian II the title of Caesar together with “the region of Zagora.”

This view, that the name Zagora is equivalent to “Bulgaria”, is however in confict with certain documentary evidence. Charles I, king of Naples, writes in a rescript to the Secretaries of Apulia, Capua, Benevento, Calabria and Sicily:

> Si processu temporis aliquos ambassatores seu nuncios de partibus Achaye, Servie, Bulgarie, Albanie aut de Imperio vel de Regno de Sagarach deferentes aliquas litteras …
>
> [If in course of time there should come any ambassadors or envoys either from the regions of Achaea, Servia, Bulgaria, Albania or from the empire (or kingdom) of Sagarach [!Zagora], with any letters,…]
>
> (Makushev 1871 p. 29).

As Dimitrov observes, “at this first appearance of Bulgarian envoys to the court of Naples on September 12, 1271 a distinction was made: „*ambassatores seu nuncios de partibus ... Servie, Bulgarie ... vel Regno de Zagarach*. For the king of Naples, in other words, there were not one but two Bulgarian states: Bulgaria proper, and Zagora, meaning the Bulgarian Vidin and Tarnovo kingdom” (Dimitrov 1998 p. 196).

The terms ‘Vidin Kingdom’ and ‘Tarnovo Kingdom’ are in fact used in modern scientific literature and textbooks. But were they used in the past? And if so, to what extent?

In his monograph Dimitrov quotes a number of examples showing the widespread use of the names “Bulgaria” and “Zagora” in association (Dimitrov 1998). These examples suggest that the name “Bulgaria” was used for the western Bulgarian lands, for territories – conditionally – “around Vidin, Sofia and Skopie”.

The above analysis outlines our hypothesis that ***“Zagora” and “Bulgaria” were two separate administrative and political units coexsiting over a long period of the Middle Ages***.

§ 2. The Bulgarian Churches under the Asen dynasty (late 12th – late 13th c.)

The use of the name “Bulgaria” for the territories thus marked on the two maps above, and in particular on Bury’s map (**Fig. 1**) is closely related to questions about the Christian institutions of the Bulgarians.

After the uprising of Asen and Peter, the so-called “Tarnovo Patriarchate” was established (or perhaps restored) at Veliko Tarnovo. Nikolova sees this act as “the emergence of a completely new ecclesiastical throne”, but cautiously adds “…about whose previous existence we have no information”.

(Nikolova 2001 p. 91). At the date of its establishment (or restoration) the “See of Ohrid” had already been in operation for many years. With the definer “of Bulgaria” invariably appended to its name. It is interesting to speculate how the See of Ohrid, to say nothing of the Patriarchate of Constantinople, will have reacted to this newcomer. For Nikolova, the change “at the outset awoke no conflict, and provoked no objections, which indicates that it took place with the consent of the founders and the Bulgarians” (Nikolova 2001 p. 91).

We should add: not only did it awake no conflict and provoke objections; this epoch-making event defies all justification and explanation.

Later, when Ivan Asen II extended his authority over the dioceses of the Ohrid and the Tarnovo Churches, he did not combine them into a single church. Why not? Was the history of these two churches – their condition in the reigns of Simeon, Peter and Samuel – in fact known in the time of Ivan Asen? Were the “Tarnovo Patriarchate” and the “See of Ohrid” at that time parts of a unitary whole?

§ 3. St. Clement of Ohrid – “Bishop of Velichi”, “First Bishop”

The supposition that Clement was the head of the Bulgarian Church is proved in detail in an article by Dragova (Dragova 1977). It also follows from a note by Krustanov that “First Bishop”, the appellation of Clement in his lengthy *Vita*, here means “Primate”, that is, “first among all the bishops”, of the Bulgarian people (Krastanov 1998).

Further arguments in support of this thesis can be found in two articles of mine (Tabov 2011 and Tabov 2014), where on the basis of abundant cartographic material, including twelve of the most authoritative and widely-used geographic atlases and maps from the sixteenth to the eighteenth centuries, the medieval

"Velitsa", seat of Bishop Clement, is to be identified with classical Nicopolis in Epirus.

It should particularly be emphasized that, on all these maps, there is on the site of the classical Nikopolis, near modern Preveza – a city marked as "Velichi" (or sometimes "Velichj"). Thus we can see that in the Middle Ages classical Nicopolis was known to the map-reading European public as Velichi. Of the maps I quote (Tabov 2011) the following should be mentioned:

- Graeciae Universae Secundum Hodiernum Situm Neoterica Descriptio. In: Abraham Ortelius. *Theatrum Orbis Terrarum*. Antwerp, 1570.

- Graecia. In: Gerard Mercator Rupelmundanus. *Atlas sive cosmographicae meditationes de fabrica mundi et fabricati figura.* Duisburgi Clivorum, MCXCV [1595].

- Europa, das ist ein Drittheil der Erden nach gelegenheit unserer zeit beschrieben. In: Sebastian Münster. *Cosmographia, Das ist Beschreibung der ganzen Welt*. Basel, 1628.

- Epirus hodie vulgo Albania, Auctore I. Laurenbergio. In: Willem Janszoon, Joan Blaeu. *Theatrum orbis terrarum, sive, Atlas novus.* c. 1650.

- Macedonia, Epirus et Achaia. J.Blaeu excudit. In: *Toonneel des Aerdryck oft Nieuwe Atlas, uytgegeven door Wilhelm en Joan Blaeu.* Derde Deel. Amsterdam, by Joan Blaeu. MDCLVIII [1648].

In his monograph on the history of the Bulgarian Church (Tzuhlev 1910), Tzuhlev discusses the work of the Apostle Paul in the Balkans; on p. 11 we read: "... The Apostle, as he himself mentioned in one of his Letters, spread the doctrine of Christ from Jerusalem to Illyricum (Rom. 15: 18-19)".

Tzuhlev adds a detail of great importance in the present context: “and he founded a church at Nikopol”. This is explained in a footnote, numbered 7, which reads: “Epistle to Titus, III, 12. Nikopol is located at the entrance of the Ambracian Gulf (now the Gulf of Arta), just north of the present town of Preveza (Pauiys *ibid*, t. V, p. 637; Leporskiiy, *ibid*, p. 326 and map). The founding of the Church at Nicopolis took Paul a whole year” (Tzuhlev 1910, p. 11).

Nicopolis, the medieval Velichi, was the Metropolis of Epirus and later of South Epirus. If Tsuhlev is right, Clement Velichki was head of the Church of Nicopolis, founded by one of the Apostles. Moreover, since this was the Apostle Paul, Clement was the head of a Church of great authority. On Bury’s map (**Fig. 1**), the northern coast of the Gulf of Arta, on which Nicopolis-Velichi (Velitsa) lies, was within in the territory of “Bulgaria”. Velichi was, therefore, a Bulgarian town[1].

§ 3. The “parts” of the Kingdom of Simeon the Great

In the Du Cange *Glossary* we read that “Clement, after becoming bishop of Tiberiopolis or Velika, was charged by Boris, King of the Bulgarians, to supervise the one-third part of the Bulgarian kingdom ...” (translation in Tapkova-Zaimova 2000).

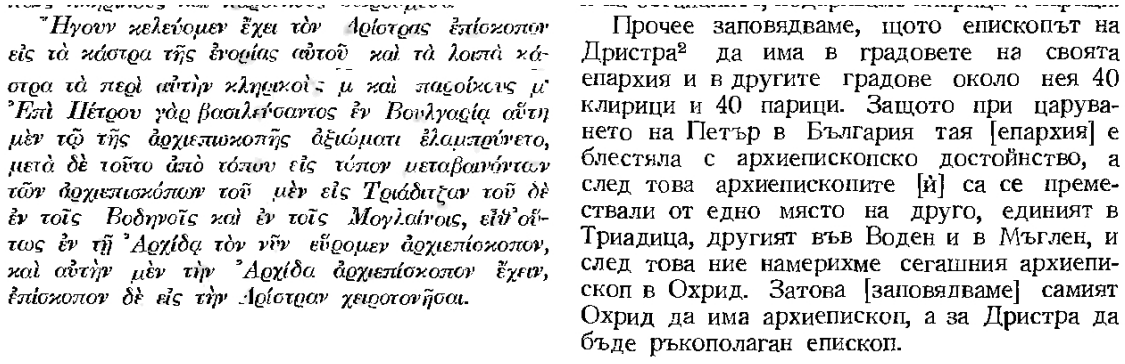
From this text, it would appear that in the reign of Boris I the “Bulgarian kingdom” had three (if not more) “parts”. This is probably an indicator of some degree of feudal fragmentation in the Bulgarian lands. One would like to know the names of these three parts. Was Zagora in the territory of one of them? and

[1] This is explained in detail in the article (Tabov 2014).

if so, what was it called? Does the celebrated Dobrogea – “the land of Dobrotitza” – have ancient administrative and political roots too?

§ 4. The two Bulgarian archiepiscopal Sees in the Charters of Basil II

A passage from a charter of Basil II dated 1020 gives information (excerpted here as **Fig. 3**) about the Archiepiscopal Sees in Bulgaria (GIBI6 1968 p. 45):



Ἤγουν κελεύομεν ἔχει τὸν Δρίστρας ἐπίσκοπον εἰς τὰ κάστρα τῆς ἐνορίας αὐτοῦ καὶ τὰ λοιπὰ κάστρα τὰ περὶ αὐτὴν κληρικοὺς μ καὶ παροίκους μ· Ἐπὶ Πέτρου γὰρ βασιλεύσαντος ἐν Βουλγαρίᾳ αὕτη μὲν τῷ τῆς ἀρχιεπισκοπῆς ἀξιώματι ἐλαμπρύνετο, μετὰ δὲ τοῦτο ἀπὸ τόπου εἰς τόπον μεταβαινόντων τῶν ἀρχιεπισκόπων τοῦ μὲν εἰς Τριάδιτζαν τοῦ δὲ ἐν τοῖς Βοδηνοῖς καὶ ἐν τοῖς Μογλαίνοις, εἶθ’οὕτως ἐν τῇ Ἀρχίδᾳ τὸν νῦν εὕρομεν ἀρχιεπίσκοπον, καὶ αὐτὴν μὲν τὴν Ἀρχίδα ἀρχιεπίσκοπον ἔχειν, ἐπίσκοπον δὲ εἰς τὴν Δρίστραν χειροτονῆσαι.

Прочее заповядваме, щото епископът на Дристра[2] да има в градовете на своята епархия и в другите градове около нея 40 клирици и 40 парици. Защото при царуването на Петър в България тая [епархия] е блестяла с архиепископско достойнство, а след това архиепископите [й] са се премествали от едно място на друго, единият в Триадица, другият във Воден и в Мъглен, и след това ние намерихме сегашния архиепископ в Охрид. Затова [заповядваме] самият Охрид да има архиепископ, а за Дристра да бъде ръкополаган епископ.

Fig. 3. Information in a passage from a Charter of Basil II dated 1020 about the Archiepiscopal Sees in Bulgaria (GIBI6 1968 p. 45).

> Then we command that the bishop of Dristra shall have, in his diocese and in the other surrounding towns, forty clerks and forty *paroikoi*. For during the reign of Peter in Bulgaria, this [diocese] shone with archiepiscopal dignity. Then the archbishops [of the diocese] moved from place to place, the one to Triaditza, the other to Vodena and Moglena. This is how we find the present Archbishop at Ohrid. So Ohrid shall itself have its Archbishop, and a bishop shall be ordained at Dristra.

Snegarov (Snegarov 1925 p. 12) makes an important comment on this text, that in it the term “Archbishop” implies residence. “It is stated explicitly”, he writes, “that the throne of the Bulgarian Patriarch (the imperial decree simply says “Archbishop”) was transferred &c”.

Thus the term “Archbishop” includes the meaning “archiepiscopal residence”. And this is logical for two reasons.

Firstly, “moving the archbishops” implies the transfer of their seats. For comparison, our sources state that St. Clement Ohridski often changed his residence and spent much time in Ohrid; here it is clear that Clement's own personal “move” did not entail moving the seat of the archbishopric.

Secondly, since “Archbishop” in the Charter refers to the single person heading the Archbishopric, the form of words “the one ... the other ...” requires two individuals. Damian moved from Dristra in Triaditza; then German /Gabriel moved from Triaditza to Vodena and Moglena. However, we know from the Vodena inscription that German/Gabriel was preceded not by Damian but by one Jeremiah. Thus there is a contradiction within this argument.

To avoid ambiguity in the translation and interpretation of the passage from the Charter, let us replace the term “Archbishop” by “archiepiscopal seat”. That gives us:

> Then we command that the bishop of Dristra shall have, in his diocese and in the other surrounding towns, forty clerks and forty *paroikoi*. For during the reign of Peter in Bulgaria, this [diocese] shone with archiepiscopal dignity. Then **the archiepiscopal seats** [of the diocese] moved from place to place, the one to Triaditza, the other to Vodena and Moglena. This is how we find **the present archiepiscopal seat** at Ohrid. So Ohrid shall itself have its Archbishop, and a bishop shall be ordained at Dristra.

This leads to a conclusion important for our ***hypothesis***: at the end of the reign of King Peter I in the Bulgarian lands there were two different Churches, each with its respective Head (Patriarch, and Archbishop). The Charter of the Byzantine Emperor (Basil II) of 1020 is interpreted as describing the movement of the seats of these two Heads.

§ 5. In support of the above hypothesis

The Du Cange *Glossary* contains a list of the Heads of six Churches over a long period of time. It begins with the Heads of the Church of Constantinople, the first being the Apostle Andrew (Barlieva 2000). It then names the Heads of the Church of Rome, the first of which are Christ and the Apostle Peter. The list continues with the Churches of Alexandria (Christ, the Apostle Mark, and the Apostle Ananias), Antioch (Christ and the Apostle Peter), Jerusalem (Christ and St. Jacob). Finally comes the Church of Bulgaria, its first Head being a fourth-century bishop named Protogen.

According to Barlieva (Barlieva 2000), the passage in the *Glossary* which names the bishops of the first five Churches – (i.e. the *Glossary* except of the part with the bishops of the Church of Bulgaria) – is based on the Apostolic Succession. This predicates that Christ's teaching was transmitted through His Apostles, and from them to the hierarchy of the Christian Church. Thus local bishops can be seen as bearers of the Apostolic tradition, while an episcopal list of individual Churches founded by one of the Apostles demonstrates their apostolicity[1]. (We should remember that the New Testament implies a *personal*

[1] Wikipedia summarises well known facts in the following way: "Apostolic succession is the method whereby the ministry of the Christian Church is held to be derived from the apostles by a continuous succession, which has usually been associated with a claim that the succession is

apostolic succession – from Paul to Timothy and Titus, for example, and that the tradition of the first centuries of Christianity gives the Apostolic Churches the right of individual and relative autonomy – 'autocephaly', to use the later term.)

However, the description of Barlieva is not complete: the first five churches are not five Apostolic Churches chosen at random; they are precisely the Churches of the Pentarchy, as it is called – the five most authoritative Apostolic Churches in the Christian world. The list assigns to each of them its Founder.

If we compare this list with the modern version of the Pentarchy, there are important differences in details.

First of all we should note that the list of the *Glossary* starts with the Church of Constantinople, unlike the present-day official order, in which the Pentarchy is headed by the Church of Rome. The second and important difference is that the Apostle Paul is not mentioned as one of the founders of the Churches. The third, and still more important difference is that the addition of a sixth Church to the "classic" Pentarchy actually creates a Hexarchy - a group of not five, but six Apostolic Churches. According to Barlieva, the presence of the Church of Bulgaria (the See of Ohrid) in the list is an explicit claim to apostolicity (Barlieva 2000).

So the apostolicity of the Church of Bulgaria is a concept inserted by the compiler of the list. If we accept the hypothesis proposed above, that the "Church of Bulgaria" is identical with the "Church of Nicopolis-Velichi", this

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through a series of bishops. This series was seen originally as that of the bishops of a particular see founded by one or more of the apostles." Apostolic succession. *From Wikipedia, the free encyclopedia*. Retrieved 12. Oct. 2016. https://en.wikipedia.org/wiki/Apostolic_succession

entails that the latter Church was “apostolic”, in the sense of having been founded by an Apostle. This would have entitled it, by tradition, to autocephaly and veneration.

Following this line of thought, we may connect the high ranking obtained by Justinian for his Justiniana Prima with the claim to apostolicity by its constituent - the church of Nicopolis-Velichi, alias the “Church of Bulgaria”. In other words, the prestige and rank of Justiniana Prima was due to its origins in the Church of Nicopolis-Velichi.

Now let us return to the details given in the list of Heads of the Bulgarian Church, in order to support the hypothesis that it has come down to us not in its original, but in a censored form.

In favor of this hypothesis, first of all, are certain unexpected features in the list:

- The Church lacks the name of its Founder. This ought to be one of the Apostles, most probably St Paul.

- The names of bishops after the Founder, up to Protogen, are also missing.

- The name of Jeremiah, German’s predecessor, though mentioned in Tzar Samouil’s inscription at Vodena, is also missing here.

Jeremiah is the name of a well known heretic. This name, and another or others before it, were very probably omitted deliberately by a copyist who decided that these were names of heretics. For example even the name of Paul could be understood as the name of the heretic Paul of Samosata; and so on.

§ 6. Problems

The above considerations and hypotheses pose interesting questions about the large component parts of Bulgarian territory; about their changes of name; about the degree to which they were autonomous (within the Byzantine Empire, within Bulgaria, or within Zagora or some other state); about the processes and the advance of Christianity among the Bulgarians in various regions; and about the creation and the development of Bulgarian Christian institutions. To address these questions requires research and analysis in depth across a wide field, making use of the most up-to-date information technology.

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О «ГЕНЕТИЧЕСКОЙ БЛИЗОСТИ» НАРОДОВ

Й. Табов, Н. Събева-Колева, Г. Гачев

Аннотация. *Анализ ДНК - это хорошо зарекомендовавший себя научный метод, который становится все более популярным на практике. Он используется и для сравнения* ***«генетической близости»*** *народов. Здесь предлагается подход к такому сравнению, основанный на подсчете и сравнении „генетических расстояний" между народами по данным генетических исследований, опубликованным на сайте Eupedia. Он дает возможность для построения наглядных схем, отражающих полученные результаты. В качестве примера приведены результаты сравнений трех групп соседних стран: 1) Болгария, Сербия, Греция, Македония, Турция и Румыния; 2) Босния, Сербия, Хорватия и Черногорье; 3) Чехия, Словакия, Польша и Германия.*

Проблемы наглядности «генетической близости» народов

Изучение генетических связей и происхождение народов является одним из интересных и важных современных применений анализа ДНК. Результаты таких исследований чаще всего представлены либо в виде «древовидной схемы», аналогичной семейным деревьям (**рис. 1**), либо как точки в плоскости, сгруппированных по «близости» (**рис. 2**), либо в виде таблицы с данными о проценте преобладающих гаплогрупп (**рис. 3**).

Пример на **рис. 1** показывает недостатки использования “дерева народов”: он подводит нас к мысли, что грузины и иранцы являются ближайшими (или одними из ближайших) “родственников” болгар. То же самое можно сказать и о представлении на **рис. 2:** там видим болгар и македонцев рядом с иранцами и далеко от румын, а чувашей – недалеко от датчан и итальянцев.

В то же время таблица на **рис. 3**, составленная только из числовых данных о соответствующих народах, скорее всего является и объективной, и достаточно точной, но не дает хорошего “наглядного представления” об относительной близости или удаленности представленных в ней народов.

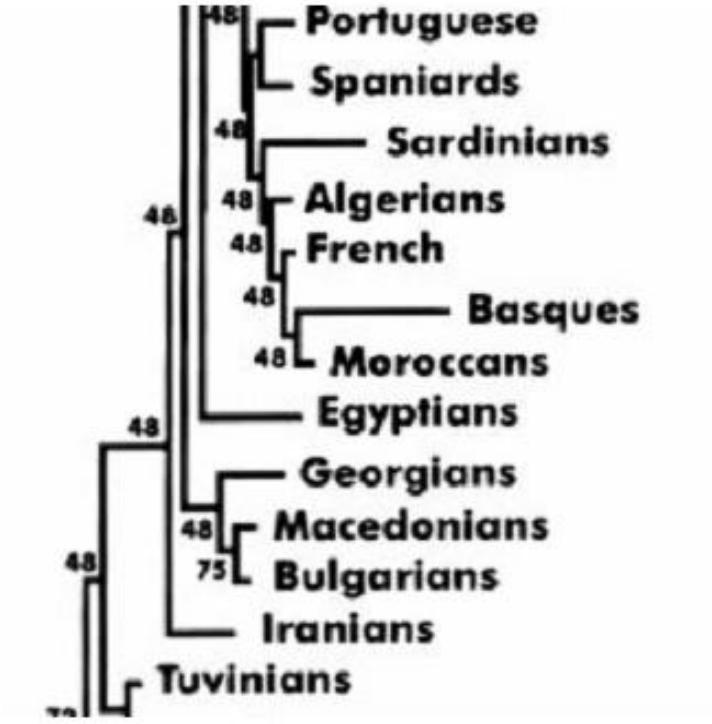


Рис. 1. “Генетическое семейное дерево народов”, отражающее результаты генетических исследований.

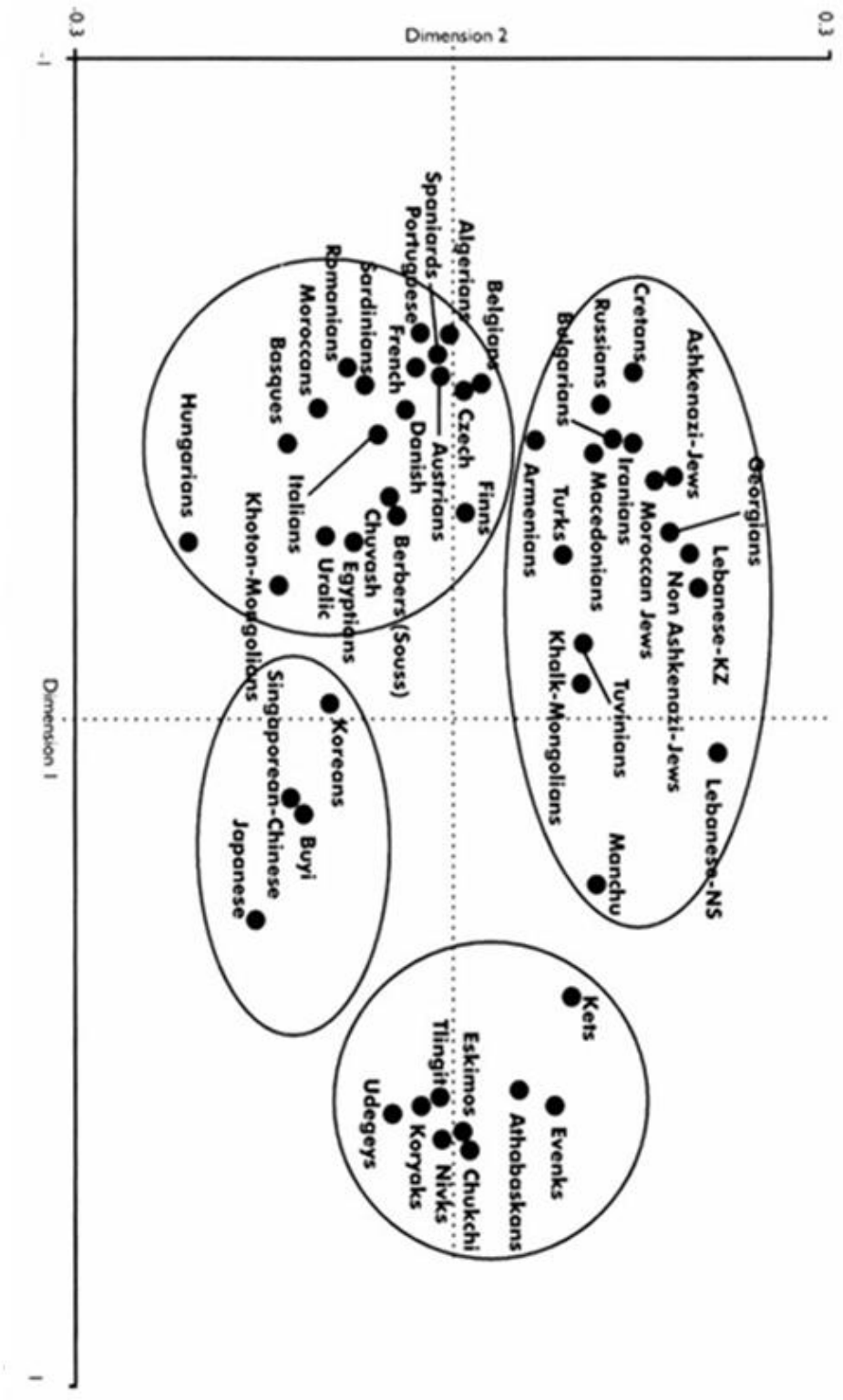
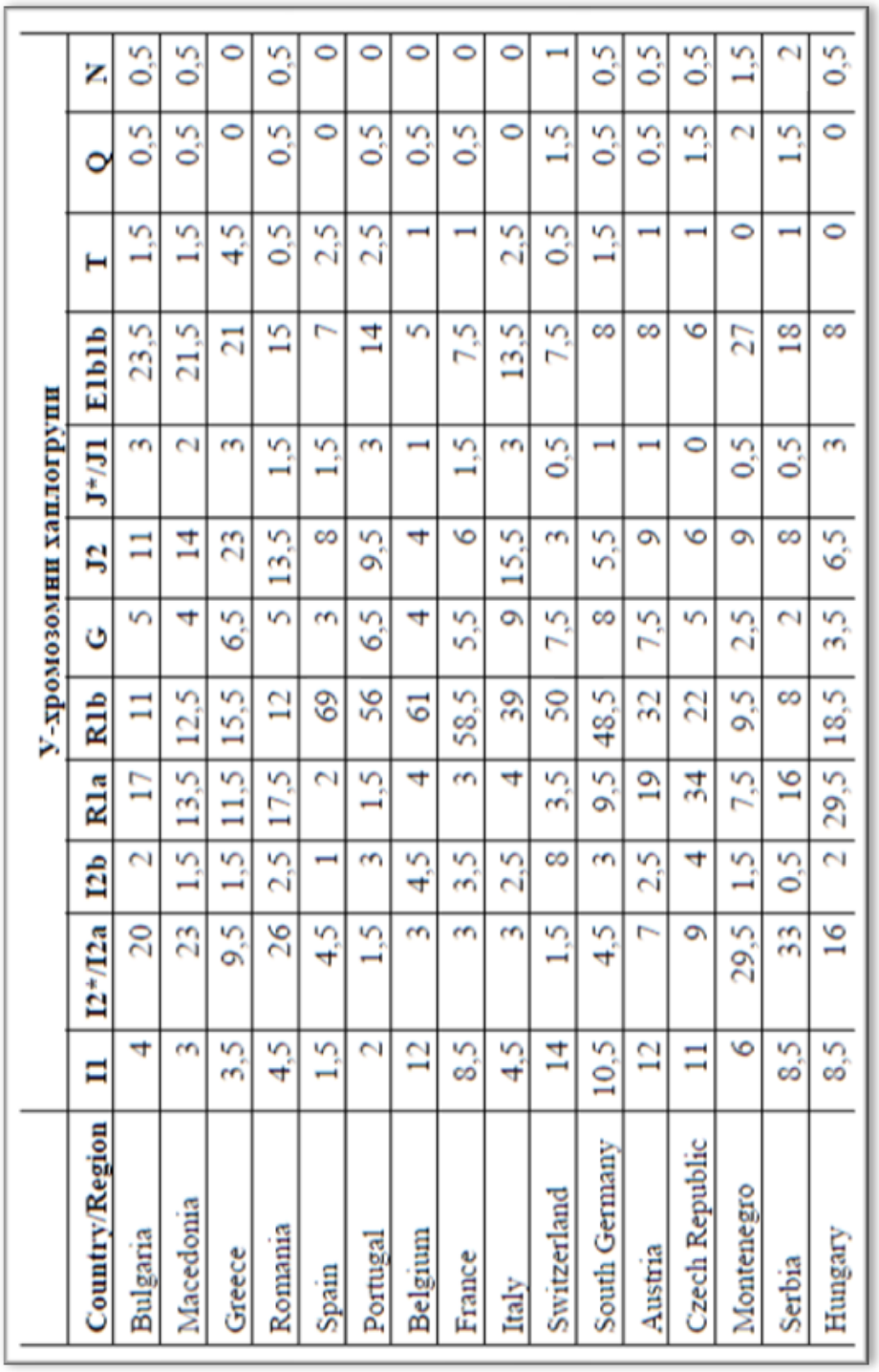


Рис. 2. Группировка народов, представленных в виде точек на плоскости, в соответствии с их генетической близости.



	У-хромозомни хаплогрупи												
Country/Region	I1	I2*/I2a	I2b	R1a	R1b	G	J2	J*/J1	E1b1b	T	Q	N
Bulgaria	4	20	2	17	11	5	11	3	23,5	1,5	0,5	0,5
Macedonia	3	23	1,5	13,5	12,5	4	14	2	21,5	1,5	0,5	0,5
Greece	3,5	9,5	1,5	11,5	15,5	6,5	23	3	21	4,5	0	0
Romania	4,5	26	2,5	17,5	12	5	13,5	1,5	15	0,5	0,5	0,5
Spain	1,5	4,5	1	2	69	3	8	1,5	7	2,5	0	0
Portugal	2	1,5	3	1,5	56	6,5	9,5	3	14	2,5	0,5	0
Belgium	12	3	4,5	4	61	4	4	1	5	1	0,5	0
France	8,5	3	3,5	3	58,5	5,5	6	1,5	7,5	1	0,5	0
Italy	4,5	3	2,5	4	39	9	15,5	3	13,5	2,5	0	0
Switzerland	14	1,5	8	3,5	50	7,5	3	0,5	7,5	0,5	1,5	1
South Germany	10,5	4,5	3	9,5	48,5	8	5,5	1	8	1,5	0,5	0,5
Austria	12	7	2,5	19	32	7,5	9	1	8	1	0,5	0,5
Czech Republic	11	9	4	34	22	5	6	0	6	1	1,5	0,5
Montenegro	6	29,5	1,5	7,5	9,5	2,5	9	0,5	27	0	2	1,5
Serbia	8,5	33	0,5	16	8	2	8	0,5	18	1	1,5	2
Hungary	8,5	16	2	29,5	18,5	3,5	6,5	3	8	0	0	0,5

Рис. 3. Таблица, которая показывает содержание (в %) 12-ти У-хромозомных гаплогрупп в соответствующих популяциях по данным проекта EUPEDIA.

Можно ли сочетать точность числовых данных в таблице на **рис. 3** с наглядностью схем на **рис. 1** и **рис. 2**? Ниже мы предлагаем способ осуществить это.

Сравнение народов: Болгария, Македония, Сербия и Греция

Сравнение данных в таблице на **рис. 3** показывает, что ближе всего к „болгарской строке" является „македонская строка". Можно ли сравнить эту „близость" с „расстояниями" между остальными строками? Этого можно добиться путем сравнения „генетических расстояний". Для этой цели мы будем интерпретировать числа в каждой строке как координаты точки в 12-мерном евклидовом пространстве, а расстояние между ними будет играть роль генетического расстояния. (О народах, для которых сумма процентов данных в таблице 12-ти У-хромозомных гаплогрупп меньше 95%, формально получаются большие отклонения от значений, подсчитанных для большего количества У-хромозомных гаплогрупп, поэтому мы их игнорируем.)

Для того чтобы сравнить (генетически) народы Болгарии, Македонии, Сербии и Греции, подсчитаем „генетиче

кие расстояния" между ними; результат показан в таблице на **рис. 4.**

	Македония	Сербия	Греция
Болгария	**6**	**16**	**18**
Македония		**15**	**17**
Сербия			**31**

Рис. 4. Таблица генетических расстояний между народами стран: Болгария, Македония, Сербия и Греция.

Теперь можно представить наглядно сравнение генетических расстояний (длины отрезков, соединяющих соответствующие точки) для троек стран:

1) Болгария, Македония, Сербия и 2) Болгария, Македония, Греция – на **рис. 5**.

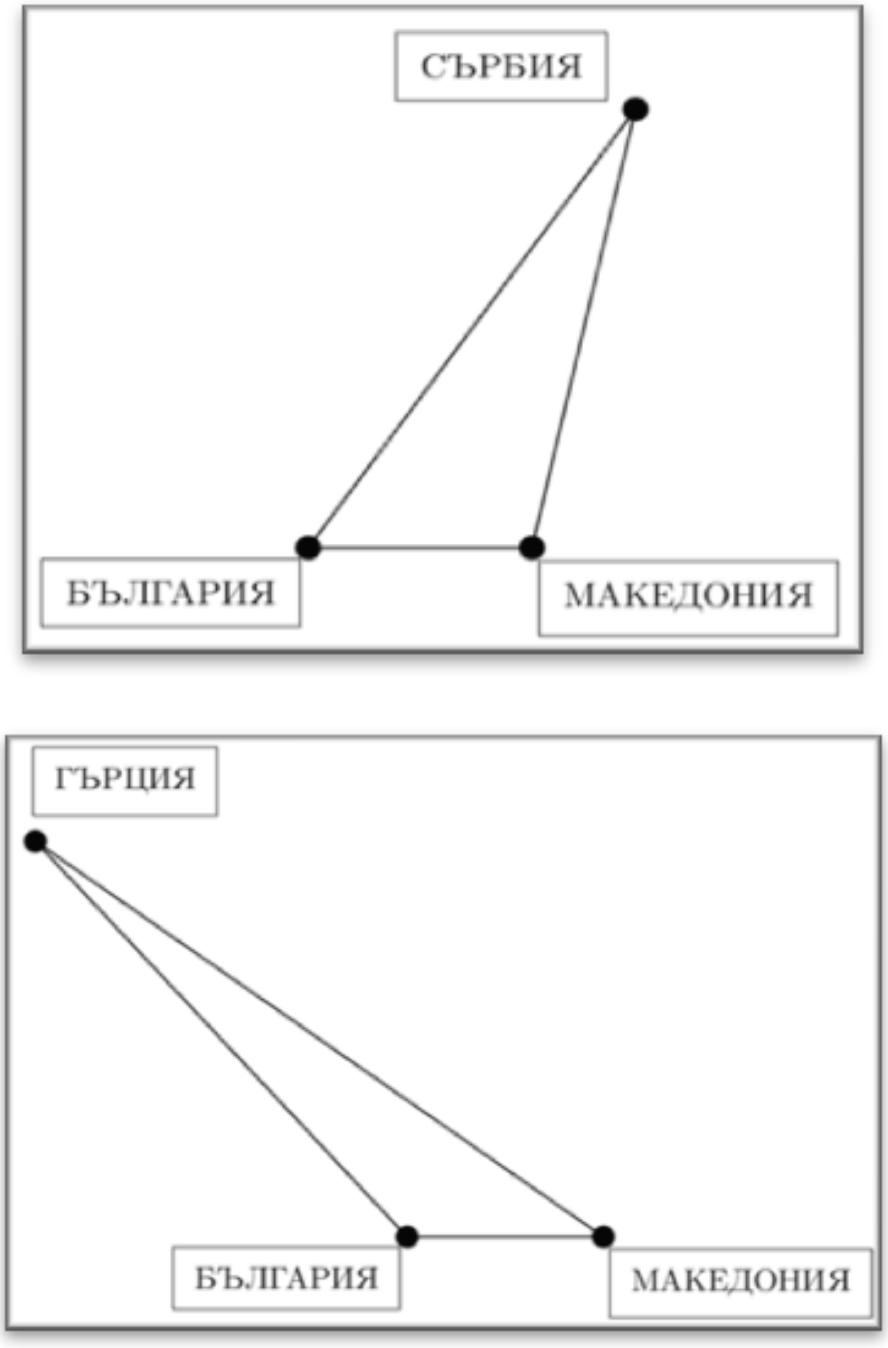


Рис. 5. Наглядное сравнение генетических расстояний для троек стран: 1) Болгария, Македония, Сербия (слева) и 2) Болгария, Македония, Греция (справа).

Подобная двумерная визуализация генетических расстояний для четырех и более стран не всегда целесообразна. Точки в многомерном пространстве, соответствующие процентам У-хромозомных гаплогрупп для каждого народа, в большинстве случаев расположены так, что при проектировании их на плоскость соотношения расстояний между ними меняются значительно. Это дает возможность для спекуляций, которые вовсе не являются редкостью при истолковании результатов генетических исследований. Но в данном случае для четверки Болгария, Македония, Греция и Сербия с небольшой ошибкой получается проекция на плоскости как на **рис. 6**.

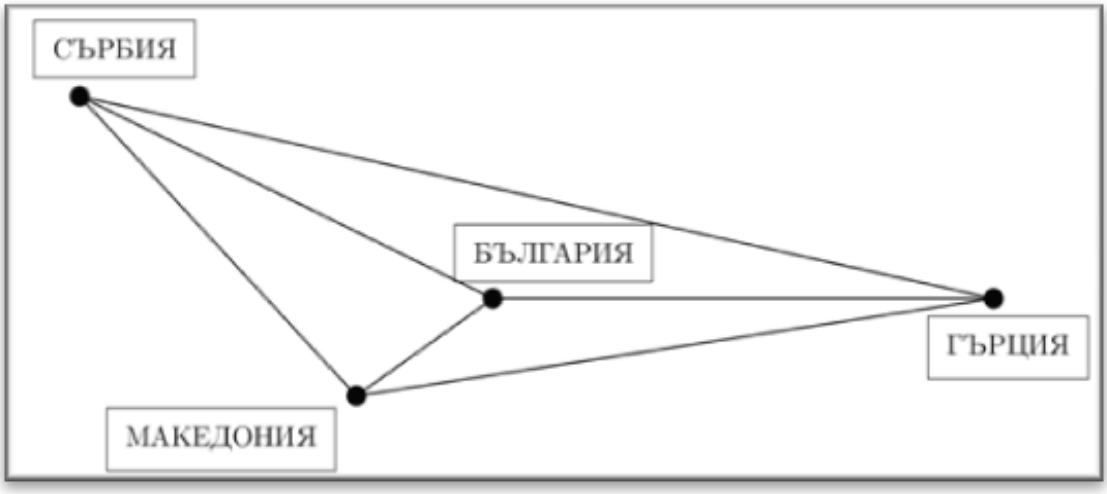


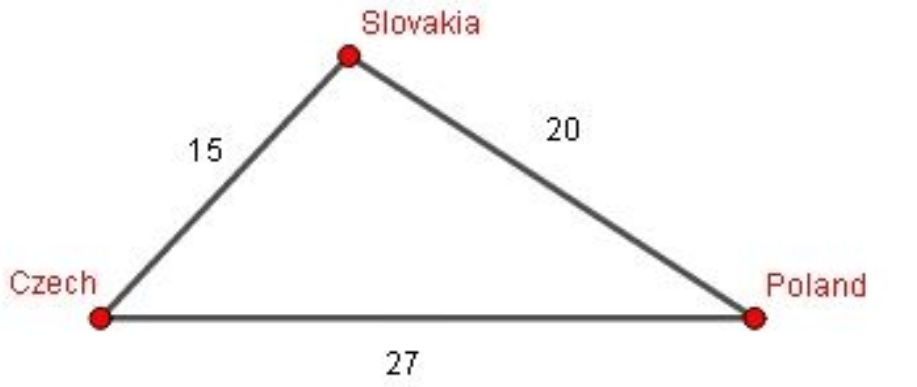
Рис. 6. Наглядное сравнение генетических расстояний для четверки стран: Болгария, Македония, Сербия и Греция.

Генетическое расстояние между народами Македонии и Болгарии определенно меньше расстояния между народом Болгарии и народами других его соседей – Сербии, Греции, Румынии. Появляется вопрос:

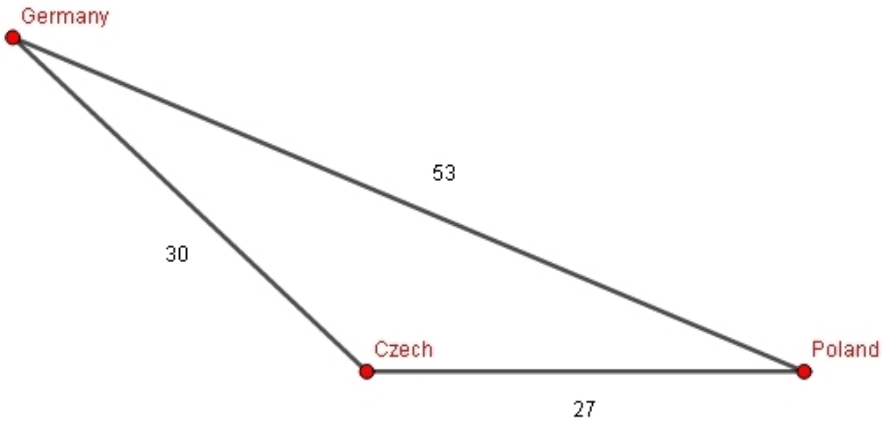
большим или маленьким является оно по *сравнению с остальными расстояниями между соседними народами в Европе*?

Чтобы подготовиться к исследованию этого вопроса, рассмотрим еще два примера.

Сравнение народов: чехи, поляки, словаки и немцы

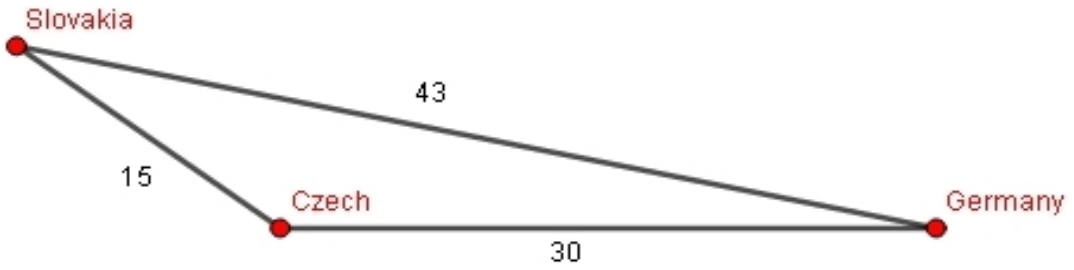


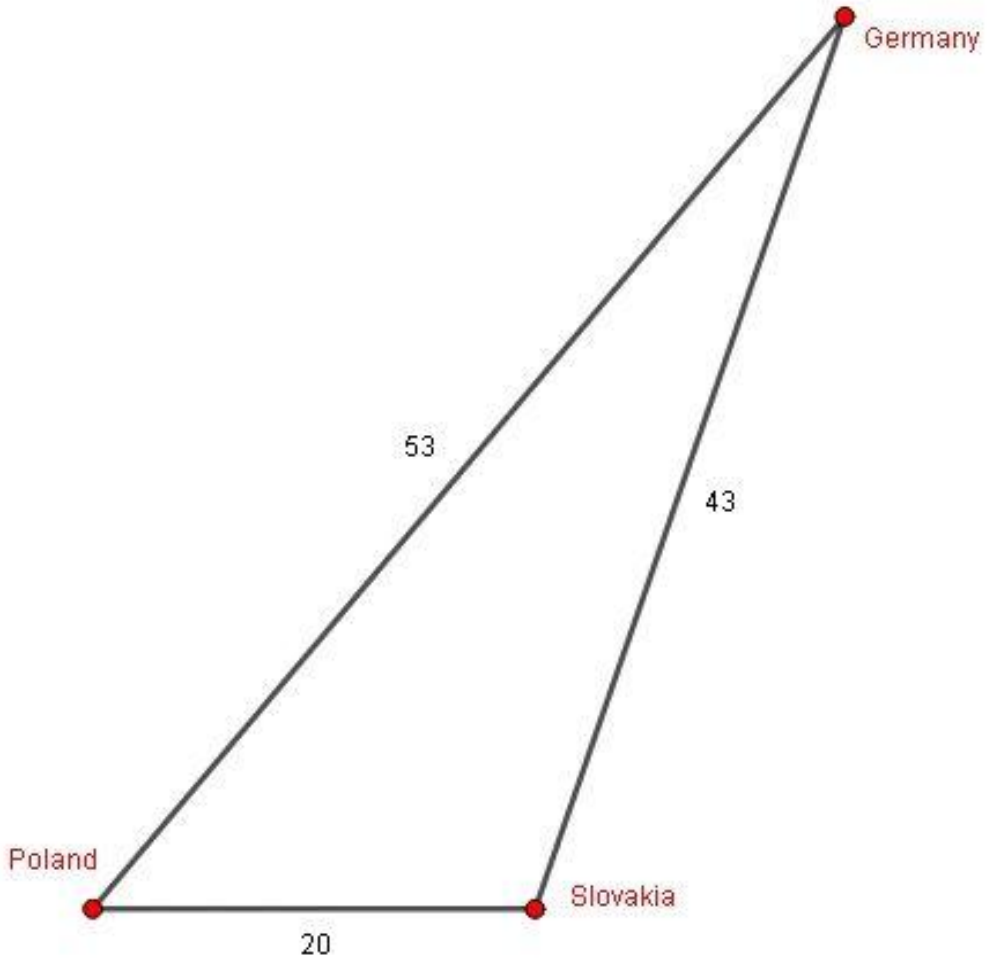
a)



b)

Рис. 7. a) Наглядное изображение „генетических расстояний" между чехами, поляками и словаками; **b)** Наглядное изображение „генетических расстояний" между чехами, поляками и немцами;





a)

b)

Рис. 8. a) Наглядное изображение „генетических расстояний” между чехами, немцами и словаками; **b)** Наглядное изображение „генетических расстояний” между поляками, словаками и немцами.

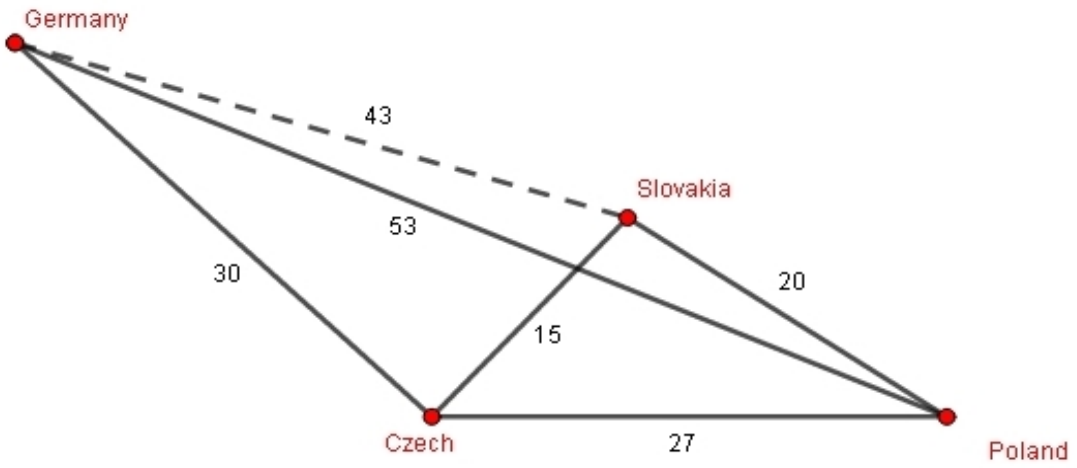


Рис. 9. Наглядное изображение (с небольшим искажением – пунктирная линия должна быть немного длиннее) „генетических расстояний” между чехами, поляками, словаками и немцами.

Сравнение народов: сербы, хорваты, боснийцы-герцеговинцы и черногорцы

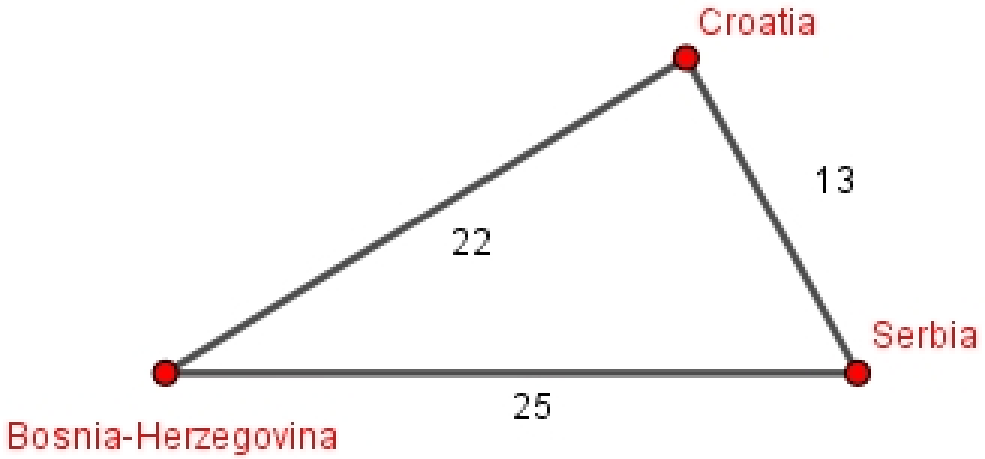
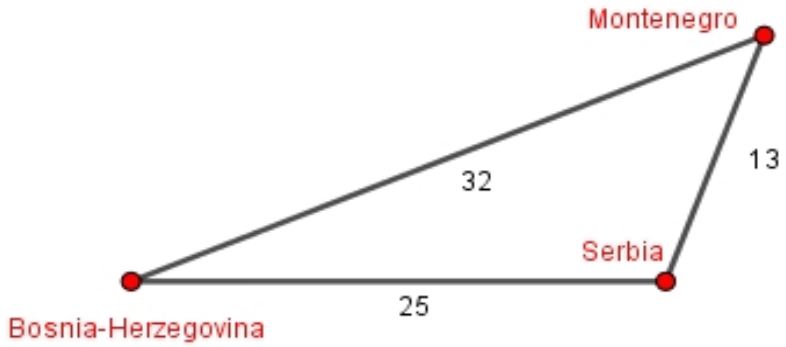


Рис. 10. а) Наглядное изображение „генетических расстояний” между боснийцами-герцеговинцами, сербами и хорватами;



b)

Рис. 10. b) Наглядное изображение „генетических расстояний” между сербами, боснийцами-герцеговинцами и черногорцами.

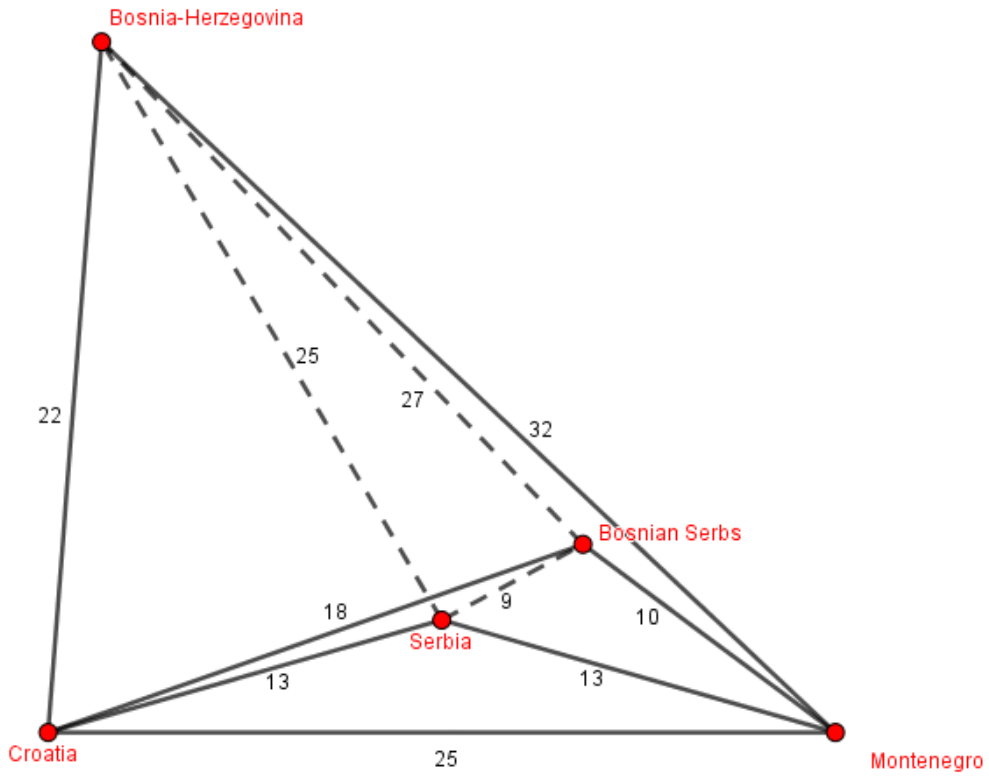


Рис. 11. Наглядное изображение (с небольшим искажением – пунктирные линии должны быть немного длиннее) „генетических расстояний” между сербами, хорватами, боснийцами-герцеговинцами, черногорцами и боснийскими сербами.

Генетические расстояния между соседними народами

Македония, Греция и Сербия являются соседними для Болгарии странами и поэтому е естественно ожидать, что расстояния между этими четырьмя народами относительно малы по сравнению со средним расстоянием между разными народами. Это ожидание оправдывается – вообще среднее генетическое расстояние между соседними народами меньше среднего расстояния между народами.

Чтобы оценить насколько близки Болгария и Македония на фоне остальных пар соседних европейских народов, мы сравнили генетические расстояния в большой случайной выборке пар соседних европейских народов (включая и расстояния между обособленными областями в пределах одного государства), состоящей из 43 пар. Восемь наименьших и десять наибольших расстояний для этой выборки показаны на **рис. 11**.

Распределение (по величине) генетических расстояний между парами соседних европейских народов (**рис. 12**) позволяет сравнить генетическую близость Болгарии и Македонии с соседними народами: это – одна из наболее близких друг к другу пар стран.

	Соседние государства	**Генетическое расстояние**
1	Франция - Бельгия	5,77
2	Западная-Южная Германия	5,94
3	Болгария- Македония	6,30
4	Восточная-Северная Германия	6,78
5	Южная Германия-Швейцария	9,68
6	Болгария - Румыния	10,93
7	Венгрия-Словения	11,51
8	Сербия-Румыния	11,83

Рис. 11. Восемь наименьших и десять наибольших расстояний для рассматриваемой выборки.

4	Южная-Северная Германия	21,66
35	Франция-Италия	23,27
36	Сербия-Босна	24,71
37	Австрия-Швейцария	25,82
38	Сербия-Венгрия	26,46
39	Чехия-Польша	26,63
40	Австрия-Словения	28,95
41	Австрия-Словакия	31,54
42	Босна-Черногорье	32,12
43	Вост. Германия-Польша	42,37

Рис. 11. Восемь наименьших и десять наибольших расстояний для рассматриваемой выборки.

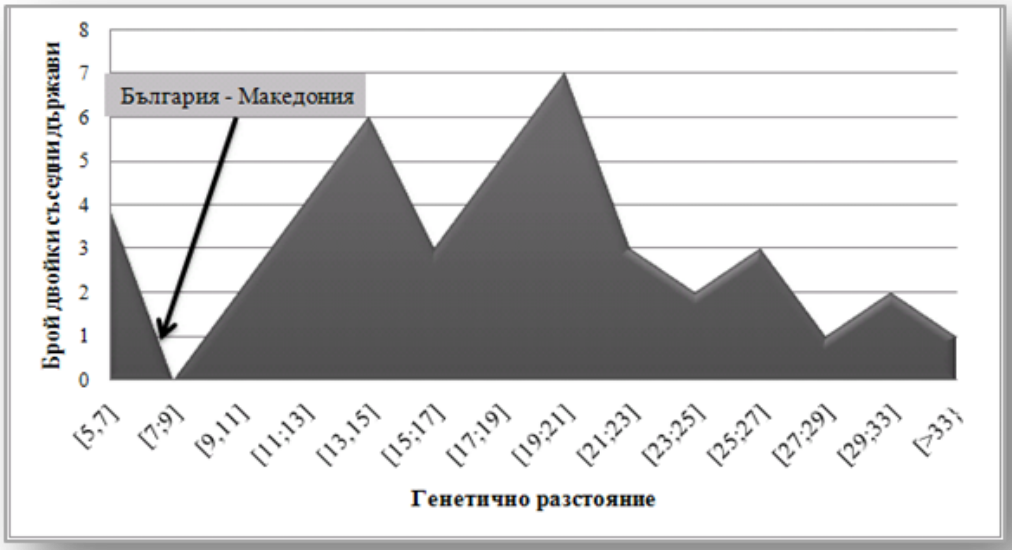


Рис. 12. Распределение (по величине) генетических расстояний между парами соседних европейских народов из рассматриваемой выборки: по абсциссе отмечены интервалы расстояний, а по ординате – число пар с соответствующими расстояниями в указанном интервале.

Гипотеза

На основе наблюдений, сделанных в ходе представленных выше исследований, можно предложить следующую гипотезу: процессы изменения в соотношениях гаплогрупп на территории Европы были близкими к диффузионным: можно сказать, что ведущее место занимал „обмен гаплогруппами” между соседними народами. Скорее всего, влияние переселений на эти процессы было менее заметным.

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On the "genetic proximity" of peoples

Y. Tabov, N. Sabeva-Koleva, G. Gachev

Annotation*. DNA analysis is a well-established scientific method that is becoming increasingly popular in practice. It is also used to compare the "genetic proximity" of peoples. Here we propose an approach to such a comparison, based on the calculation and comparison of "genetic distances" between peoples according to genetic studies published on the Eupedia website. It provides an opportunity to build visual schemes that reflect the results. As an example, the results of comparisons of three groups of neighboring countries are presented: 1) Bulgaria, Serbia, Greece, Macedonia, Turkey and Romania; 2) Bosnia, Serbia, Croatia and Montenegro; 3) Czech Republic, Slovakia, Poland and Germany.*

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