# Virtual Laboratory for Coding Theory Training

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*Abstract: The report presents a virtual laboratory for experimental study of the coding theory methods in computer systems. The virtual laboratory includes twelve interactive tools, schematic editor and simulator for error correcting codes training. The tools are designed to attract students and explain the coding theory with more simulations and visual elements.*
*Key words: virtual laboratory, e-learning, coding theory.*

## INTRODUCTION

Coding theory is very widely used in data compression, in improving reliability of communication channels, for security, privacy and confidentiality in the information society. Coding theory, also called "theory of error correcting codes" is important in all systems that work with digitally represented data: computers, internet, mobiles, TV, satellites and etc. Coding theory methods are used for reliable storage and transmission of information. Coding theory codes detect errors and more important they correct errors in real-time working systems such as server machines (RAID, ECC memory and etc.), [1, 2].

Coding theory is an integral part of the training of computer specialists. Bachelor degree course "Computer Systems and Technologies" in University of Ruse taught the course "Reliability and Diagnostics of Computer Systems", [6]. In workshops students need to use programming tools that simulate the coding theory codes for better understanding of theory notes.

There are good practices and examples of virtual tools, which deal with the different coding theory codes [3, 5]. Hamming Code Simulator for example [4] is a virtual tool for studying the Hamming code using matrix method. There is a possibility to enter some data in binary or hex type. Based on the input data, a hamming syndrome matrix is generated and the control bits are calculated. The users can simulate an error, modify the received code word and find the matrix syndrome for the error. A significant disadvantage of Hamming Code Simulator Tool is that the encoding and decoding process is hidden. The rules for the construction of the encoded code combination are not shown.

After a survey of existing virtual tools, which simulates coding theory codes, the following requirements can be summarized:

- The existing solutions cover only part of the subject area of the course "Reliability and Diagnostics of Computer Systems". The Virtual Laboratory for Coding Theory Training is necessary to include the full range of codes studied during workshops;

- It is important to have in mind that the good interface makes the students feel familiar. The interface of the virtual laboratory should be intuitive and easy to use. In this sense, it is suitable to organize the access to applications' functionalities not through menus, but using buttons, as visual, as possible, arranged in toolbars;

- The virtual training tools need to be designed in small units. The processes of encoding and decoding are appropriate to be separated for better understanding;

- The tools have to serve as a self-training tool for the students and as a demonstration tool for the teacher. From the educational point of view, the tools should be explanatory and, in the same time, simple enough to facilitate understanding and learning the basic concepts related to error-correcting codes and their usage;

- The processes of encoding and decoding have to be clear for the students. Students have to follow coding and decoding process step by step for better understanding. At certain stages of the work help messages have to be displayed to explain the basic steps, depending on the specific actions of the trainees;

- The student is appropriate to be in sequence training. For this purpose, a variety of metrics that show what part of the process is completed can be used.

A virtual laboratory for coding theory training is designed according to the specified requirements. The laboratory can be successfully used for distance learning and includes the entire cycle of twelve virtual tools that students actually need to use during workshops:

• Virtual tool for coding and decoding using an even parity code;
• Virtual tool for coding and decoding using an odd parity code;
• Virtual tool for coding and decoding using a Hamming code;
• Virtual tool for coding and decoding using code module 3;
• Virtual tool for logical control operation "AND";
• Virtual tool for logical control operation "OR";
• Virtual tool for logical control operation "XOR";
• Virtual tool for logical control operation "Shift";
• Virtual tool for arithmetic control operation "Addition";
• Virtual tool for arithmetic control operation "Subtraction";
• Virtual tool for arithmetic control operation "Multiplication"
• Virtual tool for arithmetic control operation "Division".

Fig. 1 shows the graphical user interface of the Virtual laboratory, as a virtual tool of Hamming code is demonstrated.
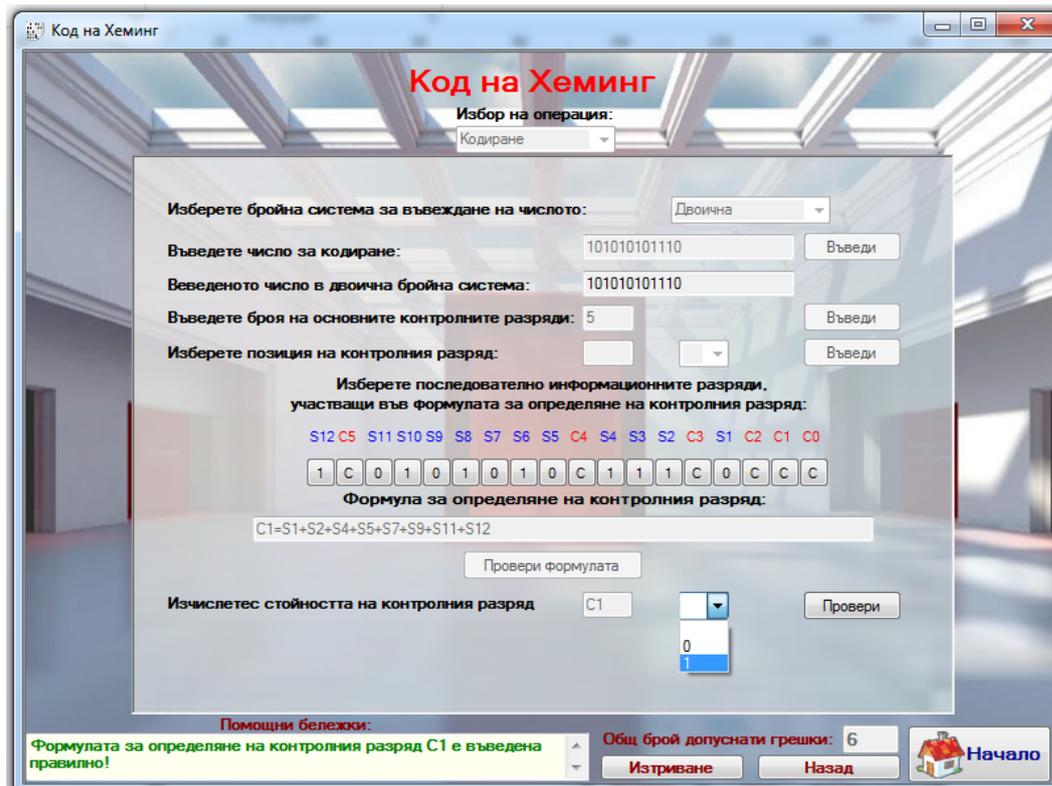


Fig. 1.  Virtual tool for coding and decoding using a Hamming code

As it is shown on fig. 1, at the beginning students start with the coding process and have to input data in binary, decimal or hex type. They have to specify the number of control bits needed for the specific data input and their exact places. The students also have to know the formula, which is used to calculate each control bit. If there are some mistakes, the program calculates them and shows the right answer after three wrong inputs. Coding and decoding process are passed step by step and the trainees show their knowledge about the specific code.

Fig. 2 shows the graphical user interface of the virtual laboratory java version, as a virtual tool for logical control operation "XOR" is demonstrated.



Fig. 2.  Virtual tool for logical control operation "XOR"

The virtual laboratory also includes editor and simulator for error correcting codes schematic diagrams. The tools offer an easy way for the students to construct schematic diagrams that could be further used for simulation of the way error-detecting codes operate. The developed library of basic logic gates also includes coder, decoder and some group elements, needed for the specific training process. The basic logic gates are developed in two modes: European and Bulgarian standard.

Fig. 3 shows the graphical user interface of the Editor tool, as a schematic diagram of Hamming code with four inputs is demonstrated.
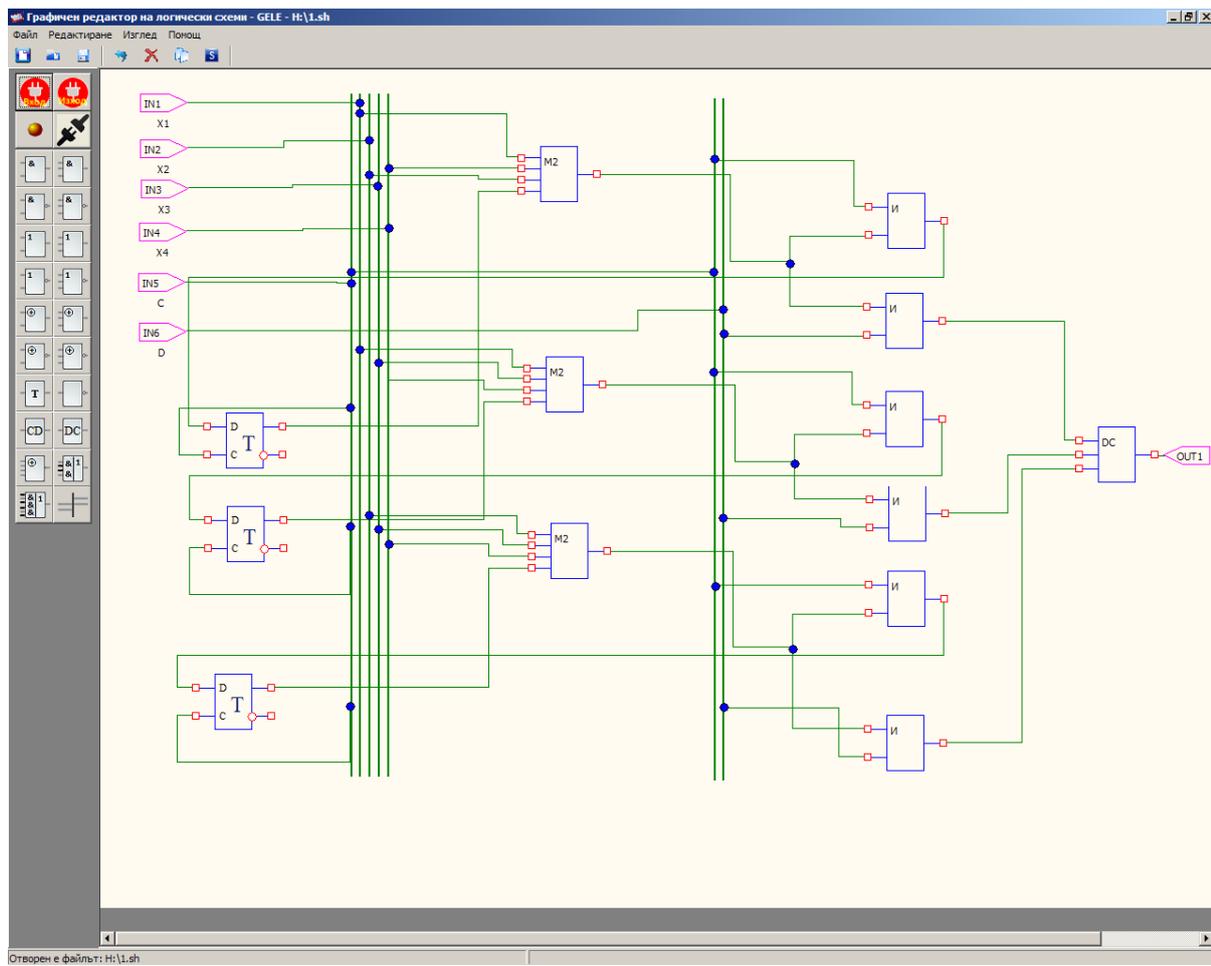
Fig. 3. Tool with a schematic diagram of Hamming code

Fig. 4 shows the graphical user interface of the Simulator tool, as a schematic diagram of module 3 code with four inputs is demonstrated.
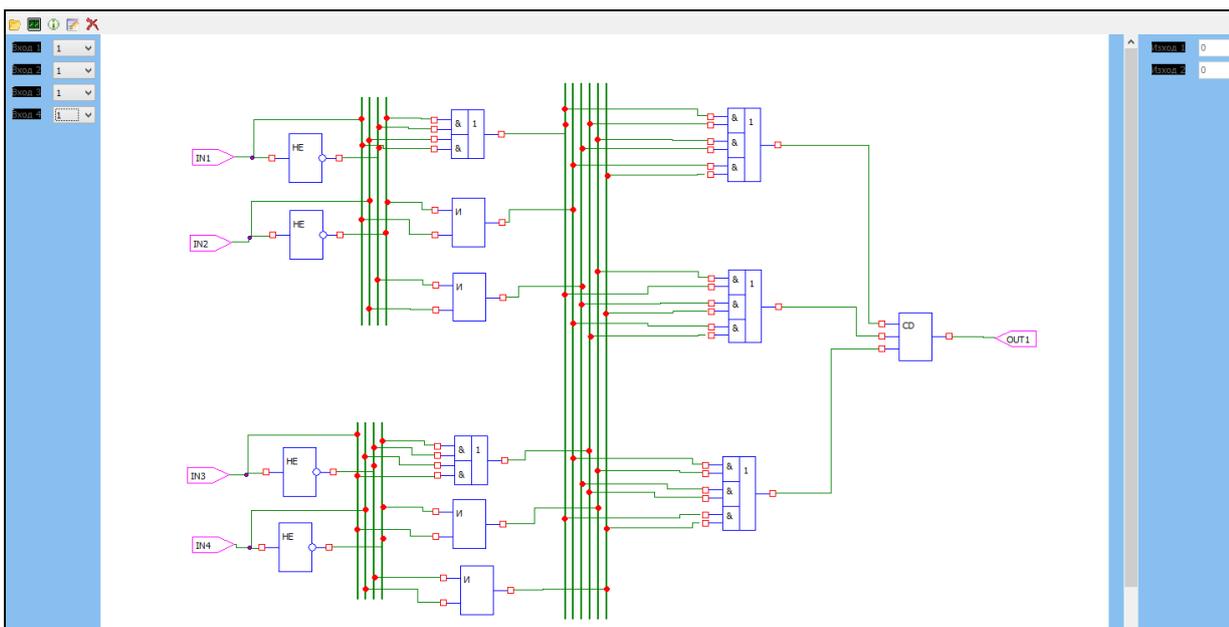


Fig. 4. Simulator tool with a schematic diagram of module 3 code

The subject level knowledge of students and their cognitive abilities are different. To achieve better results in the virtual laboratory students need also self-discipline and

motivation. The motivation for the new generation students depends on the way of training. Today students need more attractive learning methods to keep their interest. Students find the virtual laboratory for coding theory training as attractive. They learn the coding theory with using interactive tools designed with a lot of simulations and visual elements. At each stage students can see help-messages, which give information how to proceed. The tools conduct them through the whole process of coding and decoding.

Using the programming tools a competition challenge can be also organized. During workshops we made an experiment and organized a competition, which students found as fun. Students were more active and enthusiastic because they had chance to compare each other in a learning challenge. During competition challenge they need to finish all exercises more quickly with fewer mistakes. The winner was announced at the end of the workshop and won a small prize.

### CONCLUSIONS AND FUTURE WORK

The developed virtual laboratory has already been used into practice and students find the tools easy to operate with. Training in the virtual laboratory allows simultaneous work of a large group of students and quick monitoring of their progress results.

In conclusion, it can be summarized that the virtual laboratory includes twelve well-organized interactive tools, schematic editor and simulator for error correcting codes training. The virtual laboratory for coding theory training enable students to have free and unlimited remote access to educational resources on the subject and can be successfully used for e-learning.

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**The paper has been reviewed.**