Experiential activities oriented to discovery of selected computer sciences concepts and principles

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Focusing of the article

- Methodology of teaching computer science (CS) oriented to discovering basic principles and rules of CS by pupils themselves with little teacher intervention.
- The first activity – discovering basic principles and rules of computer communication, e. g. the message accompanying information (the structure of TCP/IP packet).
- The second activity – understanding the principles of information encoding, unambiguous of encoding, the code length dependence of the quantity of states, the use of n-ary trees in encoding, etc.

1st activity: Data transmission network, IP packet

- *Problem*:
  - What form and requisites should the message in network internet have?
  - Design the structure of this message.
  - According to which rules governing communication on the internet?

Objectives

- Specify the parts of message necessary for successful communication in the Internet network.
- Explain the importance of parts of messages over the Internet network.
- Explain the importance of communication protocol.

Process

- During this activity pupils simulate a computer network and communication in it.
- Messages are sent in written papers.
- The teacher can generate sequences of various errors. It depends on the actions and reactions of pupils.
- The pupils' task is to specify the rules of communication in the network to eliminate the consequences of these errors.

Possible course of action 1/2

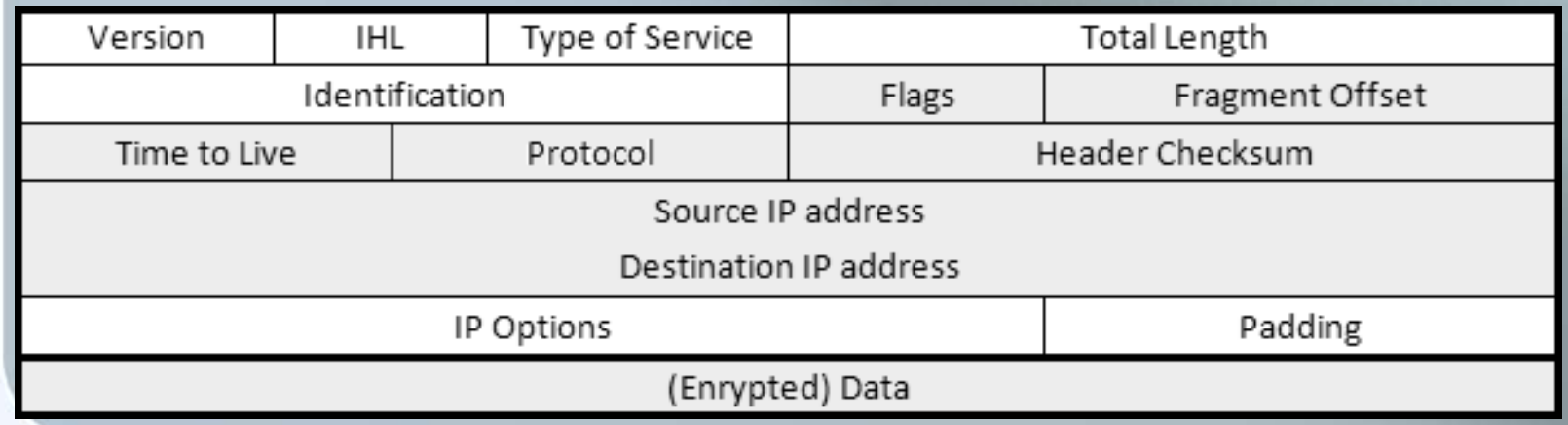
- Identifiers of sender and recipient have to be parts of message
  - We chose one with pupils and gave him the role: "Choose one of your classmates and send him a specific question!"
- Acknowledgment of receipt
  - Here, too, we asked a pupil to send a question to one of the classmates. But the teacher (the error generator) destroyed the paper on the way.

Possible course of action 2/2

- Message fragmentation
  - We selected a pupil and ask him to devise a way to send an extensive message to his classmate and to send this message in this way.
- The contents of message checking
  - We have asked one of the pupils to send a question to the selected classmate.
- Data privacy
  - Again we asked the selected pupil to send a question to a classmate. The answer, however, should be private. The pupil's task was to figure out how to conceal the message.

The IP packet structure

- Our goal is not to give the finished knowledge to pupils. Our goal is that pupils discover this knowledge by themselves and give reasons for their conclusions through solving simple problems.
- We are confident that many of the concepts and principles of computer science are based on common sense and logical thinking.



2nd activity: „Card guessing game“ – Information encoding, binary search

- *Problem:*
  - Describe the way how to find out one card chosen from a package of 32 German cards.
  - Do you proceed randomly or according to some rules?
  - How many trials did you need to find the chosen card?
  - Can you improve your procedure of finding the chosen card?
  - Explain the relationship between finding a card and information encoding.

Objectives

- To explain that the amount of information necessary to determine a chosen card depends on total number of cards and also on the manner of questioning (the number of different answers to the questions).
- To explain that after each answer to a question we acquire more and more information, after binary question we acquire 1 bit of information (after ternary question 1 trit of information, after decimal question 1 dit of information).
- To give reasons that for clear determination of one chosen card from package of 32 cards we need to ask 5 binary questions (for one from 27 cards we need to ask 3 ternary questions, in general for determination a card from a package of N cards we need to ask $\lceil \log_N K \rceil$ n-ary questions at most).

Process

- In 1st phase of solving the problem the pupils themselves play the game in pairs, where they alternate in guessing the chosen card.
- In 2nd phase, by means of the Socratic debate with teacher, pupils will discover a sophisticated way of determination of the chosen card.
- In 3rd phase after playing the card guessing game, pupils will study information encoding using binary numbers, calculating the amount of information, using binary tree for searching, information encoding and showing the unambiguous of this encoding.

Example of dialogue – 1/7

- Teacher: "Considering the random guessing of a card, can we guess the card on the first try?"
- Pupil: "Yes, but in this way we will not be always successful."
- Teacher: "How many trials we can reach in the worst case?"
- Pupil: "Well, when we have a great misfortune, till the 32nd attempt."
- Pupil2: "We can do maybe more than 32 attempts, but I think that 31 attempts will be sufficient for guessing in the worst case."

Example of dialogue – 2/7

- Teacher: "What can we say about a set of cards with searched card during gradual questioning?"
- Pupil: "That this set will reduce question by question."
- Teacher: "How will it reduce?"
- Pupil: "After each question this set will be one card smaller."
- Teacher: "Yes, in a random guessing a set with searched card will shrink by 1 until we guess the searched card."

Example of dialogue – 3/7

Next, the teacher puts the cards on the table face up and organizes them by colour (suit) and values. He/she can use also data projection for showing the cards to all pupils and continues a dialogue.

- Teacher: "Try to ask a question in order to reduce the set with the searched card by more than only one card?"
- Pupil: "Is it green?"
- Teacher: "Yes, great. How big will be a set with searched card?"
- Pupil: "If the answer is "yes" then searched card will be one of 8, otherwise one of 24 cards."

Example of dialogue – 4/7

- Teacher: "OK. Try asking question in a way so regardless of the answer "yes/no" to have equal chances in which group the searched card would be."
- Pupil: "Is the value of the searched card a number?"
- Teacher: "Excellent. And how will it reduce a set with the searched card?"
- Pupil: "By half."
- Teacher: "Yes, exactly. Now try to ask a question concerning colour of the searched, which narrow the set with the searched card in half."
- Pupil: "Is it red card or green?"

Example of dialogue – 5/7

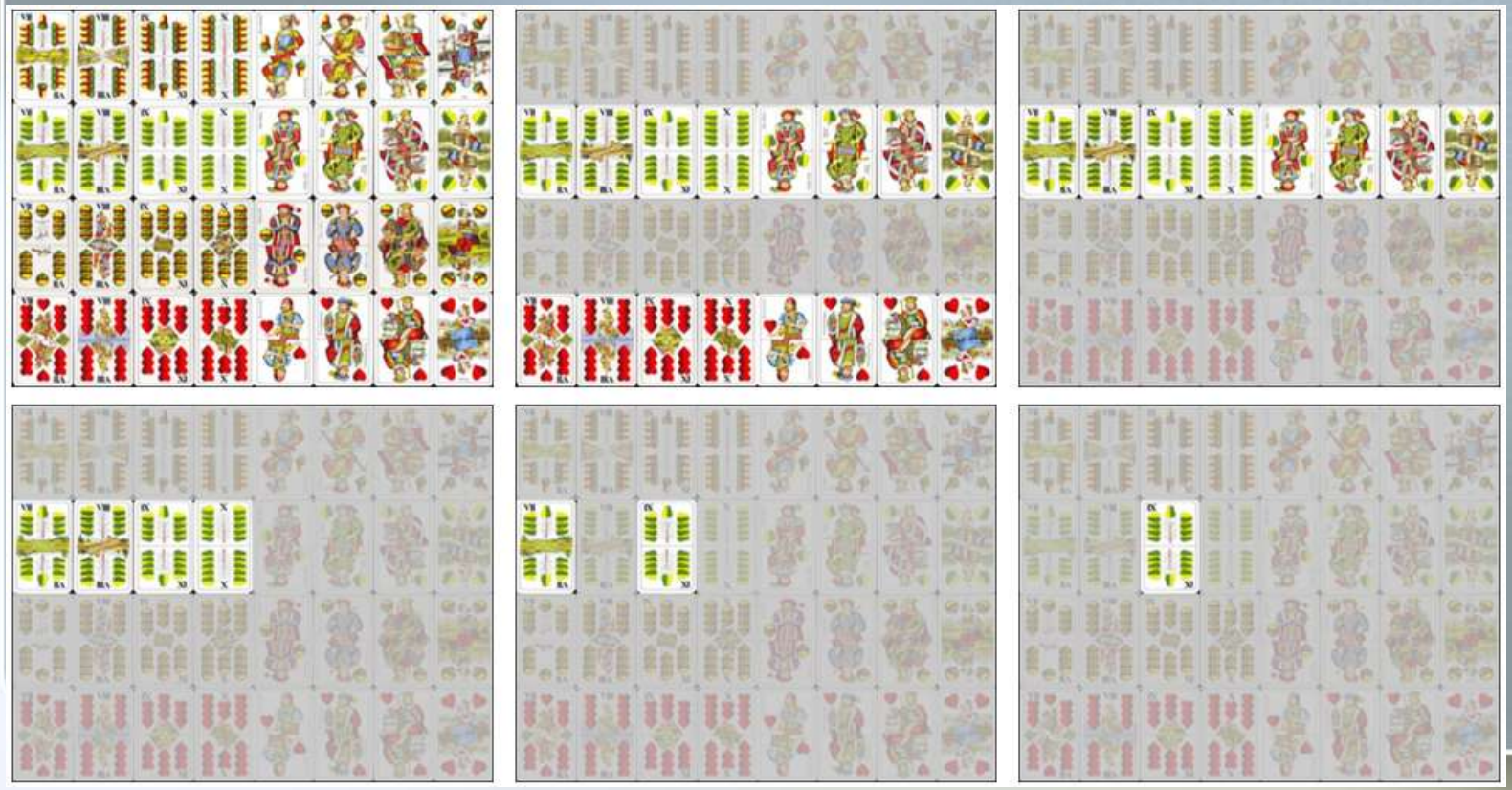
- Teacher: "Excellent. Is the colour of the searched card some from the following colours: red, green? What will be the further question concerning colour of searched card?"
- Pupil: "Well, after this question I know that searched card is either from colours set {red, green}, or colour set {acorn, ball}. Then I ask for one colour from the selected set. E.g. when the first set is chosen, so I ask – Is it red? And then I definitely know what colour has searched card."
- Teacher: "Yes, first you asked about one pair of colours and then you asked about one of them. At the beginning we have 32 cards. After answer of the first "yes/no" question a set with the searched card reduced to 16 elements, after next answer to 8 elements.

Example of dialogue – 6/7

- Teacher: ”I believe that it wouldn’t be difficult for you to propose further questions for determining the value of the searched card.”
- Pupil: “I ask whether the card is a number. After answering this question only 4 cards remain. Either they will be numbers, or figures. After my next question only 2 cards will remain and finally by the last question I will definitely assign the searched card.”
- Teacher: “Perfect. During asking questions there is important to find and to formulate a convenient attribute through which a set with the searched card will be reduced. How many questions did we need for guessing, or finding the searched card?” – Pupil: “5.”

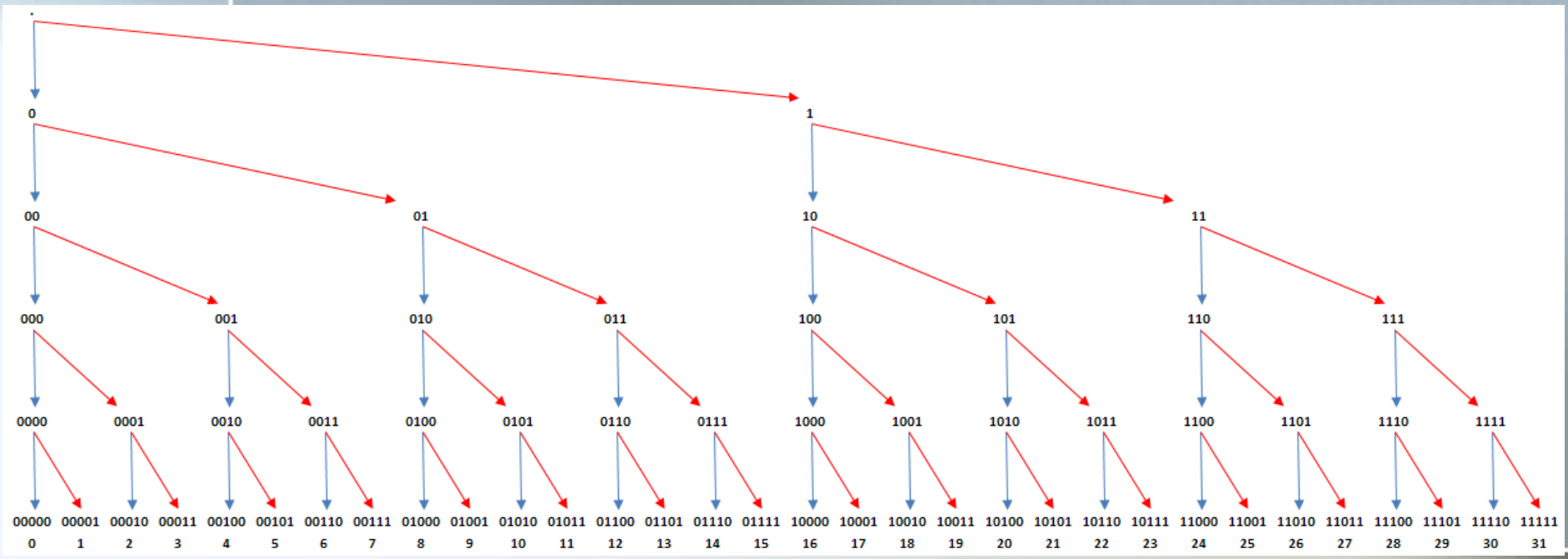
Example of dialogue – 7/7

- Teacher: "Yes, we need 5 questions. At the beginning a set with the searched card has 32 elements. After each answer this set will reduce by half gradually to 16, 8, 4, 2 cards and finally to 1 card, which is illustrated in the Figure.



A binary tree

- There is a binary tree that is considered as a useful tool for understanding the relationship between the total number of elements (e.g. cards) and the number of bits necessary for encoding all the elements and also the number of binary questions for finding out a search element.



Conclusion

- Two proposed activities are oriented to learning of conceptual knowledge (notions/concepts, principles, rules, etc.) exploiting and also developing pupils' curiosity, questioning, discussing and critical thinking.
- We believe that these two activities with methodology comments will be inspirational and worth for computer science teachers to try them to use in their computer science lectures (F2F, e-learning - appropriate learning objects).
- The activities described in article are proposed as unplugged and experiental activities, using various modes of acquiring information – diagrams, text and formulas, discussions.
- Delivering this methodology to many teachers by e-learning (text, diagrams, formulas, discussion, videoclip, applet ...)

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