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Brazilian Olympiad in Informatics

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Abstract. The Brazilian Olympiad in Informatics (OBI, in Portuguese) is a contest promoted by the Brazilian Computing Society (SBC) and its main purpose is to raise the interest of students in such an important science for a student's education as Computing Science, through an activity that involves challenge, ingenuity and a healthy dose of competition. The contest is composed of two different categories, for two levels of contestants: a programming contest for high school students (Programming Category) and a logic contest for elementary students (Logic Category). In this paper we will discuss the main aspects and challenges concerning the OBI organization.

Key words: programming contest, logic contest, grading systems, programming training camp.

1. Introduction

The Brazilian Olympiad in Informatics (OBI, in Portuguese) is a contest promoted by the Brazilian Computing Society (SBC), and is one of the Scientific Olympiads in Brazil – among Mathematics, Physics, Astronomy and others. The Institute of Computing (IC) at the State University of Campinas (UNICAMP) is in charge of OBI's organization and coordination since its first edition in 1999. The contest has as the sole sponsor *Fundação Carlos Chagas*, a non-profit organization that promotes education in Brazil.

The main purpose of OBI is to raise the interest of students in such an important science for a student's education as Computing Science, through an activity that involves challenge, ingenuity and a healthy dose of competition. The OBI is also a way to promote Computing activities at schools, which could help the students in their future career.

The Olympiad is composed of two different categories, for two levels of contestants: a programming contest for high school students (Programming Category) and a logic contest for elementary students (Logic Category). Both categories are further divided into two levels, depending on the age of the contestants. The contest is organized in two rounds. In the Local Round, contestants take the test at their own schools. The top ranked contestants in this first round are invited to take part in the National Round. For both categories, the best classified contestants are invited to a week of activities that takes place at UNICAMP during the winter break. For contestants in the Logic Category, activities are composed of introductory courses in programming; for contestants in the Programming Category, the activity is a classical Training Camp, with exams for selecting the members of the Brazilian team for the International Olympiad in Informatics.

The main challenge faced by the organization is to motivate schools to take part in the competition. In OBI's 9th edition (2007), about 8,000 students registered for the competition while 300,000 students registered for the Brazilian Olympiad in Mathematics. The main reason for this, we think, is that Brazil does not include Informatics, let alone programming, in its official elementary or high school curricula. Most schools do not have an informatics teacher, nor even computers available to the students, which makes it especially difficult to raise the students and schools' interest.

Many other challenges have to be addressed: the number of girls decreases enormously between the two contests (Logic and Programming), some schools in remote regions do not even have the money or resources to make copies of the exams, the Training Camp costs are enormous, mainly due to the price of air tickets (cities may be 3000 km apart, too far to travel by bus), and others. These challenges and the solutions we found are further discussed in other points of the paper.

This paper is divided as follows: Section 2 introduces the categories, levels and rounds adopted at OBI. Section 3 presents our grading strategies for Logic and Programming categories. Section 4 discusses the training camp and the training camp exams which select the contestant members of Brazilian Team for IOI. Section 5 shows the conclusions and future work.

2. Categories, Levels and Rounds

At OBI the contestants are divided by their knowledge level in categories; these are also divided into levels, according to which academic year each student is in at that moment and his age. These are the categories at OBI:

- Logic Category:
  - level 1, for students up to 7th year of elementary school,
  - level 2, for students up to 9th year of elementary school;
- Programming Category:
  - level 1, for students up to 1st year of high school,
  - level 2, for students up to 3rd year of high school, or who have been enrolled in high school until December of the previous year and are no older than 20 years on July the 1st of the contest's year.

The Logic category, with multiple choice questions, evaluates the logical reasoning of the students, trying to identify earlier some contestants which could develop good skills in computer programming. The questions are usually on same difficulty level as used on SATs (School Admission Test) in the USA. There is an example of a task of the Logic contest in Appendix 5.

The Programming category is composed of programming tasks, like the International Olympiad in Informatics. The purpose of Programming Category Level 1 is to identify students with basic programming knowledge and to develop advanced programming concepts like graphs and dynamic programming with them. The Level 2 contest is the competition which selects the four contestant members of Brazilian Team at IOI. The languages

used in programming category are the same accepted at IOI: Pascal, C and C++. In Appendix 5 there is an example of a programming task used at OBI.

Each category and level of OBI is divided into two rounds:

Local Round: The objective of this round is to allow the highest number of contestants. To achieve that, the students do the exams in their own schools or, if it is not possible, in another school which accepts invigilating the exam for that student. Each school fills in a registration form and choose a school member (usually a teacher) to be the "Local Representative" of OBI at his school. This person is in charge of printing the tests, setting up the computer environment according to OBI regulations (if necessary) and sending the students' answers to the OBI coordination (at UNICAMP) to be graded. In both contests grading is done automatically, centralized at the coordination.

National Round: The top ranked 10 percent of contestants at each level are invited to participate in the National round, in which exams are done in universities located in the states' capital cities, important regional centres and cities with a large number of invited contestants. The "National Representative" of OBI is chosen by the National Committee of OBI and is also responsible for the tests and the computer environment, like the Local Representatives. A financial aid is provided to universities that host the National Round.

The contestant solutions, in both Categories, in both rounds, are all graded at UNICAMP, where the OBI central office is located. The office has the administrative support of one secretary hired by the Brazilian Computing Society. The secretary is in charge of keeping the website up-to-date and doing the administrative tasks concerning the OBI administration. The OBI office is also responsible for organizing the Local and National Rounds, and for grading the students solutions.

2.1. *Task Creation and Distribution*

There are two committees for task creation, one for each category. Usually the task creation committee members live in different cities, sometimes outside Brazil, separated by thousands of kilometers in some cases, and they have their own jobs and appointments; it is almost impossible to set a meeting with all the members. The management of the tasks and the committees is done electronically, by a customized bulletin board system that is password protected. All communication among committee members is cyphered with a public-key schema, typically DSA and Elgamal provided by GPG. The committee members are former contestants of OBI, ICPC contestants and former contestants and faculty members.

In 2007, about 20 Logic tasks were made, each one composed of 5 or 6 multiple choice questions for the four Logic exams. Each exam contains between 20 and 30 multiple choice questions. There were also about 25 programming tasks created for the four programming exams of OBI and the Qualification Exam (which will be described in Section 4).

Since the cost of distributing paper versions of task sets to schools would be too high, considering the distances in the country and the weight of the packages, tasks sets for both the Logic and the Programming Category are made available for download by the OBI's representatives in PDF format, using a secure OBI sub-system. The representative must print the task set locally and make copies for each contestant.

As the Logic Category exams are tests, a student solution is a paper form with checkboxes filled (answer forms). The answer form for each student is made available in the Internet for download, together with the tasks, in PDF format (the set of forms for one school is one single multiple page file). Separate answer forms, without contestant information, are also available in case of necessity (for example, when a student smears or blotches her/his answer sheet).

3. Grading Systems

Grading of solutions in both categories, in both rounds, is done automatically, centralized, at the OBI central office.

3.1. *Programming Category*

For the programming category, the contestants' solutions are sent to the OBI office through an electronic system, where the Local and National Representatives submit the tasks, after archiving the contestants solutions into one file. The system verifies the consistency of the archive (names and extensions of the individual submissions), providing a report; if inconsistencies are found, the system directs the Representatives to fix the problem and try again. After receiving all tasks, they are electronically graded, using a set of test cases for each task. A test case is composed of one or more instances and a contestant's solution is only accepted on a test case if every instance is considered correct.

The programming grading system is capable of grading programs implemented in a wide range of distinct compilers and configurations, like several versions of `gcc`. This is necessary because the schools have some freedom to set up their computer environment and, as a result, use many operating systems and compilers at the Local Round. During the National Round the computational environment is controlled and there is no need to use several compilers, but the grading system used in that case is the same as used on Local Round.

The main problems concerning the programming grading system are caused by wrong submissions from Representatives, who sometimes send the solutions by email or in an unrecognizable format. This requires a manual intervention to correct these problems and sometimes inserts the tasks directly into the grading system without a submission. The tasks are never corrected outside the system and no alteration is made in any contestants' solution.

3.2. *Logic Category*

The Logic Category exams are sent by mail to the OBI office and their answer sheets are transformed into digital images by a fast scanner and then digitally analysed to obtain the contestants' answer to each multiple choice question. Each set of answers is compared to the key answers of corresponding exam and graded according the number of correct answers.

The representatives print the task sets and answer sheets in any printer available. For the Programming Category this has no implication, but for the Logic Category this makes things more difficult for the automatic grader, because some printers may scale the pdf when printing. The scanner may also slightly rotate the sheet when scanning. For these reasons, the grader first "normalizes" the image, eliminating rotation and scaling, based on four registration marks in each corner of the answer sheet, before analysing the digital image for grading. The scanner used can scan about one page per second, and the grade program, written in python (using PIL and Numarray), also takes about one second to grade each sheet.

Unfortunately, some students do not follow the instructions and sometimes fill the answer sheet in a wrong way, for example not completely filling the checkbox, making it impossible to grade the sheet. In these cases manual intervention is required to correct these problems, if at all possible.

4. Training Camp

This section presents the training camp courses. The top ranked contestant in each category and level are invited to take part in the courses. Between 15 and 20 students are invited in each level, the exact number depends on the level ranking, which could contains some students with the same score. In 2007, 54 students were invited to participate in the Basic Programming Course (Section 4.1), 10 were invited for the Advanced Programming Course (Section 4.2) and 12 took part in the IOI Training Camp (Section 4.3).

In this section is also discussed the structure needed to the training camp courses (Section 4.4) and the costs involved in the camp (Section 4.5).

4.1. *Basic Programming Course*

The Basic Programming Course is given to the top ranked students on Logic Category and its purpose is to show basic programming techniques and problem solving using the computer. Obviously, a computer language is shown to the students, usually C. However, the aim of the course is the problem solving, with notions of algorithms complexity. The course lasts five days, with classes during the morning and laboratory classes in the afternoon. The topics discussed are:

- Day 1: Introduction to computer programming, computer-aided problem solving, programming languages.

- Day 2: C programming language, initial commands, input and output, decision structures.
- Day 3: Loops.
- Day 4: Functions.
- Day 5: Vectors and Matrices.

4.2. *Advanced Programming Course*

The Advanced Programming Course is given to the top ranked students on Programming Category Level 1 and invited students from Level 2 who could participate of OBI for at least one more year. Its aim is to improve the contestants' knowledge about programming, discussing topics like algorithm complexity and dynamic programming. The course focus on practical aspects of the selected topics, not on the more mathematical approach which is taught at colleges. The topics discussed are:

- Day 1: Introduction to algorithms and complexity.
- Day 2: Data Structures and greedy algorithms.
- Day 3: Graph Algorithms.
- Day 4: Dynamic Programming.
- Day 5: Geometric Algorithms.

4.3. *IOI Training Camp*

The IOI Training camps are given to the top ranked students on Programming Category Level 2. Their purpose is to prepare these students for the IOI. In this camp the four best students are chosen to form the Brazilian Team for IOI. There are two training camps:

- The first training camp takes place in June every year and last 6 days. About 10 contestants are invited to attend the course and take the qualification exams. The exam is divided into three short tests on third, forth and fifth days and a final exam on the sixth day. The local and national round exams' score is added to the qualification exam's score to determine the four contestant members of Brazilian Team for IOI. During the course the students learn advanced programming techniques and solve several programming problems from University of Valladolid problem set archive or other programming problem repositories.
- The second training camp takes place in July, together with the Brazilian Computing Society Annual Congress. The four members chosen to form the IOI Team are invited to attend a week of problem-solving classes.

The classes are given by former contestants of OBI and ICPC contests and faculty members. The qualification exam's tasks are prepared by the programming scientific committee.

4.4. *Structure*

The courses take place at Institute of Computing of UNICAMP. Two classrooms and two computer laboratories are used during the course. The computers have two operating

systems (Linux and Windows 2000) and several development tools, like Pascal, C and C++ compilers, text editors and manuals on both operating systems. The Institute does not charge the OBI organization for the use of its structure.

Ten assistants are necessary to take care of the contestants during the training camp. The contestants are usually teenagers, from 11 to 19 years old, and it is necessary to look after them constantly during their classes, meals and on their way between the hotel and UNICAMP, especially the younger ones. The assistants are undergraduate and graduate students of Instutute of Computing.

4.5. *Costs*

The Brazilian Olympiad in Informatics is sponsored by *Fundação Carlos Chagas*, a non-profit organization that promotes education in Brazil. Our annual budget is about US$ 75,000.00 and covers all the costs of OBI, including the training camps, OBI office and the participation at IOI.

Our highest costs are the programming course and training camp costs. About half of our budget is spent to bring the contestants to Campinas, where the courses take place. The main reason for that are the high costs of transportation, especially the air tickets. For example, among the 40 students attending the Basic Programming Course in 2006, 20 needed to travel more than 2,000 km to attend the course. Each airplane ticket costs about US$ 250.00, resulting in US$ 500.00 per participant and a total of approximately US$ 12,000.00 in 2006 for all courses and training camps. Another US$ 500,00 was spent with participants who needed ground transportation to attend the course.

Moreover, although there is a student dormitory at UNICAMP, it is not possible to use it to accommodate the contestants during the camp, when forces us to allocate the students in a hotel. This cost is comparable with the transportation cost and they compose the largest part of the training camp budget. The rest is spent on teachers' and assistants' payments, meals and prizes for the students (certificates, medals and t-shirts). The 2006 training camp cost is shown on Table 1.

On 2006 our budget also included about US$ 10,000.00 to maintain the OBI office and about US$ 11,000.00 to take the contestants and leaders to IOI countries, which costs

Table 1
Training Camps' costs

Activity	**Cost (US$)**
Transportation (ground and air tickets)	12,500.00
Hotel	13,000.00
Meals	2,700.00
Medals, certificates and t-shirts	900.00
Payment to teachers and assistants	1,400.00
Total	30,500.00

Table 2
Brazilian IOI Team' costs

Activity	**Cost (US$)**
Transportation (air tickets)	8,000.00
Insurance and registration fee	1,300.00
Total	11,300.00

are detailed on Table 2. All values shown are approximate values and are given only for information.

5. Conclusion and Future Work

Here are some planned future work to be done for promotion and improvement of OBI:

- A booklet written by the members of Logic scientific committee and other professors, with Logic categories questions and key answers. Two thousand books will be printed and distributed by mail to every participant school of OBI 2007 or future participant schools or to every one who asks for a copy.
- A CD developed by the members of Programming scientific committee which contains a small version of the submission and grading system and past programming tasks with solutions and test cases, to be distributed as described above.
- On-line contests during the second semester of each year, to promote the main contests and raise interest in students and schools in logic and programming.

Appendix A. Logic Category Task Example

MP3 Player

Francisco must select three CDs to record on his mp3 player. He owns 6 CDs labeled K, O, S, T, V and W. Francisco must follow the following conditions:

- K must be selected, S must be selected or both must be selected.
- O or V must be selected, but neither V nor S could be selected together with O.

1. Which one is a valid CD set to be recorded on MP3 player?
   (A) K, O and S
   (B) K, S and T
   (C) K, S and V
   (D) O, S and V
   (E) O, T and V
2. If K and O were chosen, which item shows a valid set of Cd's that Francisco could choose without breaking any condition?

(A) S and V
(B) T and W
(C) V and W
(D) S, W and T
(E) V, W and T

3. If S were chosen, which CD must be chosen?
   (A) K
   (B) O
   (C) T
   (D) V
   (E) W
4. If V was not chosen, which CD pair must be chosen?
   (A) K and O
   (B) K and T
   (C) K and W
   (D) O and T
   (E) O and W
5. Which CD pair must not be chosen at the same time ?
   (A) K and O
   (B) K and T
   (C) O and W
   (D) T and W
   (E) V and W

Appendix B. Programming Category Task Example

Maze

A friend of yours is very excited about a new game he downloaded to his mobile phone. The game is a kind of maze which could be represented by a N by M matrix. Each cell of the maze contains a platform which is at a certain height from the floor, which could be represented by an integer from 0 (the lowest) from 9 (the highest). Initially, you are on cell $(1, 1)$ (superior left corner) and your purpose is to reach at the end of the maze at cell (M, N) (inferior right corner).

To leave the maze you should move from a cell to an adjacent one. The problem is: your avatar cannot jump, so, if the destination cell is more than one unit higher than your current height, you can't move.

In each round you can move to one of four adjacent cells (up, down, left, right) *if the height of the destination cell is less or equal your current cell height plus one*. That is, if the height of the cell is a, you cannot move to an adjacent cell if, and only if their height is less or equal than $a + 1$.

To make the things worse, in each round, *after the player's action*, each cell increase its height by one. If the height of a cell is exactly 9, its height becomes 0.

Observe that, in a round, the player does not need to move, he could just wait for the platforms movement. Moreover, notice that not every cell has 4 neighbors, because movements outside the maze are not allowed.

You, as a good programmer, decided to write a program which calculates the lowest number of rounds necessary to reach the exit of a given maze.

Task. Write a program which, given a maze, returns the lowest number of rounds necessary to reach the exit with the restrictions described above.

Input. The input must be read from the standard input device, usually the keyboard. The first line contains two integers N and M ($2 \leqslant N, M \leqslant 50$) separated by a space, which represents, respectively, the amount of lines and columns on the maze. The N following lines contain, each one, M integers which represents the initial height (at round 0) of the platform. The platform is always between 0 and 9.

Output. Your program must print, on the standard output device a single line, containing the lowest number of rounds to reach the exit.

Source file: `maze.c`, `maze.cpp`, *or* `maze.pas`

Input	**Input**	**Input**
`4 3`	`3 3`	`3 5`
`0 0 0`	`1 2 3`	`1 3 1 1 1`
`0 0 0`	`4 5 6`	`1 3 1 3 1`
`0 0 0`	`7 8 9`	`1 1 1 3 1`
`0 0 0`		
Output	**Output**	**Output**
`5`	`12`	`10`

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R. M. Menderico participated in OBI as a contestant in 2001 and since then has helped in OBI organization, initially as an assistant and then he has served on the scientific committee of OBI. He also attend the IOI as Brazilian Delegation's deputy leader in 2005 and team leader in 2006. Raphael received his BSc degree in computer engineering in 2005 at UNICAMP and is currently enrolled in PhD course at Institute of Computing at UNICAMP. He is also a part-time lecturer at UNICAMP.