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Programming Contests for School Students in Bulgaria

Krassimir MANEV
Faculty of Mathematics and Informatics, Sofia University
1164, 5 J. Bourcheir blvd., Sofia, Bulgaria
e-mail: manev@fmi.uni-sofia.bg

Emil KELEVEDJIEV
Institute of Mathematics and Informatics, Bulgarian Academy of Sciences
1113, 8 G. Bonchev str, Sofia, Bulgaria
e-mail: keleved@math.bas.bg

Stoyan KAPRALOV
Department of Mathematics, Technical University of Gabrovo
5300,4 H. Dimitar str., Gabrovo, Bulgaria
e-mail: skapralov@tugab.bg

Abstract. Competitions in programming for secondary and high school students in Bulgaria have long traditions. The National Olympiad in Informatics started in 1985. Even before 1985, competitions on national and regional level were popular. Bulgaria is founder and the first host of the International Olympiad in Informatics in 1989. The paper presents the current situation and challenges in the area of Informatics competitions in Bulgaria. The structure of the competition system, including the Bulgarian National Olympiad in Informatics is outlined.

Key words: programming contests, olympiad in informatics, IOI, training, preparation.

1. Introduction

Education and competitions are closely related. We may present at least two reasons to assert this (Verhoeff, 1997):

- it is natural for children to compete, so they can easily understand any attempt of the teacher to put the competitions into use of education;
- competitions may be important in adult life, so we should especially teach children to compete – this is a part of the education.

Not all opinions on the role of competition in education look fairly straightforward. Educational theorists do not agree on whether competitions should be encouraged or constrained. Some of them assert that, because competitions are part of every culture and because education should transmit culture, it is necessary to incorporate competitions into education to help children get ready for it later. The others contradict that, because

competitions are opposed to collaboration, and therefore are an evil element in culture, they should be avoided.

Nevertheless, competitions in education have their long history, which can be traced back to the centuries B.C. We present a brief time line:

- in first century B.C. Marcus Verrius Flaccus, a Roman teacher, introduced the principle of competition among his students as a pedagogical aid;
- in 1500 Battista Guarino, an Italian scholar, wrote that the students are stimulated best by competitions, instead of physical punishment;
- in 1894 the time when Pierre de Coubertin struggled to revive the Olympic Games, the Eötvös Loran University in Budapest organized the first national contest in mathematics;
- the idea of Science contests spread through Central Europe and Russia. In North America William Putnam started a mathematics competition for college students in 1938;
- in 1959 the first International Olympiad in Mathematics was hosted in Romania;
- in 1989 the first International Olympiad in Informatics was hosted in Bulgaria (below we will describe how this happen).

The competitions have much to offer in education. They are a good measure of how well a discipline is accepted. The competitions should be further developed; their organizing (especially organizing good competitions) is a major challenge.

2. At the Beginning

2.1. *First Programming Contests in Bulgaria*

The programming contests for school students in Bulgaria started in early 80's of the past century. In the schedule of traditional Winter Mathematical Competitions, organized by the Union of the Bulgarian Mathematicians (UBM), a Programming tournament was included. The participants had to write a program in one of the languages FORTRAN or PL/1, that solve a given algorithmic task, to punch source on cards, compile it (computers was IBM/360 compatible machines from the ES-series) and to try to debug the program for 3–4 runs (no more runs were possible in limited to four hours contest).

In 1982 Bulgaria started to produce the Apple II-compatible machine Pravetz 8. Very soon each Bulgarian school had at least one computer lab. So, each participant in Winter tournament had the possibility to work on an individual computer. The languages BASIC and Pascal (UCSD) replaced FORTRAN and PL/1. Evaluation of solutions in those years was pure manual and some quantity of marks was assigned for the style of programming.

2.2. *National Olympiad*

Four years expertise from Winter tournament was enough for the Team of the UBM to dare to organize a National Olympiad in Informatics (NOI). In 1985 the First NOI took

place. This was a two day contest. In the first day contestants had to solve some theoretical task – concerning the algorithmic knowledge and knowledge of the programming language. The second day was similar to the Winter tournament – the contestants had to write and debug a program. Since the Second NOI, in each of two days contestants had to solve one task by writing a corresponding program. There was no special qualification for participating in the Final round of the NOI. Each school organized its own contest to decide which students would be sent to the Final.

In parallel with the NOI some efforts were made to involve as much as possible students in the game. In the program of Winter tournament a new age group was included – for students in 5th–7th grade. The older students participated both in Winter tournament and Final round of the NOI.

2.3. *International Contest*

In 1987 Sofia – the capital of Bulgaria – hosted the International Conference of IFIP and UNESCO "Children in Information Age". Prof. Blagovest Sendov, member of the Academy of Sciences and President of the Organizing committee proposed to the Team from the UBM to organize during the Conference an international programming contest for school students. The contest was organized in two age groups (younger and older than 14 years). Students from 7 countries took part in this event (Check–Slovak Republic, Federal Republic of Germany, German Democratic Republic, Poland, Rumania, Soviet Union and Bulgaria).

The results of this experiment were fantastic. All participants were very enthusiastic about the future of programming contests. They shared their experience in preparation of teams and some ideas about organization of the future contest. As a result Prof. Sendov asked the authorities in UNESCO for permission to start a new Olympiad – International Olympiad in Informatics, using the model of the other scientific International Olympiads for school students and especially the model of International Olympiad in Mathematics.

The first International Olympiad in Informatics was held in June 1989 in Pravetz, small town, placed about 50 km North-East from Sofia. The town was not only the center of Bulgarian computer industry, but the birth place of the Head of State Council (equivalent to President) of Bulgaria in that time, too. The term *Informatics*, not so popular in English-speaking countries was chosen, after long discussions, to replace *Computer Science* or *Programming* because of very good looking abbreviation IOI (not simply palindrome, but a graphical palindrome, too). The President of First IOI was Prof. Peter Kenderov, a mathematician with huge experience from mathematical Olympiads.

Students from 13 countries took part. The teams were composed of a Leader and 3 students. Contest was organized in one day. The students had to solve the following task (here is a simplified version of the statement):

Task. A sequence of $2N$ boxes is given. In $N-1$ of the boxes white pieces are placed, in other $N-1$ of the boxes – black pieces, and 2 consecutive boxes are empty. The following movement is permitted – to take pieces from two consecutive boxes and to move them, conserving the order, into empty boxes. Write a program to arrange, with

minimal number of movements, white pieces leftmost of black pieces (the final place of two empty boxes does no mater).

The absolute winner of the contest was 15 year old student from the Second Bulgarian Team – Teodor Tonchev. He had a very precisely planned BFS and solved the largest test case. For more details about the proposed tasks, the contests, and results of the First International Olympiad in Informatics see (Kenderov, Maneva, 1989). We are planning a new edition of this brochure for the celebration of 20-th anniversary of the First Olympiad during IOI'2009.

3. Current State of the National Programming Contests

3.1. *Organization*

Many institutions and people are involved in the organization of the national competitions in Informatics.

The two main organizers at the conceptual level are the Ministry of Education and Science (MES) and UBM. The link between them is the National Committee (NC). The chair and the members of the NC are proposed by the UBM and are approved by the Minister of Education and Science. The membership in the NC is a kind of a voluntary activity. The main responsibility of the Committee is carrying out the annual competition schedule that includes NOI and a number of national tournaments.

At more practical level the organizers of the national competitions are universities and schools. There are different kinds of high schools in Bulgaria. The most popular are math schools and language schools. The best students as a rule attend these two kinds of schools. Typically the education in high schools is from 8th to 12th grades but in many math schools there are also students from 5th to 7th grades. The math schools are the main source of competitors for the national contests in programming.

3.2. *Structure of NOI*

The NOI started with one age group in 1985. Now the contestants are divided in 5 age groups – E (4th–5th grade), D (6th–7th grade), C (8th–9th grade), B (10th–11th grade) and A (master group). Contests in different groups have different duration – 3 hours for E, 4 hours for D and C, and 5 hours for B and A. Contests are purely conforming to the format of IOI. Does not matter in which group participates, each contestant has an own work place and must solve three task of algorithmic type, writing the corresponding programs in one of the official languages of IOI – C/C++ or Pascal.

For 22 years the NOI of Bulgaria totally changed. Nowadays we have 3 rounds – Local/School (in February), Regional (in March) and Final/National (in April). The schools or villages where some students declared a will to participate in the round are free to prepare their own tasks. For helping schools (especially in small villages) that are not able to prepare tasks, the NC proposes a set of sample tasks for this round but does not

participate in grading. The round is not a formal qualification. The teachers, that evaluate the contestants, decide who is ready to participate in the Regional round.

Tasks for Regional and Final round are prepared by the NC. Regional round is organized in schools in one day with common start. Solutions of the pupils are sent immediately to the work groups of NC that evaluate and grade them with common set of test data. The round is a qualification for the Finals of the NOI – 50–60 students in group A, and 10–20 from the other groups are invited to take part in the Finals round.

The Final round is organized in a different town each year. There is one contest for groups B, C, D and E, and two contests (in two consecutive days) for group A. The first 10 students from the Final round in group A form the long list of National Team for Balkan Olympiad in Informatics (BOI) and IOI. A sample of the tasks from the Final round in this group is given in Appendix 1. Since this year some Bulgarian students aged less than 15.5 year will participate in Balkan Olympiad in Informatics for Juniors (JBOI), which will be finished at the moment of presenting this paper. Following the above described procedure, this year, 12 best students (aged less than 15.5 years) were selected from the Final round in group C and formed the long list of Junior National team. A sample of the tasks from contest in group C is given in Appendix 2.

3.3. *National Tournaments*

In parallel with the NOI a system of National Tournaments (NT) is organized by the UBM and with the help of the MES. The season starts with the Fall tournament in November. The traditional Winter tournament is in January and the final for the season is the Spring tournament in the end of May or the beginning of June. The NT's are open. Each student could participate in each NT. Format of the contests in NT's is the same as those of the NOI. But, in principle, tasks are more difficult, and frequently, during these contests, some experiments are made. Some new topics or types of tasks usually first appear in one or two NT's before to be given in the NOI.

The NT's are not only a possibility for students to have regular contest during the season. By the results of Fall tournament, Winter tournament and the two days of the Final round of the NOI, the last 2 places in the long list of National Team are filled. It is not a rare case when students obtained one of this two "wild cards", later took place in the National team. Something more, the Spring tournament is a decisive contest for the election of the four students, which will represent Bulgaria in the BOI and IOI (since this year the same is valid for JBOI, too).

4. Preparing Contestants and Training the National Teams

Programming competitions are attractive, because the winners are considered among the classmates as programmers of a very high rank and the competitors with the best results have the right to enter university usually without other exams, which is not negligible. In many countries, including Bulgaria, the question how to help students to prepare themselves for competitions in Informatics arises, especially for those who do not attend specialized schools.

4.1. *Out of Class Forms*

The official curriculum in Bulgarian secondary schools include one year teaching of Informatics (9th grade) and one year teaching of IT (10th grade) for regular students. In some schools (especially math schools) students could take part in special (profiling) education of Informatics. But neither regular nor profiling education in Informatics is enough to prepare a student to participate in programming contests. It happens in out of class CS-schools. The famous CS-schools in Varna, Shoumen, Rosse, Stara Zagora, Veliko Tarnovo, Bourgas, Yambol, Gabrovo, Pleven, as well as these in City Math School of Sofia and National Math School (situated in Sofia also) recruit practically all members of the National teams recently.

Lecturers in the schools are qualified teachers and professors from the local universities with the active support from ex-contestants that study in Bulgarian and world universities. These are the people preparing the tasks for the national contests as well. Unfortunately, we are speaking for less then 25 persons that work with great enthusiasm, practically on voluntary principle, lead their CS-schools, prepare tasks for the National contests, give lectures during the preparation camps, write teaching materials and so on.

4.2. *Preparation Camps*

Traditionally the National team for IOI is trained during a summer camp organized a couple of weeks before the Olympiad. The camp is a mixture of lectures and competition days, simulating the International Olympiads. The camp is organized in the Black Sea area for 8–10 days and is accompanied with sport activities, visiting of the beach and cultural events (the famous Jazz Festival in Varna is scheduled in the same time as our camps).

Because of the complex situation with lack of qualified teachers, since 2006, the NC starts to organize some training camps for students of small age groups C, D and E. In 2006 three and in 2007 two such camps were organized with duration of one week each and in the format of training camps of the National teams. For this purpose, a National ranking list of contestants was elaborated, based on the results of students in the National contests, and 10–15 pupils from each age group are invited for a camp. This approach significantly ameliorated the quality of contestants in small age groups and stimulated the interest to competitive programming in towns, hosting the camp.

4.3. *The Balkan On-Line Training Program **campion***

One of the interesting forms of preparation, in which Bulgarian school students take part, is the Balkan on-line training program **campion**, organized by our Romanian colleagues. This is a form of training of Romanian students, similar to the American USACO, but since 2006 it is open for participants of all Balkan countries. The training consists of regular on-line contests for three age groups (one contest per month in average) and a final round for best ranked students in each age group. Participation of our students in this training program was very stimulating and helpful.

4.4. *Distant Competitions of Bulgarian Magazines*

On the pages of some related to IT Bulgarian magazines (*Computer Magazine* of The New Tech Publishing company and *PC Magazine* of IDG group, supported by software company Musala Soft), distant competitions in programming has being maintained during the past 20 years. We will point out the following main features of that kind of competitions:

- student has a plenty of time to solve the proposed problem – typically a month;
- student's solution has to contain not only a programming code, but also some explanations;
- the evaluation uses test examples;
- the evaluation also uses examination of student's explanations;
- after the end of the period, when the participants should submit their solutions, the author of the proposed problem publishes a detailed description of his own solution, accompanying it with explanations and discussions of students' works.

4.5. *Other Activities*

Among the other activities for preparation of contestants it is worth to mention the publishing activities and maintaining of a site dedicated to the programming contest.

An old idea of the NC is to publish series of books dedicated to the competitive programming. Despite the big difficulties three such books were published till now – an introductory book on programming in C/C++ for 11–12 years aged students (Yovcheva&Ivanova, 2006), one book on competitive programming for same age (Kelevedjiev&Dzhenkova, 2004) and one on dynamic programming for elder contestants (Kelevedjiev, 2001). Two other books – a second part of the introduction to programming in C/C++ and an introduction to algorithms in graphs have been prepared and will be published soon.

A Bulgarian Internet portal for competitive programming was created more than 10 years ago by the talented contestant (at that time) Svetlin Nakov. Latter the portal was generously hosted and maintained by the software company Musala Soft and could be found at address `http://infoman.musala.com`. All materials of the Bulgarian programming contests (statement of the tasks, tests, answers, checkers, as well as the solutions of all contestants) are regularly published on the pages of that site. In such way the NOI is the most transparent of the scientific Olympiads in Bulgaria.

Something more, the site is regularly publishing analysis (mathematical explanations and model solutions) of the competitive tasks, written by the authors, by students or editors of the site. The site also informs for incoming events, gives references to training materials and other resources and maintains a forum, where Bulgarian contestants could share experience, discuss the problems, etc.

5. Conclusion

As a general supporter of the activities concerning the International Olympiad in Informatics we should note the American foundation for Bulgaria, which is founded by some successful American businessmen with Bulgarian origin and leaded by a former participant in (and Golden medalist from) the International Olympiads in Mathematics. We would like to express, in behalf of the Bulgarian programming contests community, our deep acknowledgements to these people.

Bulgaria has long traditions in organizing programming contests for school students. After the First IOI in 1989 we hosted two Balkan Olympiads (1995 and 2004). Bulgaria was chosen to organize IOI'2009, just for celebration of the 20th anniversary of the beginning of the IOI. We hope that during the IOI'2009, in the picturesque city of Plovdiv, we will be able not only to demonstrate our hospitality but to share more of our experience, too.

Appendix 1: Example of Tasks for Group A

Below a typical set of tasks from the master group A of the Bulgarian NOI (Day 2 of the Final round of 2007) is given

Task A1. Area. A rectangle Q with sides parallel to the axes of orthogonal planar coordinate system and a point T, which is internal for the rectangle, are given. N lines are also given ($0 < N < 50$), not passing trough T. For each line let us consider the half of the plane defined by the line, that contains the point T and to form the area of the plane that is an intersection of all such half planes. Write a program **area** to find the face of the obtained area.

Input. The first line of the standard input contains the coordinates (x_B, y_B) of the bottom left and (x_E, y_E) of the upper right corner of the rectangle Q. The second line contains the coordinates of the point T. The third line contains the number N. Each of the following N lines contains the coordinates (x_1, y_1) and (x_2, y_2) of couple of points that define one of the given lines. All coordinates are non negative integers, less than 10000. All lines, including the lines defined by the corners of the rectangle Q are such that no three lines that pass through a common point.

Output. The program has to print on the standard output one integer – the found face truncated after the decimal point.

EXAMPLE.

Input	**Output**
0 0 5000 5000 4000 2500 2 2800 4100 400 4300 800 2200 4600 80	14348737

Task A2. Numbers, numbers, ... Let N be a natural number and D is the product of its digits in decimal system. Let us define an operation over N giving as a result the numbers $N_1 = N - D$ and $N_2 = N + D$. Let us apply the operation to N_1 and N_2, to the numbers obtained from them, and so on. A question: is it possible, starting with a given number N and applying the operation, to obtain the number N again? For some numbers it is easy to answer, positive or negative, of the question, for other numbers it will be difficult to find the answer and there are numbers for which finding the answer seems impossible.

Input. Ten files are given, named `numb.01.in`, `numb.02.in`, ..., `numb.10.in`. In the single line of each file 10 different integers between 0 and 1000 will be given.

Output. For each file `numb.xx.in` you have to produce a file named `numb.xx.out` containing string of length 10, composed of characters `0`, `1` and `2`. Each character corresponds to one number from the input. The character has to be 1, if you established that the corresponding number in the input could be obtained by itself with applying the operation. The character has to be `0`, if you established that the corresponding number in the input could not be obtained by itself with applying the operation. If you where not able to establish the true then the character has to be `2`.

EXAMPLE.

numb.xx.in	**numb.xx.out**
10 11 12 13 14 15 16 17 18 19	1000100010

Evaluation. If your output file is the same as the file of the author then 10 points will be assigned for the test. For each `2` in your output, placed where `0` or `1` is expected, the result will be decreased by 1 point. If in your input there is `1` in place, where `0` is expected or the opposite – 0 points will be assigned for the test.

Task A3. Strings. The string S of length L is composed of the characters of given set T. Write a program `string` to find the number of different strings X of length P, composed of the characters of T, such that S is not a substring of X.

Input. On the first line of the standard input the string S of length L will be given ($1 \leqslant L \leqslant 2000$). Second line of the input contains also a string such that each character of T appears once in it. The characters of T are small and/or capital letters of Latin alphabet (so the size of T is no more than 52). On the third line of the standard input the number P will be given ($1 \leqslant P \leqslant 2000$). In 30% of tests the set T contains 2 letters and $P \leqslant 20$.

Output. On the single line of the standard output the program has to print required number of strings reduced by modulo 10^6.

EXAMPLE.

Input	**Output**
aa ab 3	5

Appendix 2: Example of Tasks for Group C

Tasks of groups C are especially interesting because of the approaching first international contest in programming for students aged less than 15.5 years – the Balkan Olympiad in Informatics for juniors. In the moment when this paper will be presented the Olympiad will be finished, we will know the tasks that were selected for the contests and if these tasks are appropriate for the students or not. Now we can only present the vision of the Bulgarian team about hardness of the tasks for an international contest for the mentioned age. Here are some tasks for group C from the Spring tournament, held in June 2007.

Task C1. Exchanges. Sporting activities are part of preparation of National team for Balkan Olympiad in Informatics for juniors. In the break between two lectures sporting coach of the team proposed following game. On the periphery of a large circle she has drown N small circles (as many as the students), labeled with the numbers from 1 to N. Then she distributed students in small circles – one student in a circle and placed in each circle one of N plates labeled also from 1 to N. By the sign of the teacher each student had to run from her/his circle to the circle pointed by the plate. The movement generated a big disorder! When each student reached the goal the teacher gave a sign again and the students had to make the exercise again. The game finished when all students reached their initial positions simultaneously. Funny, isn't it? Write a program `change`, to calculate how many movements will be necessary to finish the game.

Input. On the first line of the standard input the number N will be given $(5 \leqslant N \leqslant 100000)$. On the second – list of the plates in order they were placed in the circles $1, 2, \ldots, N$, respectively.

Output. On the single row of standard output the program has to print the number of exchanges. In 80% of test cases the result will be less than 2000000000.

EXAMPLE.

Input	Output
5 3 5 4 1 2	6

Task C2. Game. A positive integer N and K positive integers, less then N, are given ($1 \leqslant N \leqslant 10^8$, $2 \leqslant K \leqslant 15$). Two players play the following game. First player choses one of the K numbers and divides N to it (integer division). Then the second player choses one of the K numbers and divides to it the result of the first player. Then the first player moves again and so on. The player that first obtains result 0 is the winner. Write a program `divgame` to check is it possible for the first player to win the game, dose not matter how the second player will move and if yes – how many among the K possible first divisors lead to a victory.

Input. For each run the program has to check two games. On the first row the numbers N and K for first game are given and on the second – the K divisors. On the third and forth line the data for second game are given in similar way.

Output. For each game the program has to print on standard output the number of divisors that lead to victory. If the number is not zero – a second line has to be printed for the game with a list of winning divisors.

EXAMPLE.

Input	Output
6 2 2 3 18 2 2 3	1 2 0

Task C3. Net

An IT company has to connect computers in a local net. A number less than 15000 identifies each computer. A list of M couples of computers that have to be linked is given. The two computers in the couple have to be linked directly or trough one other computer. Write a program `net` to find the minimal number of direct links that are enough for creating the net.

Input. First line of the standard input will contain the number M ($M < 5000$) of couples that have to be linked. Each of the next M lines contains one of the couples – two identifiers separated by single space.

Output. On the single line of the standart otput the minimal number of direct links has to be printed.

EXAMPLES

Input	3 1 2 1 3 2 3	6 1 2 0 2 5 1 0 1 5 2 6 5	7 1 4 6 10 4 6 2 3 5 1 4 10 1 6
Output	2	4	5

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K. Manev is an associate professor at Sofia University, PhD, teaching discrete math and algorithms. Since 1982 he is a member of the Bulgarian NC for olympiads in informatics and leader of NC from 1998 to 2002. He participated in organization of the First IOI and was leader of the Bulgarian team for IOI's and BOI's, president of the SC of two BOI's. Elected member of IC of IOI from 2000 to 2003 and member of IC of IOI from 2005 to 2010 as a representative from the host country of IOI'2009.

E. Kelevedjiev is a research fellow in Institute of Mathematics and Informatics of Bulgarian Academy of Sciences. His field of interests includes algorithms in computer science, operation research, digitization techniques, etc. He is a member of the Bulgarian NC for olympiads in informatics since 1993; leader or deputy leader of the Bulgarian team for many IOI's and BOI's.

S. Kapralov is an associated professor at the Technical University of Gabrovo, doctor of sciences in mathematics, teaching discrete mathematics and programming. He is vice president of UBM, responsible for olympiads in informatics; member of the Bulgarian NC for olympiads in informatics since 2000 and leader of the NC since 2002; leader or deputy leader of the Bulgarian team for many IOI's and BOI's.