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Selection Mechanism and Task Creation of Chinese National Olympiad in Informatics

Hong WANG
Department of Computer Science and Technology, Tsinghua University
100084 Beijing, China
e-mail: wanghong@tsinghua.edu.cn

Baolin YIN
School of Computer Science and Technology, Beihang University
100083 Beijing, China
e-mail: yin@nlsde.buaa.edu.cn

Rujia LIU
Eryiju Science and Technology Company Limited
100084 Beijing, China
e-mail: rujia.liu@gmail.com

Wenbin TANG, Weidong HU
Department of Computer Science and Technology, Tsinghua University
100084 Beijing, China
e-mail: tangwb06@gmail.com, wd.h@163.com

Abstract. In this article, we present a general overview and associated issues of the selection mechanism for the IOI China team of the Chinese National Olympiad in Informatics (CNOI), and some approaches and management experience to assure task quality during the past years. First, the existing contests and activities of CNOI are introduced. Then we focus on multi-test selection and multi-aspect assessment for top ranked contestants, building up of task creation team, task innovation and improvement, etc. A task example from the IOI China Team Selection Competition is also given in the appendix.

Key words: selection mechanism, contestant assessment, task creation, task innovation.

1. The Existing Contests and Activities of the Chinese National Olympiad in Informatics

The NOI Scientific Committee (NOISC) and NOI Competition Committee (NOICC), under the guidance of the China Computer Federation (CCF), are responsible for the technical organization and management of CNOI. There are several related contests and activities every year in China (Wang, 2007). The major events are given as follows, in increasing order of task difficulty:

(1) *National Olympiad in Informatics in Province*

National Olympiad in Informatics in Province (NOIP) is held in the middle of October and November each year. Contestants are divided into two levels: junior and senior, which two rounds for each level.

Preliminary round: a conventional paper-based test consisting of multiple-choice questions and short-answer questions. It's an elementary contest aiming to test the basic knowledge and skills of the contestants. On average, over 80,000 contestants participated each year in this round from NOIP'2006 to NOIP'2009. After this round, the top 15% contestants advanced to the final round.

Final round: a computer-based programming contest. Contestants have 3 hours to solve 4 tasks which have the same format as IOI tasks, but are more elementary.

(2) *National Olympiad in Informatics*

NOI test includes two competition days (5 hours for 3 tasks on each day) and one week activity similar to the IOI. NOI is the highest level national-wide contest of China. The contestants of NOI are usually winners of province-wide competitions. A team competition was introduced in NOI'2006. NOI sets gold (10%), silver (20%) and bronze (30%) medals.

(3) *NOI Winter Camp Competition*

NOI Winter Camp Competition (NOIWCC) contains an intense training course of one week during January. Students are required to take a five-hour competition on the last day – that's the NOIWCC. The tasks of NOIWCC are more difficult than those of NOI competition. The scores of NOIWCC are also considered in selecting the IOI China team (see below).

(4) *The Final China Team Selection Competition*

The final China Team Selection Competition (CTSC) is the most important competition for the IOI China team selection, which is always held in early May every year. The format is similar to the IOI (two days, 5 hours for 3 tasks each day). Its size and influence is not as big as NOI, but the tasks of CTSC are arguably the most difficult among all CNOI contests.

2. Selection Mechanism for the Contestants of the IOI China Team

After practicing and exploring more than 20 years, we have established a strict mechanism with a set of rules, for selecting talented students and building the IOI China team. The mechanism and rules are based on different investigations and comprehensive surveys, including multiple contests and paper defence. It guarantees that the selected contestants have outstanding programming skills, psychological quality and comprehensive ability.

2.1. *Multi-Test Selection*

Obviously, there could be some contingency for an individual contest score because of task style and other reasons. It's necessary to arrange multiple contests in order to reflect the general ability and actual quality of candidates. Our IOI team selection process can be divided into four stages:

(1) The top 20 contestants from the last NOI contest form National Training Team (NTT) for the IOI of next year (candidates for the IOI China team).
Take the selection of the IOI'2010 China team as an example. The process began in NOI'2009 during July–August of 2009. The top 20 contestants of NOI'2009 became the members of the NTT for IOI'2010. In the next three stages, we will track the performance of the NTT members and finally build the China Team from them.
(2) All the NTT members must participate in the NOI Winter Campus training and final competition-NOIWCC. The competition score of each individual NTT member contributes to his total score for IOI team selection. At present, NOI WCC has a weight score of 25 (out of 110, see below).
(3) The final and most important selection competition for IOI team – CTSC. All the NTT members must participate in CTSC. This contest has a total weight score of 60 (30 for each day).
(4) A few hours after CTSC, we accumulate the total score for each NTT member. Only top 6 students have the opportunity to participate in the final oral defence, from which we select the best four students to form the IOI China team.

2.2. *Multi-Aspect Assessment*

Besides contest scores, we also make comprehensive assessments related to oral expression, psychological quality and English proficiency of NTT members. A personal statement and letter of commitment is requested from each individual member. The main assessments include:

- During nearly one year between last the NOI and next CTSC, every the NTT member is required to design their own contest problems as part of their obligatory homework. At the meanwhile, there is some necessary discussion and communication.
- During the NOI Winter Camp training and contest, each NTT member must participate in an oral paper presentation and defence (10 min + 5 min). The judgement from the jury has a weight score of 15.
- In the final oral defence for the top 6 contestants, each student is expected to introduce himself in English and answer questions in front of the jury and hundreds of spectators.
- Each contestant is required to provide a personal statement and letter of commitment.

Table 1
Selection process and corresponding weight scores

Items	Weight score	Remarks
Homework	10	
NOI Winter Camp Competition (NOIWCC)	25	
Paper presentation and oral defence	15	15 minutes/contestant
China Team Selection Competition (CTSC)	60	2 days, 30 for each
Total score	110	

2.3. *Simulation Training before IOI*

After selecting 4 contestants, we also arrange a training competition between IOI contestants and ACM/ICPC contestants. The problems are usually adopted from previous ACM/ICPC competitions. Each IOI contestant solves the problems by himself, while ACM/ICPC contestants solve problems in teams of three.

The purpose of the simulation training is to provide a contest atmosphere for IOI contestants to retain optimum status for the upcoming IOI. Moreover, it also provides a chance for discussion with ACM contestants, especially the former IOI medallists. Contest experience and problem solving tactics of these former IOI medallists can benefit current the IOI team considerably. They're especially helpful for contestants who is about to participate in the IOI for the first time.

2.4. *Brief Summary of the Selection Process*

To sum up, after all 20 members of NTT is selected from NOI, there are four contests and activities that contribute to the selection process. They are shown in the Table 1, with corresponding weight scores.

Finally, after we sum the scores for all four parts, top 6 contestants of NTT will get the chance to participate in the final oral defence. After that, the best 4 contestants forming IOI China team are announced.

3. Several Approaches to Assure Task Quality

Task creation is at the heart of contest arrangement. High-quality tasks not only boost the overall public valuation of the competition, but also ensure effective selection of talented students and fair game.

3.1. *Organizing the Task Creation Team*

(1) Core members of task creation committee consist of former IOI and NOI medallists, experienced ACM/ICPC contestants (both present and former) and faculty

members of university. This assures the members have a good understanding of high level training and the ability of solving contest problems. Because the members have their own jobs or studies, they serve as volunteers usually.
(2) Members of two committees, NOISC and NOICC, play a key role in the work of contest task creation. NOISC holds meetings to discuss the tasks for every contest.
(3) Besides faculty members of university, there are also some student members in NOISC. They are undergraduate students or graduate students, including PhD candidates. This special treatment plays a very important role in the task creation.

3.2. *Preserving Task Innovation*

(1) Core members of task creation team are usually active in the various programming contests. They participate in the ACM/ICPC and other programming competitions with strong competency. For example, the 6 members of task creation team for NOI2009, making use of the time between the two contest days of NOI2009, flew to Shenzhen to take the Tencent Innovation Programming Contest. The 6 members won 2nd–6th and 9th place respectively in the competition. All the members of task creation team are the ACM/ICPC present contestants or former ones, including ICPC world finals gold medallists. This assures the NOI tasks with the advanced issues and concepts.
(2) Students with strong theoretical and algorithmic background tend to utilize the ideas from novel algorithms and data structures for the task creation. There were tasks related to all kinds of applications of algorithms and knowledge, such as the maintenance of the segment tree, computational geometry and network flow, etc. This extended the range and depth of tasks.
(3) Problem setters are often trying to make problems interesting to attract more contestants. There were quite a few tasks with interesting stories behind, such as the task "Plants vs Zombies" (NOI'2009), N^2 digital games (puzzle, CTSC'2009), Target-shaped Sodoku (NOIP'2009). These tasks are attractive to students. It stimulated youth's creative imagination and study enthusiasm.

3.3. *Task Discussions and Publications*

(1) Summing-up and idea-exchanging are also very important to improve the task quality. When the manuscript of a task is finished, we arrange different discussion and to ask for suggestions.
(2) There is a task solution report and discussion after every contest. It is usually arranged in the afternoon of the each contest day. Contestants are encouraged to ask questions and join discussions during the session. It is very helpful to the discovery the imperfection of tasks and usually leads to quality improvement for the future.
(3) The Publication of the yearbook of NOI. We have published a yearbook of NOI each year since 2006. Each yearbook covers all the tasks with solutions, from all 4 contests during that year. Official test data and reference solutions can also be

found in the companion CD. The yearbook has become the necessary reference material for informatics olympiad field in China. We began to publish NOI tasks in English since 2009.

(4) We also encourage and support the publication of books related to NOI trainings and contests, especially comprehensive skills, the art of programming languages, algorithms, contest task solutions, and dedicated contest training textbooks in algorithms and data structures. Mr. Rujia Liu, past NOISC student member and current NOICC member, has designed over 30 tasks for CNOI and ACM/ICPC Asia regional contests. He published his first book "*The Art of Algorithms and Programming Contests*" in 2004. Then he translated "*Programming Challenge*" into Chinese and published it in 2009. Recently, he's planning to publish a book series of the art of algorithms and programming contests.

4. Conclusion

This article gives some ideas and existing practice establishing the selection mechanism for the IOI China team, and some approaches and management experience to assure tasks quality of CNOI during the past years. The selection mechanism and assessments for the best contestants has been proven to be effective. CNOI plans to continue building up a powerful task creation team, and preserving task innovation and exploration by the untiring effort of NOISC and NOICC under the guidance of the CCF.

Appendix. IOI China Team Selection Competition (CTSC) Task Example

Magic Garden
(Proposed by Weidong Hu, revised by Madhavan Mukund)

[Task Description]
The Magician Dongdong has a beautiful magic garden that is full of flowers all the year round.

The garden's watering system has been specially designed by Dongdong. He has conjured up n magical taps suspended in mid-air that are connected to the river nearby. When Dongdong waters the garden, each tap sends out a stream of water in an arc that falls on a single plant. Thus, the n taps together water exactly n magic plants.

Dongdong has placed all taps at the same height h. The water flows out horizontally from each tap when it is opened. The horizontal speed at which the water flows out of the tap varies from tap to tap. Since it is a magic garden, there is no air resistance and the stream of water that emerges horizontally from each tap traces out a perfect parabola under the influence of gravity. The acceleration of gravity in the magic garden is denoted by g.

The taps are arranged such that at most three streams of water pass through any single point in the air. The flow of one stream is not affected in any way when it crosses another stream in mid-air.

Over the years, the river has become polluted due to the growth of factories. Thus, Dongdong has to purify the water that falls on the plants. He can only purify the water after it emerges from the taps.

To purify the water, he creates an invisible magic filter at some height that he chooses. The magic filter is a horizontal convex region, parallel to the ground. Any water that passes through this magic filter will be purified. The energy used to create the magic filter is directly proportional to the area of the filter: 1 unit of energy is required to create 1 square unit of the filter.

Dongdong needs a filter that will purify all the water that emerges from the n taps. He wants to minimize the energy he uses to create the filter that he requires.

The taps and plants in the garden are described in terms of a 3D rectangular cartesian coordinate system. The northwest corner of the garden at ground level is the origin for the coordinate system. The x-axis runs from west to east, the y-axis runs from north to south and the z-axis runs vertically from bottom to top.

In terms of this coordinate system, the position of the ith tap is represented as (x_i, y_i, h), while the position of the jth magic plant is represented as $(x'_j, y'_j, 0)$.

[Input Format]
The first line contains two real numbers h and g, the height of the taps and the acceleration of gravity in the magic garden. The second line contains an integer n, the number of taps. This is followed by n lines, each line contains 4 integers x_i, y_i, x'_i, y'_i, separated by spaces, where (x_i, y_i, h) gives the position of the ith tap and $(x'_i, y'_i, 0)$ gives the position of the plant that is watered by this tap.

[Output Format]
The output should be a single real number, the minimum energy that Dongdong needs to use to purify all the water. Retain at least 3 digits after the decimal point in your solution.

[Sample Input]
```
36 2
3
99 100 105 100
101 100 95 100
100 99 100 105
```

[Sample Output]
```
0.000
```

[Sample Explanation 1]
All streams pass through the point (100, 100, 35). Create a filter at this point with 0 area. Since the area is 0, so is the energy required to create the filter.

[Sample Input 2]
```
10 9.8
```

```
3
0 0 0 0
1 0 100 0
0 50 0 1
```

[Sample Output 2]

```
25.000
```

[Sample Explanation 2]

Create a filter at height 10 in the shape of a right-angled triangle with vertices (0, 0, 10), (1, 0, 10) and (0, 50, 10). The area of this triangular filter is 25.000, so 25.000 units of energy are needed.

[Scoring]

For each test case, if your answer differs by at most 0.001 from the standard answer, you score 100%. If your answer differs by more than 0.001 from the standard answer but at most by 0.002, you get 50% of the score. Otherwise, you get 0.

[Constraints]

For 20% of the test cases, $1 \leqslant n \leqslant 10$;
For 50% of the test cases, $1 \leqslant n \leqslant 50$;
For 100% of the test cases, $1 \leqslant n \leqslant 100$;
$0 < h \leqslant 10000.0, 0 < g \leqslant 100.0, 0 \leqslant x_i, y_i, x'_i, y'_i \leqslant 1000$.

[Hint]

Let $L = (x_i - x'_i)^2 + (y_i - y'_i)^2$,
Initialized speed $v_0 = \sqrt{\frac{Lg}{2h}}$
The speed in horizontal direction at time t: $v_H(t) = v_0$
The speed in vertical direction at time t: $v_V(t) = gt$
The speed at time t: $v(t) = \sqrt{v_H^2(t) + v_V^2(t)}$

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H. Wang is an associate professor at the Department of Computer Science and Technology, Tsinghua University. He received his PhD degree in computer science from Tsinghua University in 1993. He has served as the chairman of Scientific Committee of National Olympiad in Informatics (NOISC) of CCF since 2006.

B. Yin is a professor at the School of Computer Science and Technology, Beihang University. He received his PhD degree in computer science from the Department of Artificial Intelligence, the University of Edinburgh in 1984. He has served as the vice chairman of Scientific Committee of National Olympiad in Informatics since 1999.

R. Liu received his master degree from the Department of Computer Science and Technology, Tsinghua University in 2008. He has been a coach of IOI China National Training Team from 2002 to 2008. He is currently a member of Competition Committee of National Olympiad in Informatics.

W. Tang is a senior student in the Department of Computer Science and Technology Tsinghua University. He has been a coach of IOI China National Training Team from 2008. He is currently a student member of Scientific Committee of National Olympiad in Informatics of CCF.

W. Hu is a PhD candidate in the Department of Computer Science and Technology, Tsinghua University. He has been a coach of IOI China National Training Team from 2008. He is currently a student member of Scientific Committee of National Olympiad in Informatics.