

# Contest Environment Using Wireless Networks: A Case Study from Japan

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**Abstract.** The Japanese Committee for the IOI (JCIOI) had held the second-round contests of the Japanese Olympiad in Informatics (JOI) in which nearly 60 contestants participated. The JCIOI did not employ networks in the second-round contests to avoid high cost. However, contestants sometimes make simple mistakes (e.g., format errors), so the JCIOI adopted wireless networks to respond to submitted source codes in the last second-round contest. This paper describes how we built the contest environment using wireless networks. In addition, we also discuss the judging system used in the second-round and final-round contests.

**Key words:** wireless network, programming competition, judging system.

## 1. Introduction

The Japanese Committee for the IOI (JCIOI) (The Japanese Committee 2006) has been holding contests to select delegates to compete in the IOIs. The contests consist of three rounds, which are the first-round, the second-round and the final-round contests.

The JCIOI had stopped sending delegates to the IOIs between 1998 and 2005 and resumed sending them in 2006. All of the contests since 2006 have been computer-based, and their tasks are IOI-like. Contestants compete over the Internet in the first-round contests. In the second-round and the final-round contests, contestants are gathered on one site to compete on allocated computers. In the last first-round contest, held in December 2010, 714 contestants participated. Likewise, 61 contestants participated in the last second-round contest, held in February 2011, and 18 of them were invited to the final-round contest. Although it was originally scheduled for March 2011, it was postponed because of the Great East Japan Earthquake on March 11, 2011. Four of them will be selected for delegates to compete the IOI 2011.

In the second-round contests in the years between 2006 and 2009, the JCIOI manually collected the programs written by the contestants by using USB flash memories at the end of the contest. In the final-round contests in the years between 2006 and 2009, the JCIOI prepared wired networks and offered the judging system PC<sup>2</sup> (California State University, Sacramento 2000) in order to select four delegates a year to compete in the next IOI. The JCIOI was not able to prepare wired networks in the second-round contests due to cost. However, in the second-round contests, one out of ten contestants on average

submitted at least one invalid program that either did not compile or produced an incorrect format. Those contestants left the contest without knowing that they had submitted invalid programs.

The author has developed a judging system named Imo Judge (Kentaro IMAJO 2008) for private contests (e.g., the 1st Imos Contest (Osaka University Competitive Programming Club 2008), JAG Practice Contest for ACM/ICPC Asia Regional Contest (ACM-ICPC Japanese Alumni Group 2010)) since 2008. The author heard about the above incidents with the IOI preparation contests and suggested to the JCIOI to adopt this judging system for grading programs in those contests. As a result, it was officially employed in the final-round contest of JOI in 2010 for the first time.

There are no wired networks in the facility where the second-round contests were held, and it is very costly to set up wired networks. Thus, the JCIOI have manually collected the programs written by the contestants until 2009. In order to prevent contestants from submitting invalid programs, we decided to adopt wireless networks in the second-round contests. We prepared wireless networks, a web server and a web-based uploading system in the second-round contest in 2010 for an experiment on wireless networks. The contestants competed on computers connected to the web server wirelessly, and they submitted programs through their web browser using the web-based uploading system. The system provided web pages including a web form to upload programs with an authentication.

In the second-round contest in 2010, we manually collected programs using USB flash memories as a backup alternative. Since there was no trouble with wireless networks and the system in 2010, we decided to offer a web-based judging system with wireless networks in the second-round contest in 2011. In addition to the functions of the web-based uploading system, it provided functions to execute the submitted programs and show the partial results during the contest.

In this paper, we describe how we built wireless networks for IOI-like contests in Section 2, and we describe our motivation in building such networks in Section 3. Furthermore, we describe a judging system that we used in Section 4. We conclude this paper in the Section 5.

## 2. Experiment

We prepared one web server, one wired router, two wireless routers and more than 60 laptop computers for the second-round contests in 2010 and 2011; see Fig. 1. The web server hosted a web service and a database service. Some of the laptop computers functioned as judge servers, whereas the others were used by the contestants. Every laptop computer was wirelessly connected to the web server through the wireless routers.

### 2.1. Wireless Networks

We used AirPort Extreme (Apple Inc. 2003) for wireless routers. AirPort Extreme has a function to construct a wireless guest network. Although laptop computers in the guest

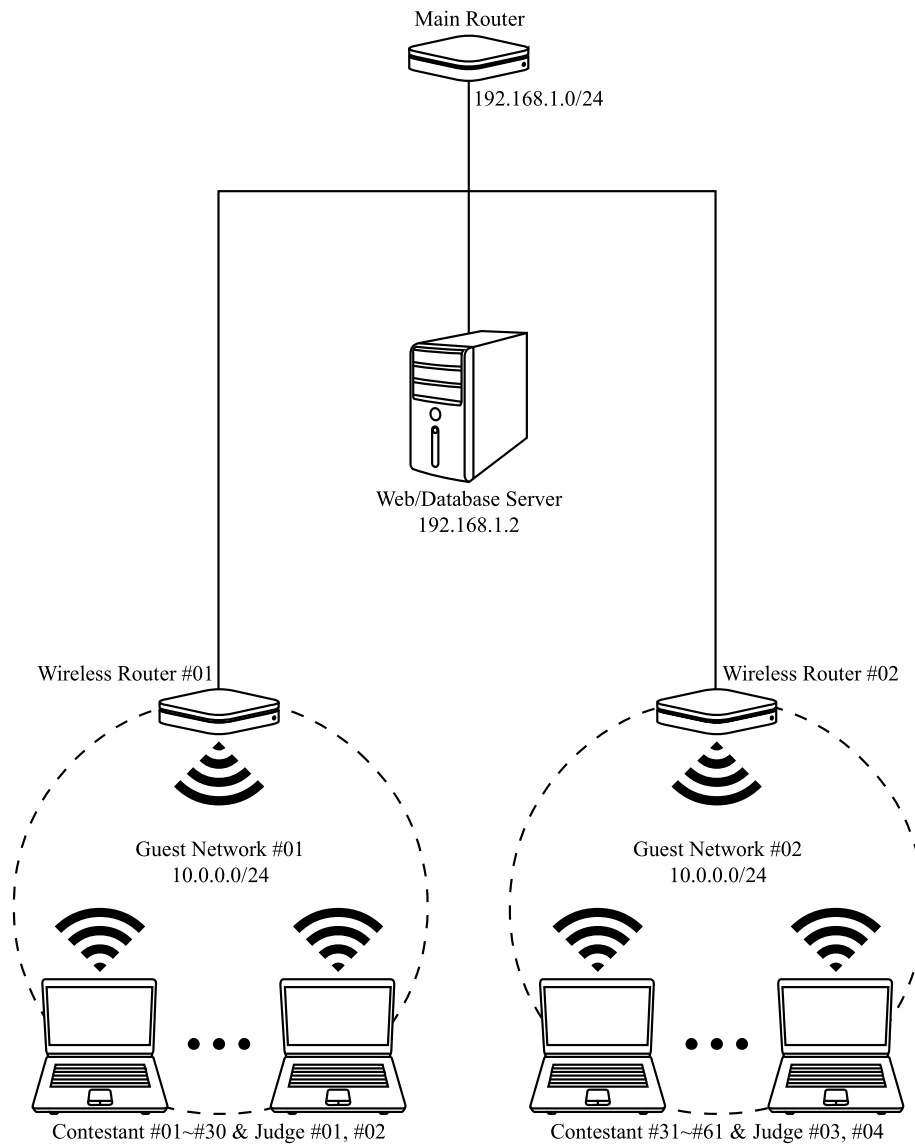


Fig. 1. Network layout in the second-round contest of JOI in 2011.

network can access computers in the Wide Area Network (WAN), they cannot communicate with other laptop computers in the guest network. In addition, they cannot be accessed passively at all since a guest network is protected by a Network Address Translation (NAT; Wikipedia 2001) firewall that modifies the IP addresses of the laptops to a single IP address, thus hiding them from outsiders. In the setup of Fig. 1, the laptops in each guest network can only communicate with the web server. Thus we used guest networks.

The wireless routers and the server were placed at one corner of the room, whereas the laptop computers were distributed around the room. However, one can use a different arrangement.

## *2.2. Judge Servers*

We operated an IOI-like web service in 2011, which is a part of the Imo Judge System. The web service receives programs and displays the execution results on site.

The Imo Judge System consists of a web service and a judge service. The two services communicate through a database service that was installed on the web server. The judge service was installed on judge servers within the same environment of the contestants' computers. Access to the judge servers was restricted because the judge servers belonged to guest networks, and the judge service in the judge servers requires pulling submission data to grade from the web server. Therefore, it periodically checks the judge queue of the database service in the web server, and it grades each submission data and records its result to the database. The number of judge servers was at most four in the second-round contest in 2011.

## **3. Results and Discussion**

This section describes why we relied on wireless networks and discusses the results of using them in the second-round contests in 2010 and 2011.

### *3.1. Durability and Security*

This time we relied on AirPort Extreme wireless routers because they can officially manage 50 wireless connections at the same time according to Apple Inc., although ordinary wireless routers can manage about 20 at the most. In fact, each wireless router was able to manage more than 30 wireless connections simultaneously in the second-round contests in 2010 and 2011. Furthermore, we examined the durability by accessing the wireless twice a second from 60 laptop computers simultaneously and for a few minutes. We noticed that the networks were able to completely withstand the load under these circumstances.

Owing to guest networks, contestants cannot interfere with each other at all, and judge servers cannot be accessed passively. Hence, we only need to be mindful of the security of access to the web server and the execution on the judge servers.

### *3.2. Expenses*

Since a wireless router can manage many users at the same time, the number of wireless routers that are required to build the wireless networks is small. The additional expenditure for the second-round contests was the price of those wireless routers at the most. The payment for the personnel who constructed these networks was minimal.

Compared with wired networks, wireless networks require no cabling. Wired networks on the other hand, not only require cables, but also cable wrappers. One should also take into account the difference in the number of staff needed to layout each type of network.

#### 4. Judging System

A judging system must be capable of handling any program safely. Imo Judge prevents various hazardous programs from causing fatal problems. This section describes how Imo Judge handles some of those programs.

##### 4.1. Protection of I/O Files

Imo Judge naturally executes programs with the privilege of a normal user. To grade programs for interactive tasks, we must restrict both reading-ahead and rewriting. Hence, I/O files must be hidden from programs. Data from standard input are given through a pipe of a process that has the root privilege in order to circumvent reading-ahead. Likewise, data from standard output are recorded through a pipe of a process that has the root privilege in order to circumvent rewriting.

##### 4.2. Resource Limitations

Resource limitations are inevitable for judging systems on account of stability. UNIX-like operating systems can easily limit resource consumption using a function *setrlimit* (Linux man page 2008a). This function prevents programs from consuming excessive resources (e.g., memory, output file size, number of processes). Moreover, they can provide information of resource consumption (e.g., memory consumption, CPU time consumption) using another function *wait4* (Linux man page 2008b).

##### 4.3. File Writing Pollution

Although a normal user cannot write in most of the directories except for its own home directory, the directories */tmp* and */var/tmp* can be written by anyone including normal users. Therefore, it is necessary to clean up those directories before executing any program; otherwise the programs can produce cache files and read them beyond their transaction.

##### 4.4. Attacks in Compilation

It is possible to make a compiler run out of control using a *template*, which is one of the functions of C++. In addition, it is also possible to make a compiler output many warnings using *templates*. Thus, a judging system must assume that a compiler may not finish compilation or a compiler may output excessive warning messages.

## 5. Conclusion and Future Plan

We have demonstrated that contests with 60 participants can be managed safely with wireless networks. The truth is that such contests can be held anywhere with sufficient power supplies, and with no special facilities or heavy investment. Moreover, the setup was quite simple. Even if something goes wrong, it is easy to identify the source of the problem and fix it by replacing a wireless router.

We will release the Imo Judge System as an open source software so that anyone can hold contests without the knowledge of Linux, server administration or databases.

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## References

- The Japanese Committee for the IOI (2006). *The Japanese Committee for the IOI*.  
Available at: <http://www.ioi-jp.org/index-e.html>.
- California State University, Sacramento (2000). *CSUS Programming Contest Control (PC\2) Home Page*.  
Available at: <http://www.ecs.csus.edu/pc2/>.
- Kentaro IMAJO (2008). *Imo Judge*.  
Available at: <http://judge.imoj.jp/>.
- Osaka University Competitive Programming Club (2008). *The 1<sup>st</sup> ImosContest*.  
Available at: <http://oucpc.imoj.jp/contest/imos01/>.
- ACM-ICPC Japanese Alumni Group (2010). *ICPC Tokyo/Asia Regional Preliminary Contest*.  
Available at: <http://judge.imoj.jp/?cid=11>.
- Wikipedia (2001). *Network Address Translation – Wikipedia, the free encyclopedia*.  
Available at: [http://en.wikipedia.org/wiki/Network\\_address\\_translation](http://en.wikipedia.org/wiki/Network_address_translation).
- Apple Inc. (2003). *AirPort Extreme*.  
Available at: <http://www.apple.com/airportextreme/>.
- Linux man page (2008a). *setrlimit(2) – Linux Manual page*.  
Available at:  
<http://www.kernel.org/doc/man-pages/online/pages/man2/setrlimit.2.html>.
- Linux man page (2008b). *wait4(2) – Linux Manual page*.  
Available at:  
<http://www.kernel.org/doc/man-pages/online/pages/man2/wait4.2.html>.



**Kentaro IMAJO** participated in the IOI 2006 and won a bronze medal. He has been involved in contests of JOI as a coach since 2007. He participated in IOI 2009 as a member of Host Science Committee. He is currently a first-year master's student in Graduate School of Informatics at Kyoto University.