

2010 Summer Entrance Examination
Department of Creative Informatics
Graduate School of Information Science and Technology
The University of Tokyo

Programming

INSTRUCTIONS

1. Do not open this problem brochure until the signal to begin is given.
2. Write your examinee ID below on this cover.
3. An answer sheet, a draft sheet and a working sheet accompany this brochure. Write down your examinee ID on these sheets.
4. The USB memory delivered beforehand to each examinee contains ASCII text files: `7.txt`, `10.txt` and `1000.txt`. Newline is represented by carriage return (CR) followed by line feed (LF) in the file.
Before the examination starts, copy these files to your PC and browse them. Make sure you can see lines of digits, and then keep your hands away from your PC. If you cannot read the files properly, consult the test supervisor. The contents of the USB memory are common to all examinees.
5. You may choose your favorite programming languages.
6. You may consult only one printed manual of a programming language in the examination. *You can use or copy any libraries or program segments existing in your PC, but you cannot connect to the Internet.*
7. By the end of the examination, make a directory/folder on your PC, whose name is the same as your examinee ID, and put your program files and related files into the directory/folder. Copy the directory/folder onto the delivered USB memory.
8. At the end of the examination, the USB memory, the answer sheet, draft sheet and working sheet are collected.
9. After these are collected, stay at your seat, until all examinee program results have been checked briefly by the test supervisor.
10. After the brief check, try to save your program execution environment on the PC so that you can run your program as soon as possible during the oral examination in the afternoon.
11. *Leave your PC and this brochure together in the room for the oral examination and leave the room until you are called.*

Examinee ID _____

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Let us consider a number of rectangles placed on a grid-structured xy plane. Every rectangle on this xy plane satisfies the following two conditions.

- (C1) Each edge of a rectangle is in parallel with either the x or y axis.
- (C2) The x -coordinate and y -coordinate of each vertex are integers from 0 to 999.

Information about the position of a rectangle is given in one line:

$$x \ y \ w \ h$$

The vertices of this rectangle are located at (x, y) , $(x, y + h)$, $(x + w, y + h)$ and $(x + w, y)$. x and y are non-negative integers. w and h are integers from 1 to 50. Text files `7.txt`, `10.txt` and `1000.txt` include information about collections of 7, 10 and 1000 rectangles, respectively.

For example, Figure 1 shows the layout of rectangles specified by `7.txt`. Rectangles are shaded by gray, and overlapping areas are shaded by darker gray.

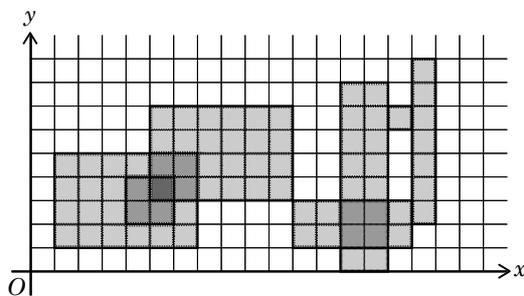


Figure 1: Rectangle layout specified by `7.txt`

Several terms are defined below:

Unit square A *unit square* is a 1×1 square delimited by the grid.

Thickness The *thickness* of the unit square is defined as the number of rectangles overlapped on the unit square.

Connectedness If rectangles are overlapped or rectangles share an edge, they are *connected*. Rectangles that share only corners are not connected, however.

Cluster A set of connected rectangles is called a *cluster*. For example, rectangles A , B and C form a cluster when A and B are connected and B and C are connected.

Number of cluster elements The *number of cluster elements* is defined as the number of rectangles which make a cluster.

Cluster area *Cluster area* means the area (or the number of unit squares) of the aggregate area covered by the rectangles of the cluster.

For example, on the rectangle layout specified by `7.txt`, the maximum thickness is 3 and there are 2 clusters. One cluster consists of 3 rectangles and its area is 44. The number of elements in the other cluster is 4 and the area is 30. Therefore the cluster with the maximum number of cluster elements is 4 and the maximum cluster area is 44.

Answer the following questions. Write your answers to all questions on the answer sheet. Write your answers referring to the output of your computer program from Q2. You do not need to write down your program on the answer sheet. You are required to explain your program at the oral examination.

Q1 Answer the following questions about the rectangle layout specified by `10.txt`.

(1-1) Write the maximum thickness.

(1-2) Write the number of clusters.

(1-3) Write the maximum number of cluster elements for a single cluster.

(1-4) Write the maximum cluster area for a single cluster.

Q2 Write the summation of the area of all 1000 rectangles specified by `1000.txt`.

Q3 Answer the following questions about the rectangle layout specified by `1000.txt`.

(3-1) Write the maximum thickness.

(3-2) Write the number of clusters.

(3-3) Write the maximum number of cluster elements for a single cluster.

(3-4) Write the maximum cluster area for a single cluster.

Q4 Let us consider adding a new rectangle R ($w = 5$, $h = 10$) onto the rectangle layout specified by `1000.txt`. R should satisfy the two conditions (C1) and (C2) shown at the beginning of this problem. Do not consider rotations of R . Answer the following questions.

(4-1) Write the number of possible arrangements of R , which increase the maximum thickness by one.

(4-2) Write the number of possible arrangements of R , which maximize the maximum cluster area.

Q5 Sketch an algorithm to compute the maximum thickness of the layout made by rectangles which satisfy the condition (C1) and the following condition (C2').

(C2') The x -coordinate and y -coordinate of each vertex are integers from 0 to 9999999.