



2108 - Houses Divided

North America - Mid Atlantic - 2000/2001

Bill and Scott are business rivals. Each of them wishes to buy a house in Javaville, but they want to live as far away from each other as possible. Since Javaville is a relatively new town, there are no maps available yet; instead, information about homes and other buildings has been collected by word of mouth and provided to both Bill and Scott. This information consists of building addresses and distances between buildings. All of the information is consistent, although it may be incomplete or redundant.

The streets in Javaville are laid out in a rectangular grid of m east/west streets (named A, B, C, ...) and n north/south streets (numbered 0, 1, 2, ...), where m and n are each between 2 and 10. Every building (either a house or some other building, such as a post office or school) in Javaville is at the intersection of two streets, and no two buildings are located at the same intersection. Some intersections have no buildings at all. All distances are measured in terms of the smallest number of whole blocks that must be traversed north, south, east, and/or west to get from one intersection to another intersection. It is known that there are no more than 50 intersections in the entire town.

Here is some sample information that might be provided to Bill and Scott by various reliable sources:

- There are 5 east/west streets and 5 north/south streets.
- House1 is located at intersection A0
- The post office is located at intersection A4
- The school is at a distance of 4 blocks from house1
- House2 is at a distance of 6 blocks from the post office
- The school is at a distance of 6 blocks from the post office
- House3 is at a distance of 6 blocks from the post office

From this we can see that there are two possible maps of Javaville—see Figure 1.

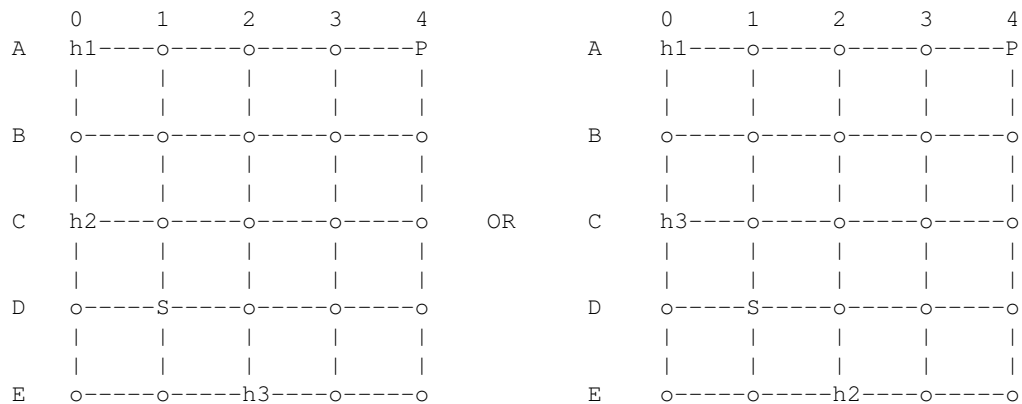


Figure 1: h1, h2, h3 = houses, P = postoffice, S = school

We see that the locations of house1, the post office, and the school are fixed, but house2 could be at either C0 or E2, and house3 could be at either C0 or E2. Clearly there is always a pair of houses separated by 6 blocks (house1 is always 6 blocks from the furthest house), but the best distance we can guarantee for any *specific*

pair of houses is 4 (since house2 is always 4 blocks away from house 3). We would report this information to Bill and Scott, telling them that, even though a separation of 6 is always achievable, the safest recommendation that we are able to make for specific houses is to have one of them purchase house2 and have the other purchase house3. (We assume that Bill and Scott will consult with one another before purchasing their houses in order to guarantee that one of our recommendations is followed.)

Bill and Scott would like you to write a program that will take location and distance information about buildings and determine two quantities, D and D' . D is the minimum, over all possible valid arrangements of buildings, of the largest house separation in each arrangement. D' is the maximum value for which there exists a pair of houses i and j that are guaranteed to be separated by a distance of at least D' . In the latter case, you should list all pairs of houses that are guaranteed to be separated by at least D' blocks.

To make sure your program is working correctly, Bill and Scott would like to be able to test it on multiple data sets, so your program will be presented with several hypothetical descriptions of Javaville.

Input

The input will consist of one or more descriptions. Each description will begin with a line containing two positive integers, m and n , representing the number of blocks in each direction ($2 \leq m, n \leq 10$). Each

description will end with a line containing the single word 'END' in uppercase. The entire data set will end with a line containing a pair of zeros. No assignment of values for m and n will result in a town having more than 50 intersections.

The remaining lines in each data set will be in one of the following two formats:

name LOCATION r c

or

name DISTANCE d *name2*

where *name* and *name2* are strings containing only digits and lowercase alphabetic characters, each of length at most 10; r is an uppercase letter between A and J; c is a digit; and d is a positive integer. If the first five characters of a *name* are the lowercase letters 'house' then it is a candidate for selection as a home for Bill or Scott; otherwise it stands for some non-residential building. In a 'DISTANCE' specification, *name2* will always be the name of some building that has occurred previously in this data set as the first *name* on one of the data lines (in other words, there are no forward references to buildings in DISTANCE constraints). Each description is consistent (i.e., there is at least one way to lay out the houses and other buildings in a way consistent with the description). Each description will include information about at least two distinct houses. At most 20 distinct building names will occur in each description, and there will be at most 21 constraints (LOCATION or DISTANCE) for each description.

Output

For each description, the output will consist of the description number, followed by the maximum achievable house separation D , followed by a list of all pairs of houses with maximum guaranteed separation D' (which might be smaller than the maximum achievable separation). No pair of houses should be listed more than

once. The output should be labeled exactly as shown in the sample output below, with a blank line separating the outputs for consecutive data sets. In each pair, houses should be ordered according to the first time they appear in the input; the list of pairs should be ordered in the same way, sorted by the first element of the pair, then by the second element.

Sample Input

```
5 5
house1 LOCATION A 0
postoffice LOCATION A 4
school DISTANCE 4 house1
house2 DISTANCE 6 postoffice
school DISTANCE 6 postoffice
house3 DISTANCE 6 postoffice
END
2 3
school LOCATION A 0
house1 DISTANCE 1 school
house2 DISTANCE 1 house1
house3 DISTANCE 1 house2
house4 DISTANCE 1 house3
house5 DISTANCE 1 house4
END
0 0
```

Sample Output

```
DESCRIPTION 1
Maximum guaranteed separation is 6 blocks.
Houses separated by at least 4 blocks:
house2 house3

DESCRIPTION 2
Maximum guaranteed separation is 3 blocks.
Houses separated by at least 2 blocks:
house1 house3
house1 house5
house2 house4
house3 house5
```

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