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159.201 Algorithms & Data Structures

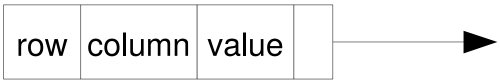
Tutorial 1

There are several areas in Physics and Engineering where computer programs have to be developed that make use of ***sparse matrices***. A sparse matrix is an extremely large two-dimensional array of integer numbers that has very few elements of interest and all the other elements are set to zero.

These matrices are sometimes too big to store in computer memory and are then represented by linked lists instead. It is common to have 1000000x1000000 matrices, however only a few thousand elements would be different than zero (usually very small floting point numbers can be rounded up to zero).

Each node in the list contains the following information:
row;
column;
matrix value at position [row, column];
pointer to next node in the list;

The node of a linked list representing sparse matrices could look like this:



Any element of the matrix where the value is zero does ***not*** have a node in the linked list.
We will assume that sparse matrices are always *square*, i.e. max rows = max columns.

Questions:

1. What is the largest 2-dimensional array of integer numbers that you can create using your usual compiler? (to be answered when you get access to a computer)

2. Discuss the conditions in which sparse matrices are better represented by linked-lists. (tip: how many bytes do you need to represent an element using arrays, and using linked-lists?)

3. Find out how to represent a matrix and how to add two matrices.

4. Check how to set up a linked list and insert elements. Consider the following questions:

- In what order should matrix values be stored in the linked list?
- Should you insert values at a particular place in the linked list?
- Or only append values to the *front* of the list?
- Or only append values to the *rear* of the list?
- Which insertion method is the easiest? Why?

5. Disregarding the order of the elements in the linked list, devise a function to search for a value at x,y. How would you use this function to add two matrices? What would be the order of the resulting matrix? Discuss the performance of this approach.