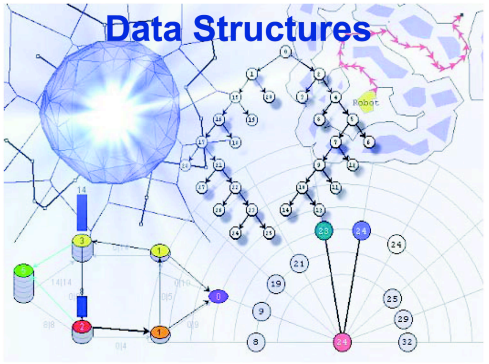
# BBM 201
# DATA STRUCTURES

**Lecture 12:**

Sparse matrix represention using circular linked lists




**2016-2017 Fall**

# Sparse Matrix Revisited

# Sparse Matrix

- Most of the elements are zero.
- It wastes space.

**Sparsity:** the fraction of zero elements.

Basic matrix operations:

1. Creation
2. Addition
3. Multiplication
4. Transpose

| A | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| 0 | 15 | 0 | 0 | 22 | 0 | -15 |
| 1 | 0 | 11 | 3 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | -6 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 91 | 0 | 0 | 0 | 0 | 0 |
| 5 | 0 | 0 | 28 | 0 | 0 | 0 |

# Sparse Matrix
## Data Structure

```
#define MAX_TERMS 101
typedef struct{
            int col;
            int row;
            int value;
           }term;
term a[MAX_TERMS];
```

- a[0].row: row index
- a[0].col: column index
- a[0].value: number of items in the sparse matrix

- Rows and columns are in ascending order!

# Sparse Matrix

| A | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| 0 | 15 | 0 | 0 | 22 | 0 | -15 |
| 1 | 0 | 11 | 3 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | -6 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 91 | 0 | 0 | 0 | 0 | 0 |
| 5 | 0 | 0 | 28 | 0 | 0 | 0 |

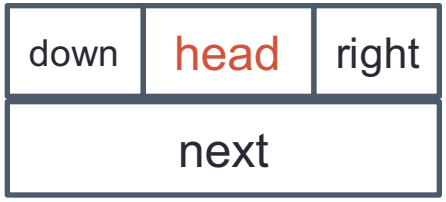
| | Row | Column | Value |
|---|---|---|---|
| A[0] | 6 | 6 | 8 |
| A[1] | 0 | 0 | 15 |
| A[2] | 0 | 3 | 22 |
| A[3] | 0 | 5 | -15 |
| A[4] | 1 | 1 | 11 |
| A[5] | 1 | 2 | 3 |
| ... | | | |
| A[8] | 5 | 2 | 28 |

# Circular singly linked list representation

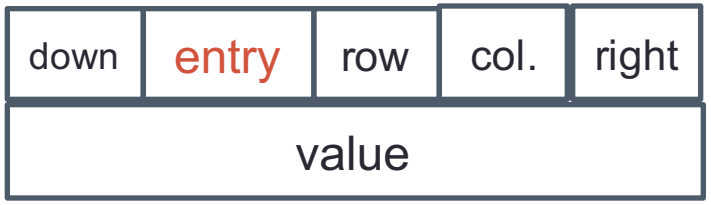
- To represent sparse matrix in circular singly linked list, we need:
  - For each column a circular linked list with a head node
  - For each row a circular linked list with a head node
  - Each node has a tag field to distinguish between head and entry nodes
  - Each head node has three fields, down, right, and next
    - Down to link into column list
    - Right to link into row list
    - Next links head nodes

- The head node for $row_i$ is also head node for $column_i$
- Total number of head nodes is

  max { number of rows, number of columns}




a) Head node




a) Entry node

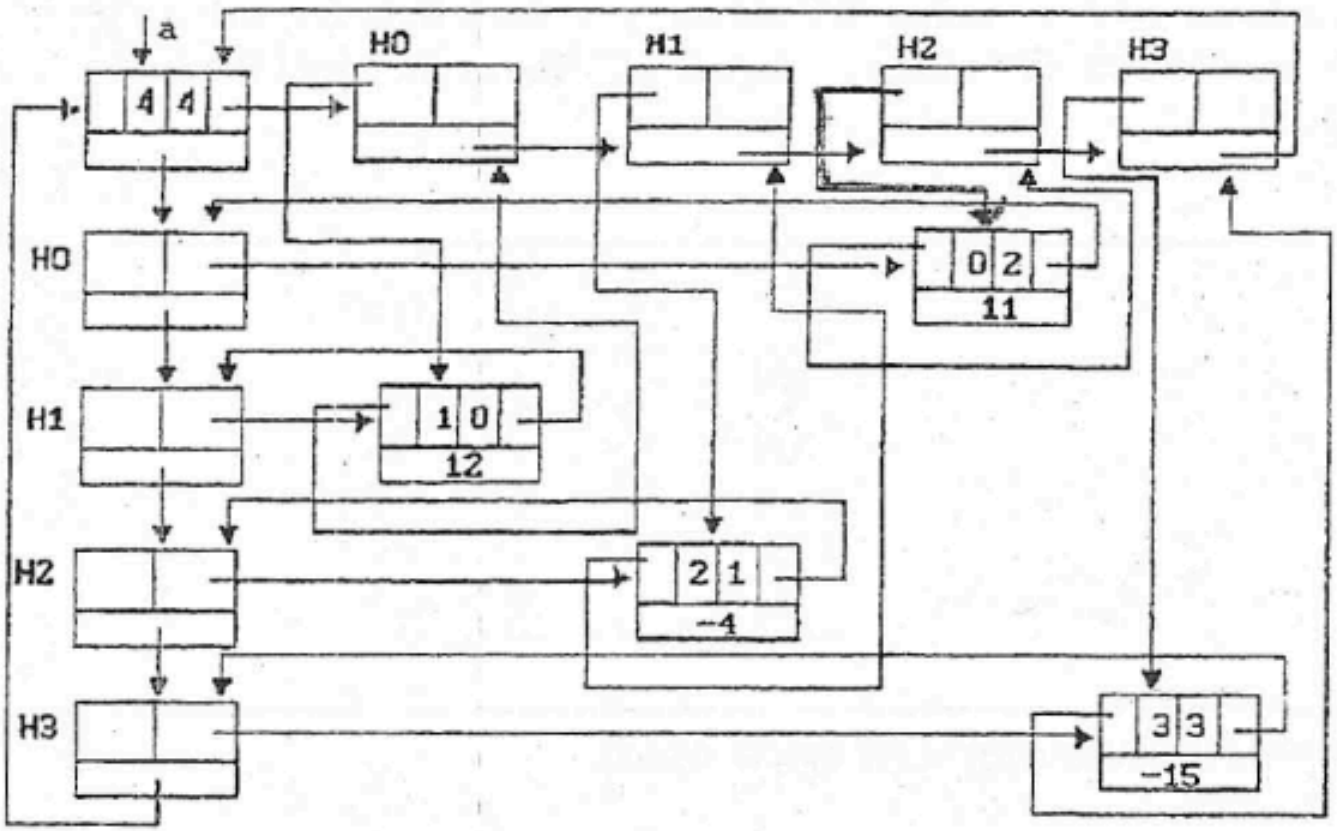

a) Set up for $a_{ij}$

- Each head node is in three lists:
  - A list of rows,
  - A list of columns,
  - A list of head nodes
- The list of head nodes also has a head node which is in entry node structure and the row and column fields of this node is used to store matrix dimensions

- Example: Given below a 4x4 sparse matrix

| | | | |
|---|---|---|---|
| 0 | 0 | 11 | 0 |
| 12 | 0 | 0 | 0 |
| 0 | -4 | 0 | 0 |
| 0 | 0 | 0 | -15 |

```
#define MAX_SIZE 50 /* size of largest matrix */

typedef enum {head, entry} tagfield;

typedef struct matrix_node * matrix_pointer;

typedef struct entry_node{
     int col;
     int row;
     int value;
};

typedef struct matrix_node{
     matrix_pointer down;
     matrix_pointer right;
     tagfield tag;
     union {
          matrix_pointer next;
          entry_node entry;
     }u;
};

matrix_pointer hdnode[MAX_SIZE];
```




NOTE: The tag field of a node is not shown; its value for each node should be clear from the node structure.

# Initializations

```
#include <stdio.h>
#include <stdlib.h>

#define MAX_SIZE 50 /* size of the largest matrix */
typedef enum {head, entry} tagfield;
typedef struct matrix_node * matrix_pointer;

typedef struct entry_node{
     int col;
     int row;
     int value;
};

typedef struct matrix_node{
     matrix_pointer down;
     matrix_pointer right;
     tagfield tag;
     union {
          matrix_pointer next;
          entry_node entry;
     }u;
};
matrix_pointer hdnode[MAX_SIZE];
```

```
void main()

{
    matrix_pointer  mread(void);
    void mwrite(matrix_pointer);
    matrix_pointer   p;

    p = mread();
    mwrite(p);
}
```

# Reading a sparse matrix

```
matrix_pointer  mread(void)
{
   int num_rows, num_cols, num_terms, num_heads, i;
   int row, col, value, current_row;
   matrix_pointer  temp, last, node;

   printf("Enter  the number of rows, columns and number of nonzero terms:");
   scanf("%d%d%d", &num_rows, &num_cols, &num_terms);
   num_heads=(num_cols>num_rows)?  num_cols  : num_rows;
   node  = new_node();
   node->tag=entry;

   node->u.entry.row=num_rows;
   node->u.entry.col=num_cols;

   if(!num_heads)  node->right  = node;
   else{   //initialize  the head nodes
       for(i=0;i<num_heads;  i++){
          temp=new_node();
          hdnode[i]=temp;   hdnode[i]->tag=head;
          hdnode[i]->right=temp;   hdnode[i]->u.next=temp;
       }
```

```
current_row=0;
last = hdnode[0];
for(i=0; i<num_terms; i++) {
   printf("Enter row, column and values:");
   scanf("%d%d%d", &row,&col,&value);
   if(row>current_row){
      last->right=hdnode(current_row);
      current_row=row; last=hdnode[row];
   }
   temp=new_node();
   temp->tag=entry;  temp->u.entry.row=row;
   temp->u.entry.col=col;
   temp->u.entry.value=value;
   last->right=temp; //link into row list
   last=temp;
   hdnode[col]->u.next->down=temp;
   hdnode[col]->u.next=temp;
}
   last->right=hdnode[current_row];
   //close all column lists
   for(i=0; i<num_cols; i++)
        hdnode[i]->u.next->down=hdnode[i];
```

```
                //link all head nodes together
                for(i=0; i<num_heads-1; i++)
                     hdnode[i]->u.next=hdnode[i+1];
                hdnode[num_heads-1]->u.next=node;
                node->right=hdnode[0];
           }
      return node;
}
```

# Write out a sparse matrix

```
void mwrite(matrix_pointer  node){

        int i;
        matrix_pointer  temp,  head=node->right;
        printf("\n  num_rows=%d,  num_cols=%d  \n", node->u.entry.row,  node-
>u.entry.col);
        printf("The  matrix  by  row,  columnn  and  value:  \n\n");

        for(i=0;  i<node->u.entry.row;  i++){
            for(temp=head->right;  temp!=head;  temp=temp->right)
                printf("%5d%5d%5d\n",  temp->u.entry.row,  temp->u.entry.col,
temp->u.entry.value);
            head=head->u.next;
        }
}
```

# Erase a sparse matrix

```
void merase(matrix_pointer  *node)
{
   matrix_pointer  x,y,head=(*node)->right;
   int i, num_heads;

   for(i=0;  i<(*node)->u.entry.row;  i++){
      y=head->right;
      while(y!=head){
          x=y;
          y=y->right;  free(x);
      }
      x=head;  head=head->u.next;   free(x);
   }

   y=head;
   while(y!=*node){
          x=y;
          y=y->u.next;
          free(x)
   }
   free(*node);   *node=NULL;
}
```

# Multilist Structure

A file structure is given as follows:

| Node | ID Number | Name | Occupation | Location |
|---|---|---|---|---|
| A | 30 | Hawkins | Programmer | Minneapolis |
| B | 25 | Smith | Analyst | New York |
| C | 60 | Jones | Programmer | New York |
| D | 55 | Austin | DataEntry | Minneapolis |
| E | 80 | Messer | Analyst | Minneapolis |

What kind of a data structure can be used?

A possible data structure to be used: