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# Programming Design In-class Practices

## Pointers

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# Problem 1: See memory allocation

- Consider the following program:
- Modify this program to see (at least on your computer):
  - How many bytes of memory space are consumed?
  - Where are the allocated memory spaces?

```
#include<iostream>
using namespace std;

int main()
{
    int anInteger = 0;
    for(int i = 0; i < 10; i++)
        int anotherInteger = 0;
    return 0;
}
```

# Problem 2: Modify a variable

- Consider the following program:
- Modify this program to:
  - Have a pointer pointing to **a**.
  - Let the user modify the value of **a** through the pointer.

```
#include<iostream>
using namespace std;

int main()
{
    int a = 0;
    cin >> a;
    cout << a << "\n";

    return 0;
}
```

# Problem 3: Pass pointers into a function

- Correct the following two programs to find the maximum of **a** and **b**:

```
#include<iostream>
using namespace std;

int* maxPtr(int* a, int* b)
{
    return *a > *b ? a : b;
}

int main()
{
    int a = 0, b = 0;
    cin >> a >> b;
    cout << &maxPtr(*a, *b) << "\n";
    return 0;
}
```

```
#include<iostream>
using namespace std;

int* maxPtr(int* a, int* b)
{
    return *a > *b ? &a : &b;
}

int main()
{
    int a = 0, b = 0;
    cin >> a >> b;
    cout << maxPtr(&a, &b) << "\n";
    return 0;
}
```

# Problem 4: Find an error, if any

- Find an error in the following program or conclude that there is none.
  - The program should print out the maximum of two input values.
  - maxAddr** should return the address of the maximum value.
  - Including potential run-time error and bad implementation.

```
#include<iostream>
using namespace std;

int* max(int a, int b)
{
    int c = a;
    if (b > a)
        c = b;
    return &c;
}
```

```
int main()
{
    int a = 0, b = 0;
    cin >> a >> b;
    int* maxAddr = max(a, b);
    cout << *maxAddr << "\n";

    // many other things

    return 0;
}
```

# Problem 5: Find an error, if any (2)

- Find an error in the following program or conclude that there is none.
  - The program should print out the maximum of two input values.
  - maxAddr** should return the address of the maximum value.
  - Including potential run-time error and bad implementation.

```
#include<iostream>
using namespace std;

int* max(int a, int b)
{
    int* cPtr = new int(a);
    if(b > a)
        *cPtr = b;
    return cPtr;
}
```

```
int main()
{
    int a = 0, b = 0;
    cin >> a >> b;
    int* maxAddr = max(a, b);
    cout << *maxAddr << "\n";

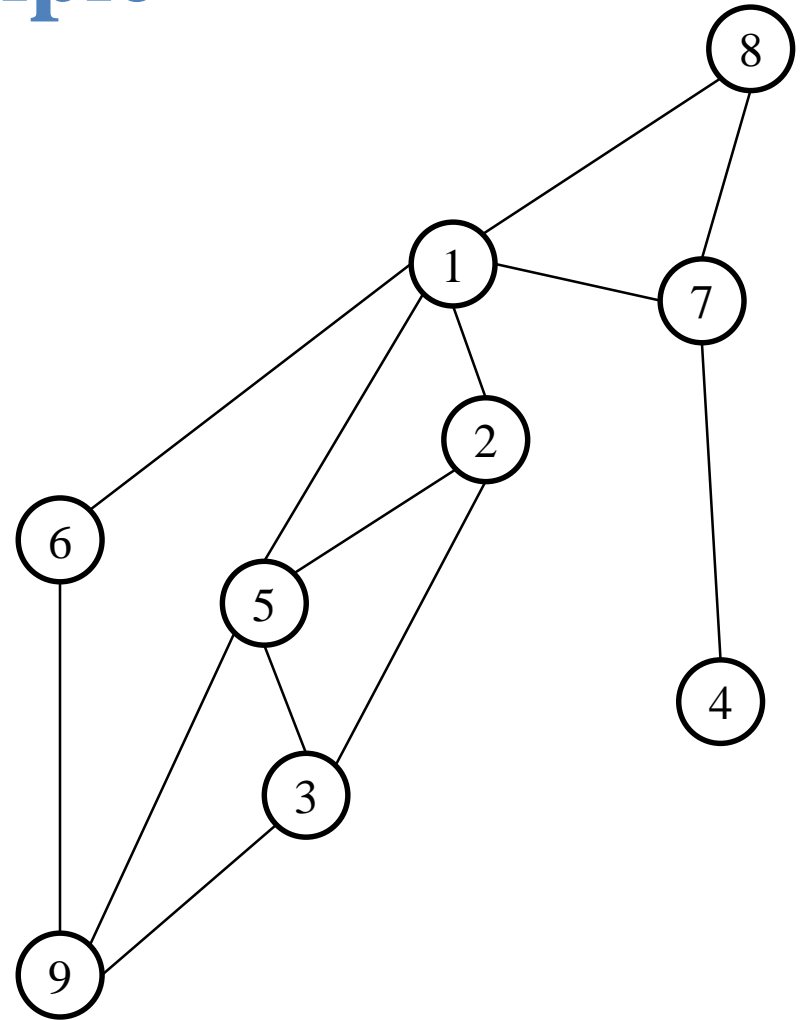
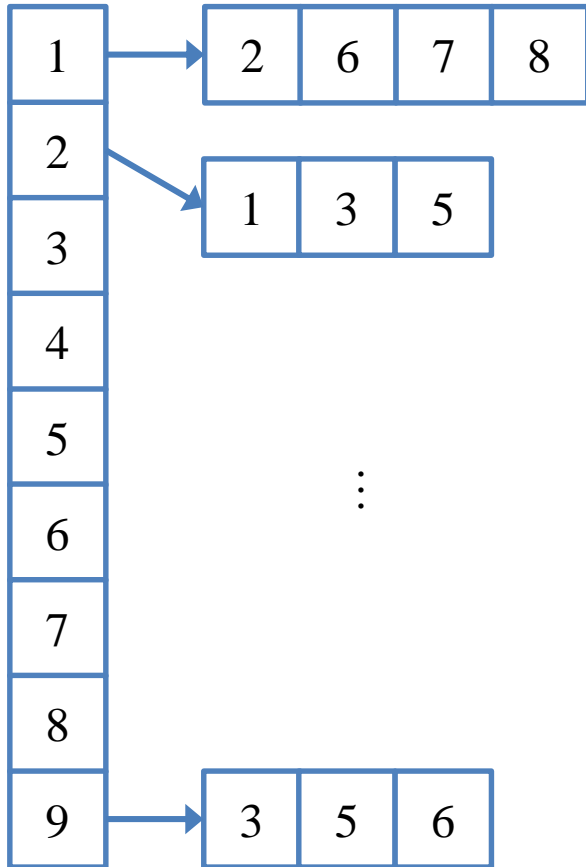
    // many other things

    return 0;
}
```

# Adjacency list

- An **adjacency list** of a graph may be constructed as follows.
  - Given the number of nodes  $n$ , create a **static array** nodes of length  $n$ .
  - Each array element is an integer pointer pointing to a **dynamic array** whose length is the node degree.
  - In a node's dynamic array, each element is the index of one of its neighbor.

# Adjacency list: an example





# Adjacency list: implementation

```
#include<iostream>
using namespace std;

const int NODE_CNT_MAX = 100;

int inputGraphInfo(int* neighbors[], int degrees[]);
void printGraph(int* neighbors[], const int degrees[], int nodeCnt);
void releaseMemory(int* neighbors[], int nodeCnt);

int main()
{
    int* neighbors[NODE_CNT_MAX] = {0};
    int degrees[NODE_CNT_MAX] = {0};
    int nodeCnt = inputGraphInfo(neighbors, degrees);
    printGraph(neighbors, degrees, nodeCnt);
    releaseMemory(neighbors, nodeCnt);

    return 0;
}
```

# Adjacency list: implementation

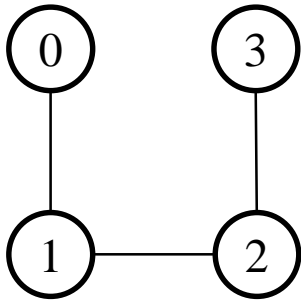
```
int inputGraphInfo(int* neighbors[],
                  int degrees[])
{
    int nodeCnt = 0;
    cin >> nodeCnt;
    for(int i = 0; i < nodeCnt; i++)
    {
        // cout << "Node " << i
        //      << "\'s degree is: ";
        cin >> degrees[i];
        neighbors[i] = new int[degrees[i]];
        // cout << "Node " << i
        //      << "\'s neighbors: ";
        for(int j = 0; j < degrees[i]; j++)
            cin >> neighbors[i][j];
    }
    return nodeCnt;
}
```

```
void printGraph(int* neighbors[],
               const int degrees[],
               int nodeCnt)
{
    for(int i = 0; i < nodeCnt; i++)
    {
        // cout << "Node " << i << ": ";
        for(int j = 0; j < degrees[i]; j++)
            cout << neighbors[i][j] << " ";
        cout << "\n";
    }
}

void releaseMemory(int* neighbors[],
                  int nodeCnt)
{
    for(int i = 0; i < nodeCnt; i++)
        delete [] neighbors[i];
}
```

# Problem 6: adjacency list to matrix

- Try it:



Input:

```
4
1 1
2 0 2
2 1 3
1 2
```

Output:

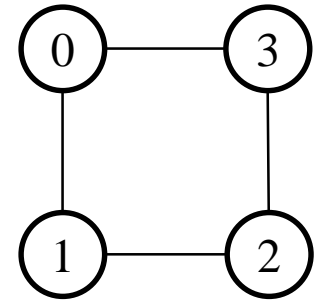
```
1
0 2
1 3
2
```

Input:

```
4
2 1 3
2 0 2
2 1 3
2 0 2
```

Output:

```
1 3
0 2
1 3
0 2
```

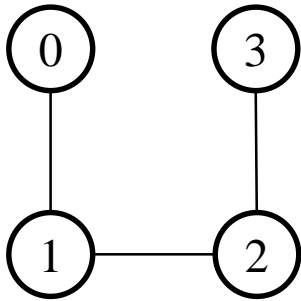


# Problem 6: adjacency list to matrix

- Rewrite the function **printGraph** to print out the graph information in an adjacency matrix.
- All nodes are labeled as  $0, 1, 2, \dots, n - 1$ , where  $n$  is the number of nodes.
- Input:
  - Line 1 contains an integer  $n$  as the number of nodes.
  - Line  $i + 2$  contains an integer  $d_i$ , the degree of node  $i$ , and then  $d_i$  integers as the indices of node  $i$ 's neighbors. Two consecutive values are separated by a white space.
- Output:
  - $n$  lines in total. Line  $i$  contains  $b_{i,1}, b_{i,2}, \dots$ , and  $b_{i,n}$ , where  $b_{ij} = 1$  if nodes  $i$  and  $j$  are neighbors and 0 otherwise.
  - Separate two consecutive values by one white space.
  - There is no white space after the last value.

# Problem 6: adjacency list to matrix

- Examples:



Input:

```
4
1 1
2 0 2
2 1 3
1 2
```

Output:

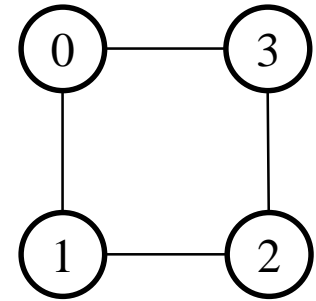
```
0 1 0 0
1 0 1 0
0 1 0 1
0 0 1 0
```

Input:

```
4
2 1 3
2 0 2
2 1 3
2 0 2
```

Output:

```
0 1 0 1
1 0 1 0
0 1 0 1
1 0 1 0
```



# Problem 7: dynamic adjacency list

- Rewrite the previous program to allow the number of nodes to change.
  - Hint: Modify `int* neighbors[NODE_CNT]` to `int** neighbors`.