



## Module4—Graph

1. กราฟคืออะไร ทำไมต้องใช้โครงสร้างข้อมูลแบบกราฟ
2. นิยามของกราฟ digraph, undigraph, vertice, edge, adjacent, incident, degree, path
3. การเก็บกราฟด้วย adjacency list
4. การท่องกราฟด้วย BFS

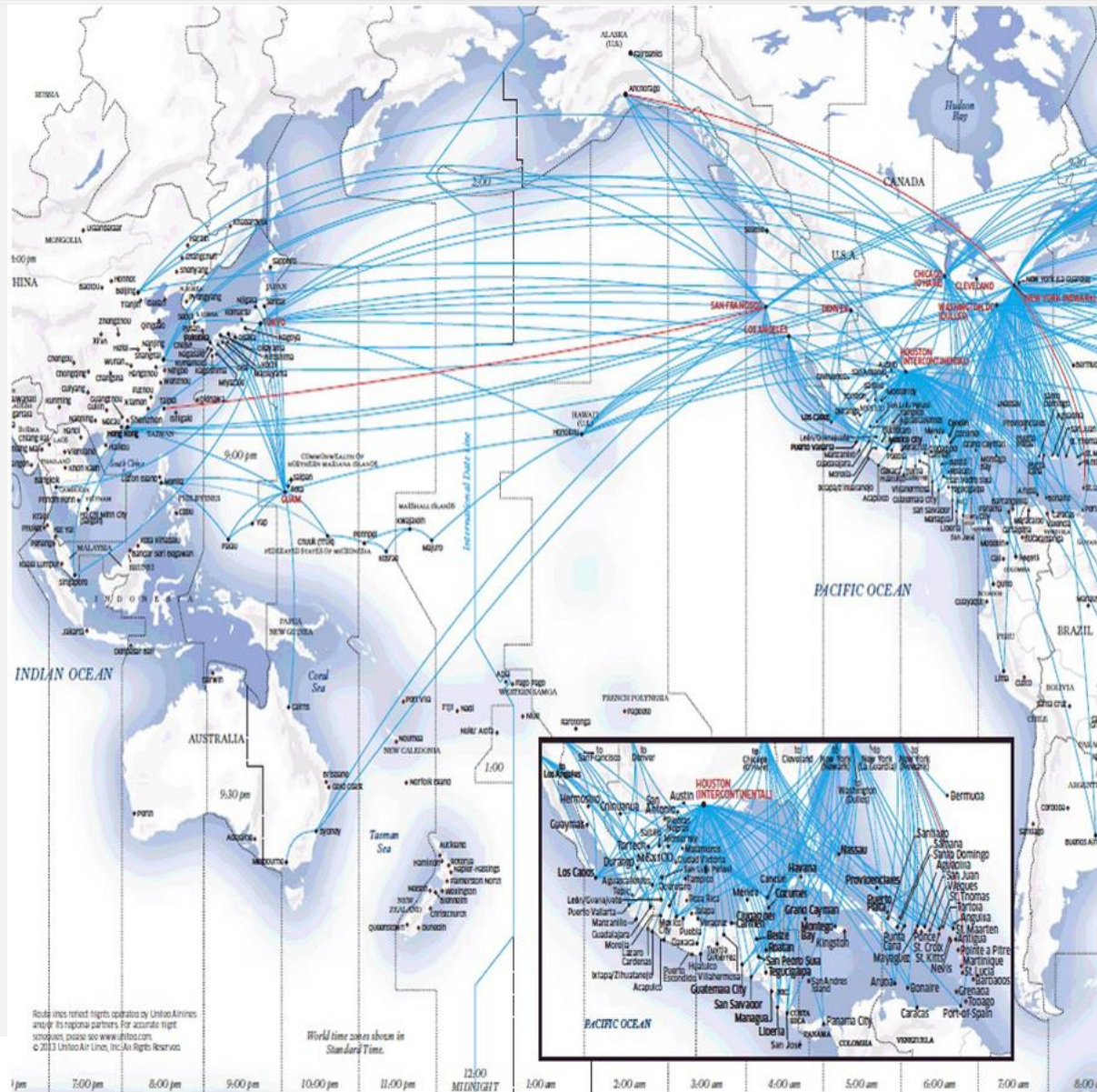


### เก็บข้อมูล

- มีทิศทาง
- มีระยะทาง

### ตัวอย่างงาน

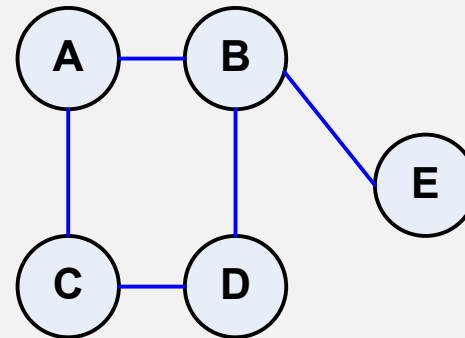
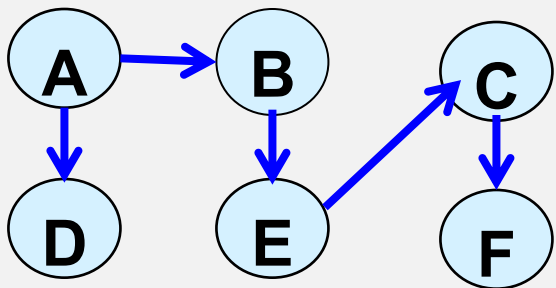
- การวางข่ายงานคอมพิวเตอร์
- การวิเคราะห์เส้นทางวิกฤติ
- ปัญหาเส้นทางที่สั้นที่สุด





## 4.1 Definition

1. directed graph(digraph)
2. Undirected graph(Undigraph)



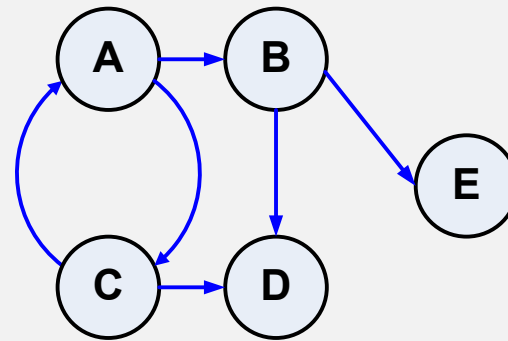


## 4.1 Definition

1) A directed graph(or digraph)  $G$  : is a pair  $(V, E)$ , where  $V$  is a finite set and  $E$  is binary relation on  $V$ .

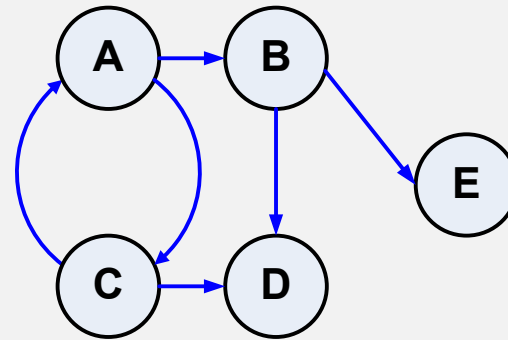
- The **set  $V$**  is called the **vertex set** of  $G$ , and its elements are called vertices.

$$V = \{A, B, C, D, E\}$$





- The **set  $E$**  is called the **edge set** of  $G$ , and its elements are called edges.



The edge set  $E$  consists of ordered pairs of vertices

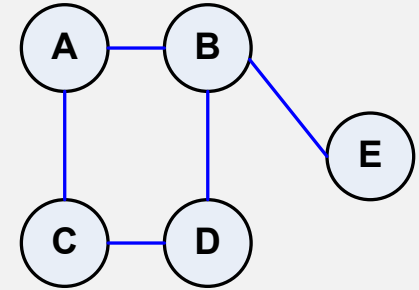
$$V = \{A, B, C, D, E\}$$

$$E = \{ (A, B), (A, C), (B, D), (B, E), (C, A), (C, D) \}$$



## 2) An undirected graph G :

$G = (V, E)$  , the edge set E consists of unordered pairs of vertices, rather than ordered pairs.



$V = \{A, B, C, D, E\}$

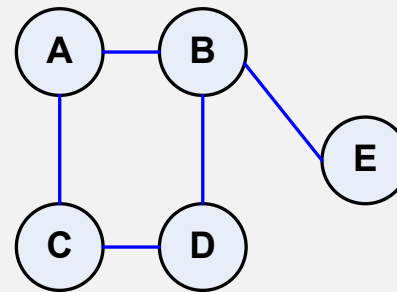
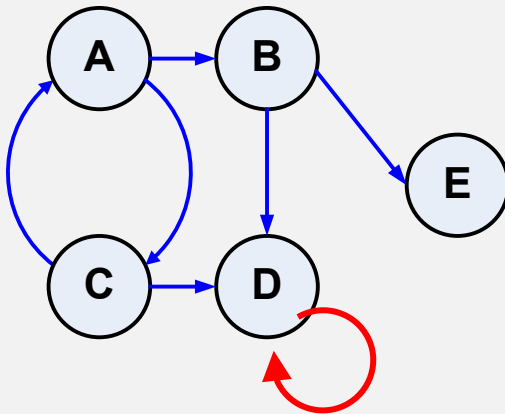
$E = \{ (A, B), (B, A), (A, C), (C, A), (B, D), (D, B), (B, E), (E, B), (C, D), (D, C) \}$



**3) self-loops** : edges from a vertex to itself.

**Undigraph self loop are forbidden**, and so every edge consists of exactly two distinct vertices.

**Cycle** : a cycle in a graph is a non-empty trail in which only the first and last vertices are equal





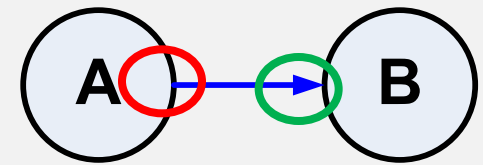


## 4) Incident :

**digraph** : if  $(u,v)$  is an edge in a directed graph  $G=(V,E)$ , we say that  $(u,v)$  is

**incident from** or leaves vertex  $u$

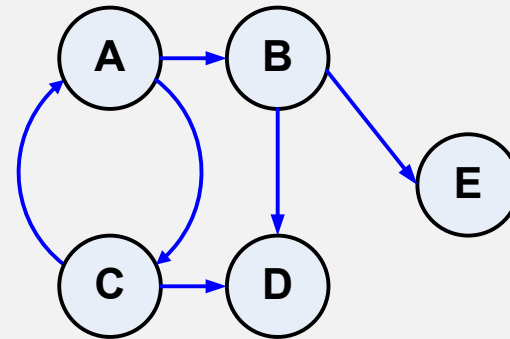
**incident to** or enters vertex  $v$ .



**Question** edge  $(B,E)$

Incident from .....

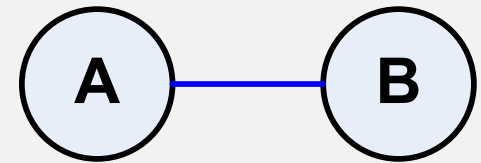
Incident to .....





**undigraph** : if  $(u,v)$  is an edge in a directed graph  $G=(V,E)$ , we say that  $(u,v)$  is **incident on** vertices  $u$  and  $v$

is **incident on** vertices  $u$  and  $v$



**Question** edge  $(A,B)$

Incident from .....

Incident to .....

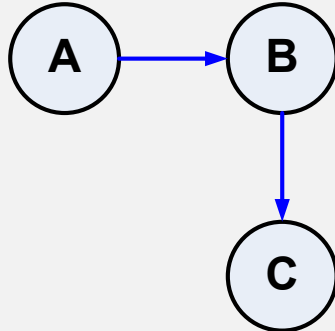
Edge  $(A,B)$  is incident on vertices  $A$  and  $B$



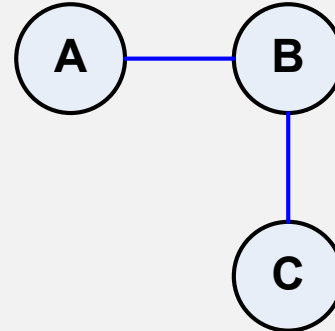
## 5) adjacent

**Digraph** : If  $(u,v)$  is an edge in a graph  $G=(V,E)$ , we say that  $v$  is adjacent to vertex  $u$ . If  $v$  is adjacent to  $u$  denote by  $u \rightarrow v$

**Undigraph** : Adjacent relation is symmetric.



B ประชิด A     $A \rightarrow B$



B ประชิด A และ A ประชิด B



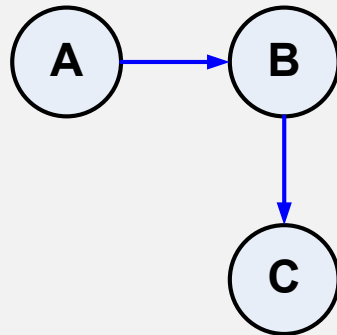
## 6) Degree

**Digraph** : in degree

(number of edges entering it.),

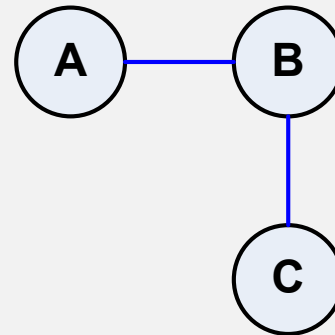
out degree

(Opposite in degree.)



A in degree = 0  
A out degree = 1

**Undigraph** : is the number of edges incident on it.



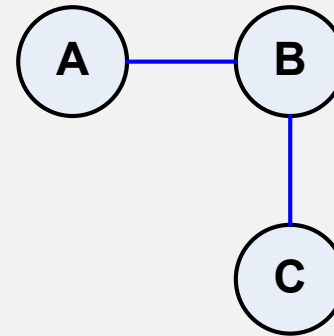
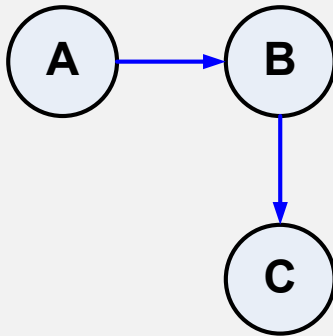
A degree = 1

B degree = 2

C degree = 1



**7) path of length** : Path  $k$  from a vertex  $u$  to a vertex  $u'$  in a graph  $G=(V,E)$  is a sequence  $(v_0, v_1, \dots, v_k)$  of vertices such that  $u = v_0$ ,  $u' = v_k$ , and  $(v_{i-1}, v_i) \in E$  for  $i = 1, 2, \dots, k$





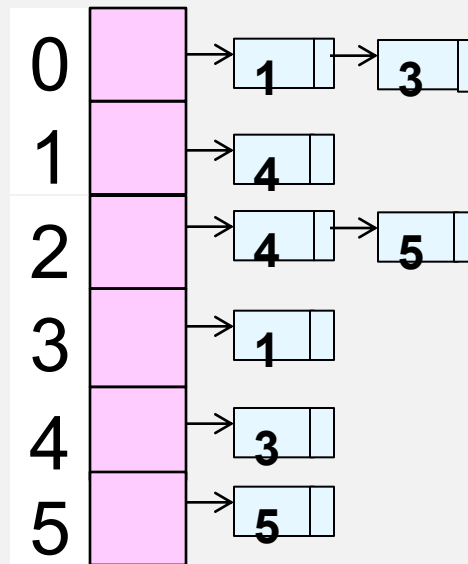
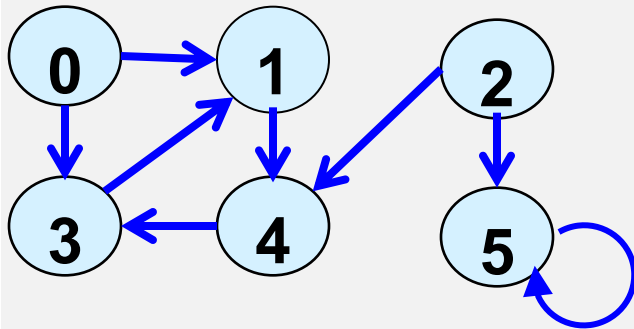
## 4.2 โครงสร้างข้อมูลที่ใช้เก็บข้อมูลในรูปแบบกราฟคือ

1. Adjacency list
2. Adjacency Matrix

โครงสร้างข้อมูลทั้ง 2 แบบนี้จะสามารถเก็บกราฟได้ทั้ง digraph และ undigraph



## Digraph

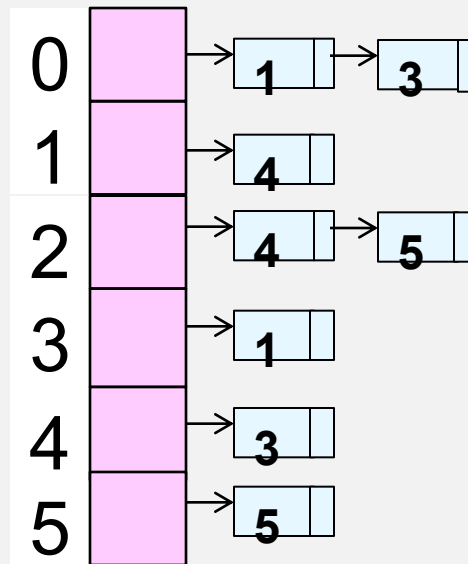
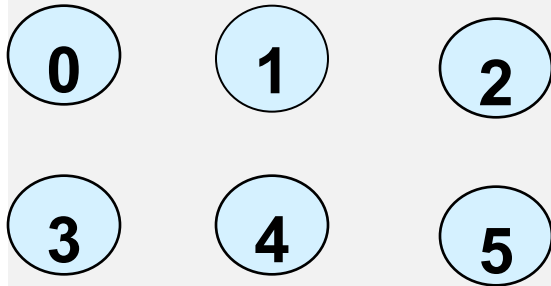


|   | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| 2 | 0 | 0 | 0 | 0 | 1 | 1 |
| 3 | 0 | 1 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 1 | 0 | 0 |
| 5 | 0 | 0 | 0 | 0 | 0 | 1 |

1. Adjacency list
2. Adjacency matrix



## Digraph

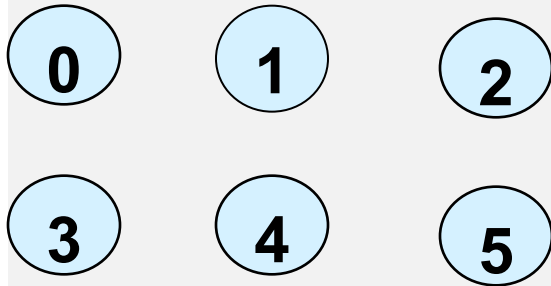


1. Adjacency list
2. Adjacency matix





## Digraph

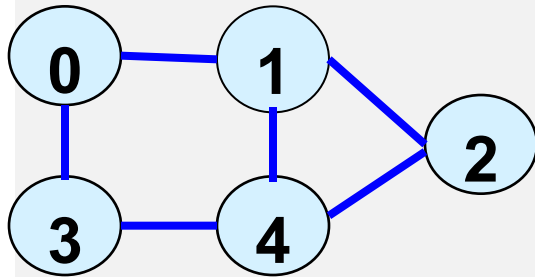


|   | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| 2 | 0 | 0 | 0 | 0 | 1 | 1 |
| 3 | 0 | 1 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 1 | 0 | 0 |
| 5 | 0 | 0 | 0 | 0 | 0 | 1 |

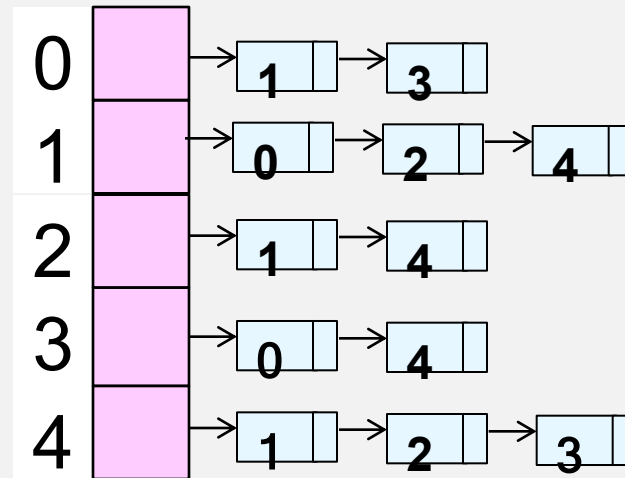
1. Adjacency list
2. Adjacency matix

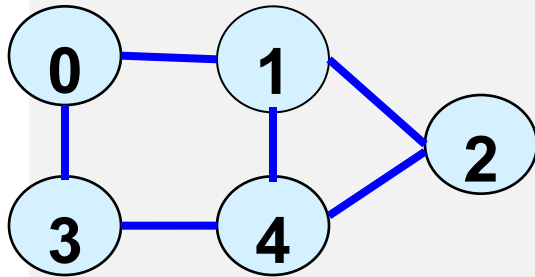


## Undigraph



## Adjacency list



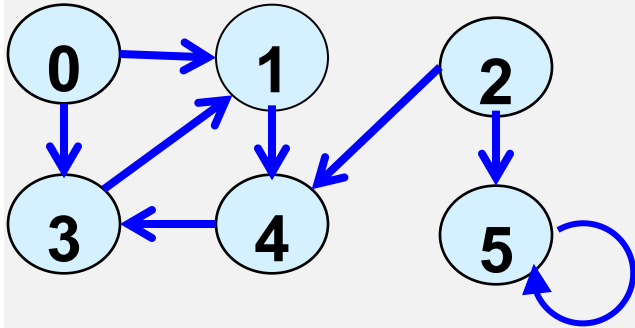


## Adjacency Matrix

|   | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| 0 | 0 | 1 | 0 | 1 | 0 |
| 1 | 1 | 0 | 1 | 0 | 1 |
| 2 | 0 | 1 | 0 | 0 | 1 |
| 3 | 1 | 0 | 0 | 0 | 1 |
| 4 | 0 | 1 | 1 | 1 | 0 |



## การบ้าน ข้อ 1



Enter

#0 : 1 3 -1

#1 : 4 -1

...

