CS1020 Data Structures and Algorithms I
Lecture Note #17

Mix-and-Match

Data Structures with
Multiple Organisation

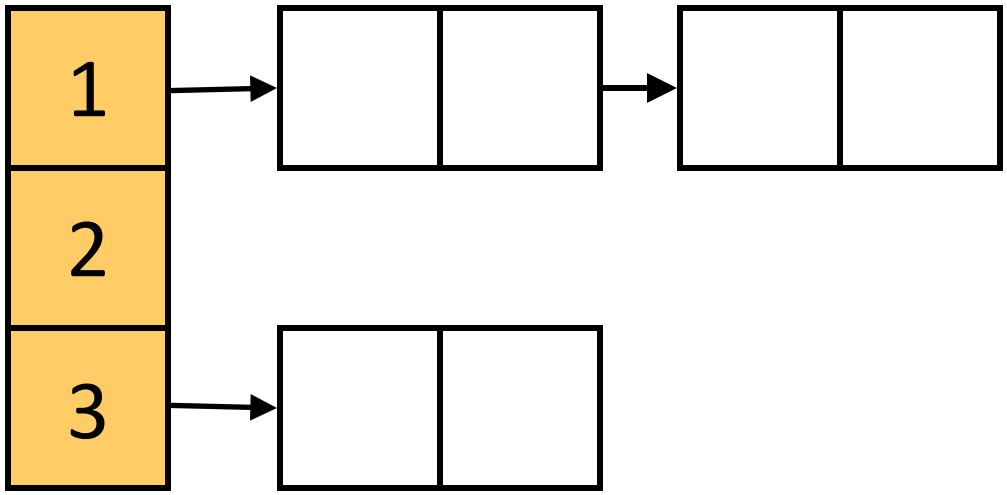
Basic Data Structures

- Arrays
- Linked Lists
- Trees (to be covered in CS2010)

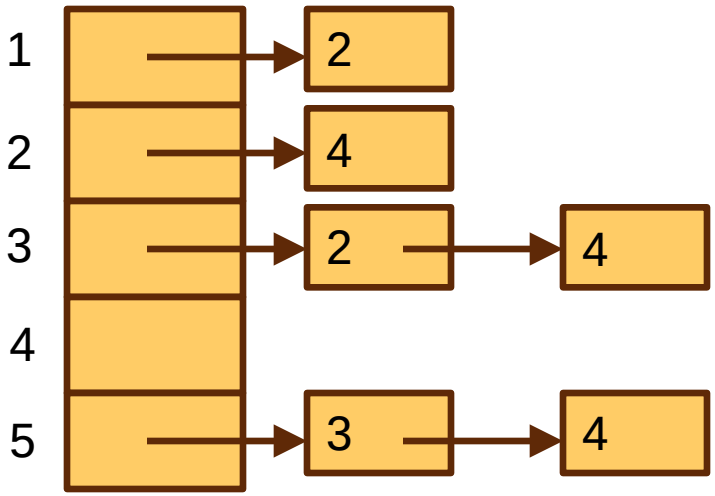
We can combine them to implement different data structures for different applications.

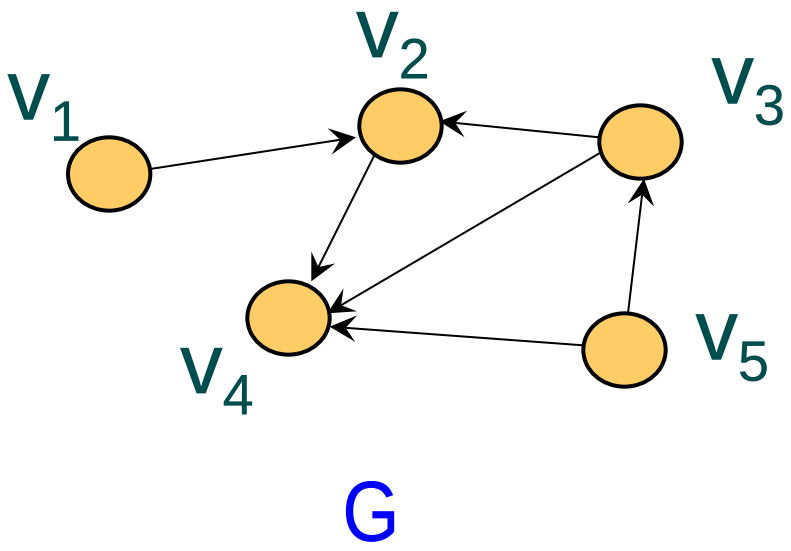
Mix-and-Match

- Array of Linked Lists
  - E.g.: Adjacent list for representing graph
  - E.g.: Hash table with separate chaining



Adjacency List for Directed Graph





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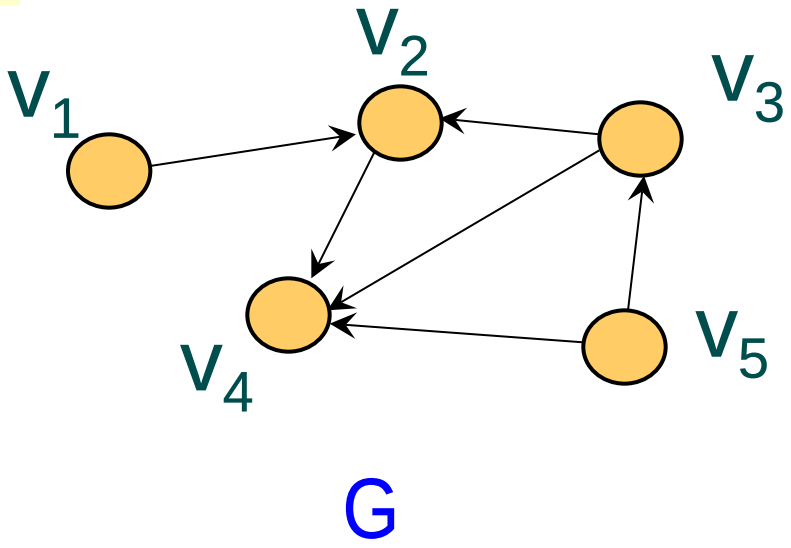
Adjacency Matrix for Directed Graph

Matrix[i][j] = 1 if $(v_i, v_j) \in E$
0 if $(v_i, v_j) \notin E$

		1 (v_1)	2 (v_2)	3 (v_3)	4 (v_4)	5 (v_5)
1	v_1	0	1	0	0	0
2	v_2	0	0	0	1	0
3	v_3	0	1	0	1	0
4	v_4	0	0	0	0	0
5	v_5	0	0	1	1	0



CS1102 AY2003

17. (16 points) Let n_i be the number of vertices adjacent to a vertex i. Suppose we want to support the following four operations on a directed graph:

- insert(i, j), which adds an edge (i, j) into the graph;
- delete(i, j), which removes the edge (i, j) from the graph;
- exists(i, j), which checks if edge (i, j) exists in the graph; and
- neighbours(i), which returns the list of vertices adjacent to i.

Describe a data structure that supports insert(i, j), delete(i, j) and exists(i, j) in $O(1)$ time, and neighbours(i) in $O(n_i)$ time. You may use diagrams to illustrate your data structure. You may simply quote data structures taught in this class without going into details.

CS1102 AY2003: Use Adjacency Matrix

Operation	Big-O
insert(i, j)	O(1)
delete(i, j)	O(1)
exists(i, j)	O(1)
neighbours(i)	O(n)

	1	2	3	4
1		T		
2	T		T	
3		T		
4	T			

CS1102 AY2003: Use Adjacency List

Operation	Big-O
insert(i, j)	O(1)
delete(i, j)	O(n)
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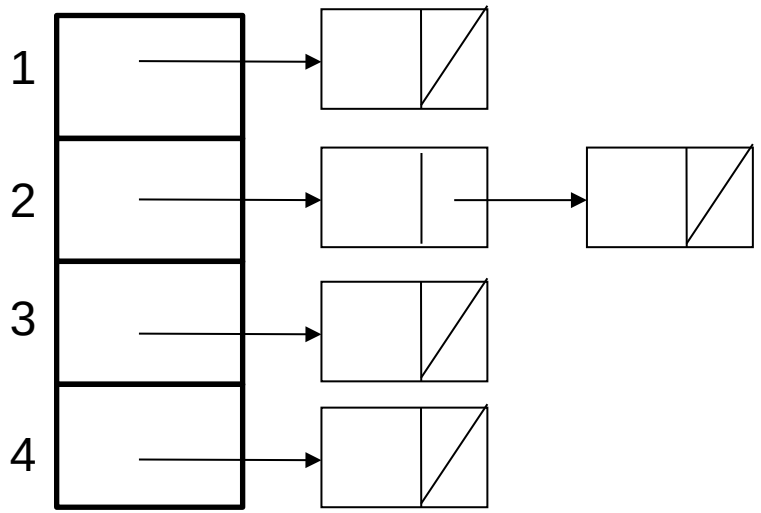
neighbours(i)	$O(n_i)$



Problem

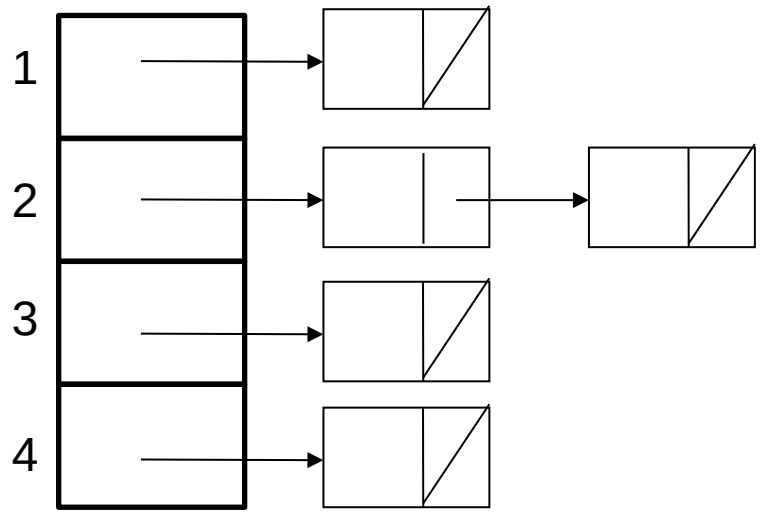
- Searching on an unsorted linked list is O(n)
- How to improve it to O(1)?

Use hashing.

(i, j) as key and the hash value returned by hash function to be index to a hash table where (i, j) is stored together with the reference to the node in the linked list.

Use Adjacency List

Operation	Big-O
insert(i, j)	O(1)
delete(i, j)	O(n)
exists(i, j)	O(1)
neighbours(i)	$O(n_i)$



Is delete (i, j) O(1)?

CS1102 AY2003

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Build an adjacency list of the graph, where the lists are doubly linked.

Build a hash table with (i, j) as key, and a reference to the node representing (i, j) in the adjacency list as value.

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