Lecture 2: Data structures (continued).

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Pointers Refresher

Pointers = variables that store memory addresses.

- **Definition:** A pointer holds the address of another variable.
- **Declaration:** `int *p;` means p can point to an `int`.
- **Operators:**
  - &x – address of variable x.
  - *p – dereference: value stored at address p.
- **Common uses:**
  - Dynamic memory allocation (new, `malloc`).
  - Building linked structures (lists, trees, graphs).
  - Efficient function parameter passing.

More: Nick Parlante – Pointers and Memory (YouTube)

Non-Contiguous Data Storage

Idea: Elements are stored at *separate* memory locations; links/pointers record relationships instead of physical adjacency.

- **Examples:** singly/doubly linked lists
- **Allocation:** each node allocated independently, can grow/shrink without moving others.
- **Navigation:** follow pointers (next, child, neighbor) to reach data.
- **Pros:**
  - Flexible size; insert/delete near a known position can be $\mathcal{O}(1)$.
- **Cons:**
  - Extra pointer overhead per element.
  - Random access is $\mathcal{O}(n)$ (no indexing by position).

Linked List (Single)

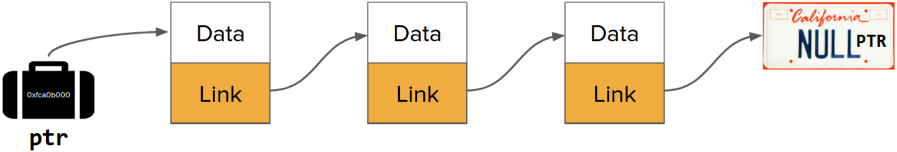

Image credit: Nick Parlante

Doubly Linked List

- A linear collection of nodes where each node stores:
  - **key/data**
  - **prev** pointer to the previous node
  - **next** pointer to the next node
- Supports efficient insertion/deletion given a node pointer.

Doubly Linked List

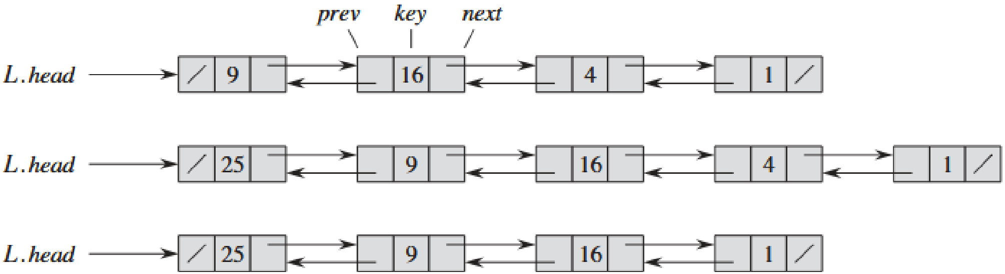

Figure: Example: insert key 25; then delete key 4.

Core Operations and Costs

Operation	Time (worst case)
Insert after/before a given node	$O(1)$
Delete a given node (with pointer)	$O(1)$
Search by key (unsorted)	$O(n)$
Access by index	$O(n)$

C++ `std::list` (Doubly Linked List)

Tutorial: W3Schools — C++ List tutorial

std::list::splice() — move nodes in O(1)

- Transfers nodes between lists (or within one list) by relinking pointers — **no copies/moves of elements**.

Tutorial: GeeksforGeeks — `list::splice` tutorial

More on Linked Lists

Resource: Linked Lists. W3Schools – Linked Lists (DSA Theory)