CS 521: Systems Programming

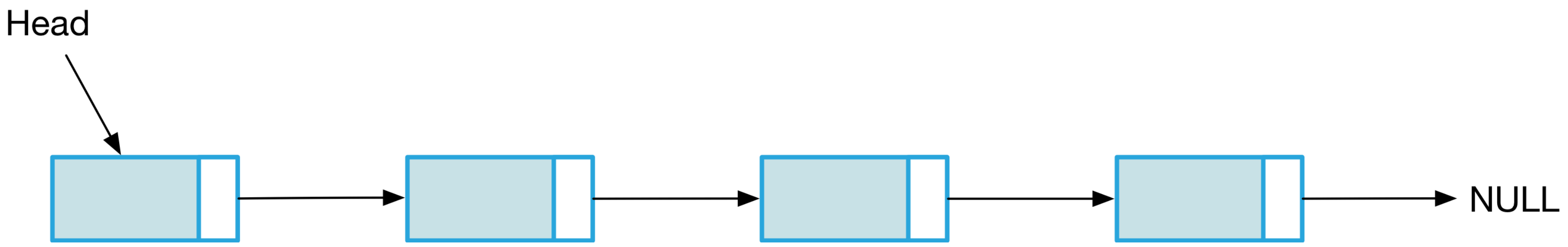
Data Structures: Linked Lists

Lecture 13

Linked Lists

- We probably all know linked lists already, and they tend to be one of those things programmers implement early on in their careers!
- Linked lists work particularly well in C
  - We can incrementally allocate memory for the list items
  - Inserting new items is trivial

A Basic Linked List



Programming Break

- Let's build a simple linked list in class, in teams of up to 3 students.
- We'll regroup to see how folks approached this

Implementation [1/2]

```
struct list_node {
    int data;
    struct list_node *next;
};
```

- We'll start with a pointer to the head of the list
- Then we have our list elements…
  - How should we represent a list element?
- Using a `struct`, we can hold data and a pointer to the next `struct` in the chain (singly-linked list)

Implementation [2/2]

- Each struct maintains a `next` pointer to another struct
- Once we hit `NULL` we know we've reached the end of the list
- We can also add a `prev` pointer to create a doubly-linked list
  - Additionally a ***tail*** pointer can be useful to allow nodes to be added at the beginning or end

Motivation: Why Linked Lists?

- Linked lists tend to be compared to arrays (or things like ArrayLists)
  - They really **aren't** meant for the same purpose, though
- A linked list is great when you will be adding or removing many items
  - Don't need to shift things around in memory or resize allocations
- Linked lists are **BAD** if you will search them frequently or want to access them via indexes

Insert

- Allocate memory for the new node
- Update the new node's data/value
- Set its **next** pointer to the current head
- Update the **head** pointer
  - Should now point to the newly-inserted node
  - How do we do this? Can it be done with a single pointer?

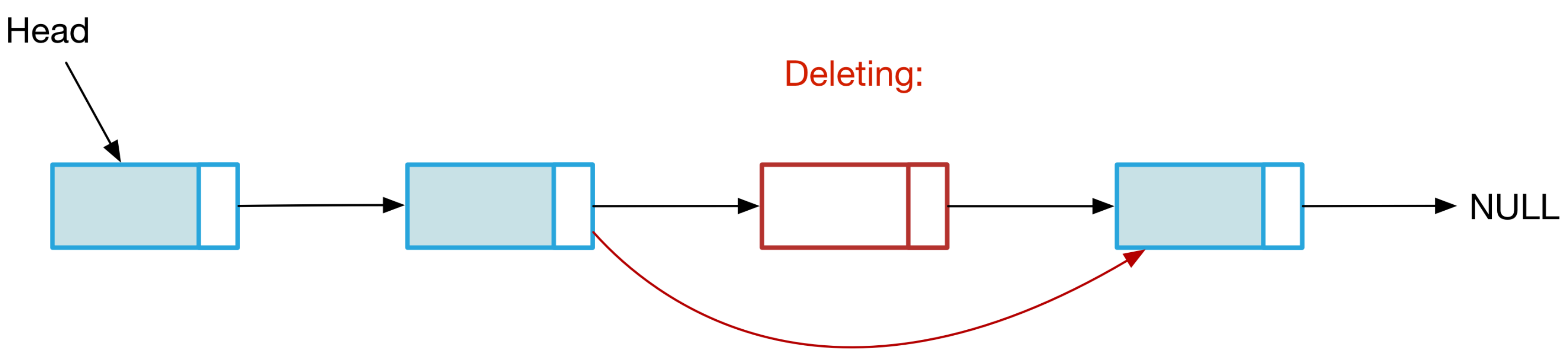
Print [1/2]

- Use a temporary variable to store the current node
- Start with `current = head`
- While the current node isn't `NULL`:
  - Print its value
  - Move to the next node

Print [2/2]

```
void print(struct list_node* head_p) {
    struct list_node *curr = head_p;
    while (curr != NULL) {
        printf("%d -> ", curr->data);
        curr = curr->next;
    }
    printf("\n");
}
```

Delete [1/2]



Delete [2/2]

- Find the node in question
- Update the previous node's **next** pointer
- **Remember**: in C, we have to take care of freeing memory ourselves!
- What happens if we delete the head or tail?

Search

- Loop through, checking every element
  - $O(n)$
- Stop once you find the element you're looking for

Our Plan

- Use what we already know about linked lists to make a memory allocator
- When The user frees a block of memory, add it to the *free list* – a linked list of free blocks!
- When doing a memory allocation, scan through the free list first to see if a block can be reused
  - If one is available, return it!