

Week 5 Lecture 2

NWEN 241
Systems Programming

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Content

- More on Linked Lists

Recap: Singly-Linked List Example

- Node type definition

```
typedef struct node
{ char data;
  struct node *next;
} Node;
```

- Node variables declaration and initialization

```
Node node4 = {'t', NULL};
Node node3 = {'s', &node4};
Node node2 = {'i', &node3};
Node node1 = {'l', &node2};
Node *head = &node1;
```

Problems with Previous Example

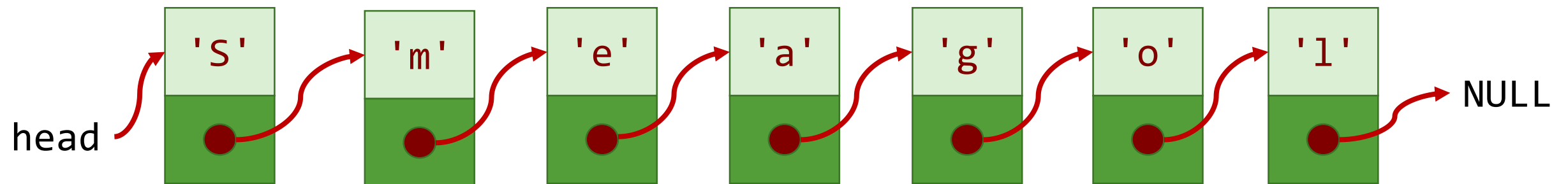
- Need to know list elements during coding
- What if the list elements are not known prior to program execution?
- The right way: **use dynamic memory allocation**

Motivating Example

- Ask user to input arbitrary string
- Convert string to a singly-linked list, with each node containing a character
- User Input:

Smeago1

- Linked List:



Preliminaries

- Node type definition

```
typedef struct node
{ char data;
  struct node *next;
} Node;
```

- Node variables declaration and initialization

```
Node *head = NULL;
```

The Rest of The Code

```
char input[100];
int i = 0;
Node *tail = NULL, *tmp;

scanf("%s", input);

while(input[i] != '\0') {
    tmp = (Node *)malloc(sizeof(Node));
    tmp->data = input[i];
    tmp->next = NULL;
    if(head == NULL) { head = tmp; tail = head; }
    else { tail->next = tmp; tail = tmp; }
    i++;
}
```

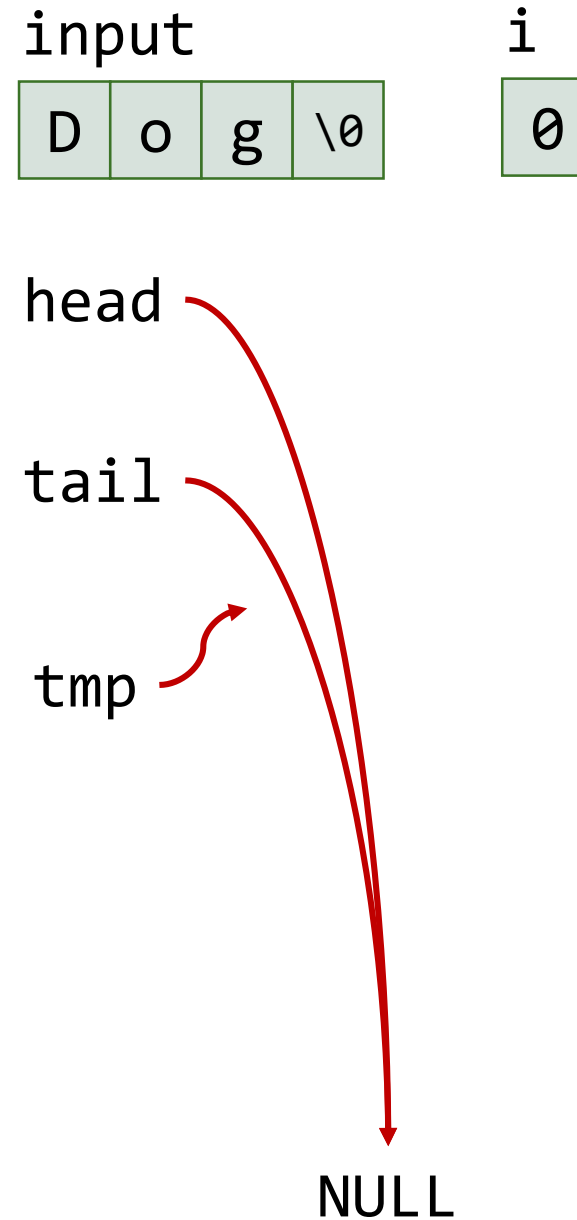
Walkthrough

- Suppose user input is **Dog**

```
char input[100];
int i = 0;
Node *tmp, *tail = NULL;

scanf("%s", input);

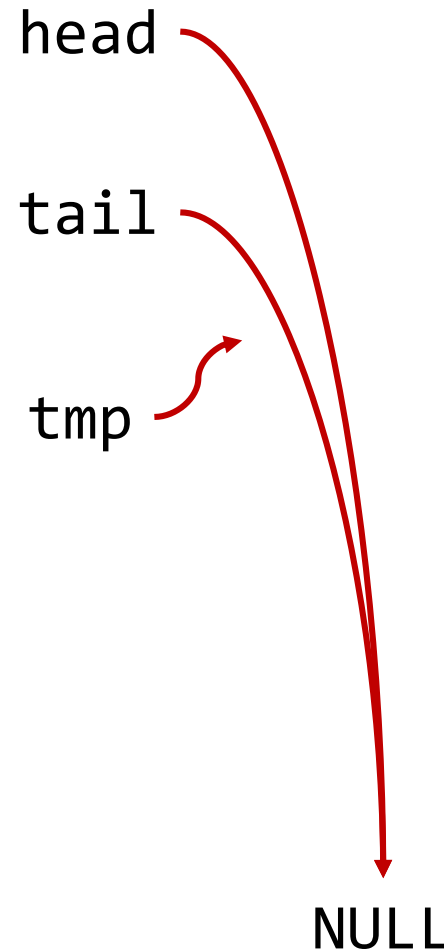
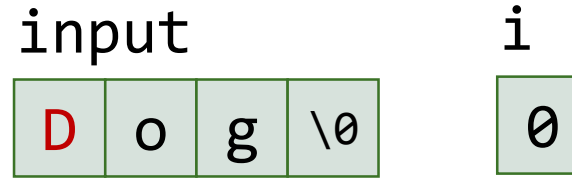
...
```



Walkthrough

- Suppose user input is **Dog**

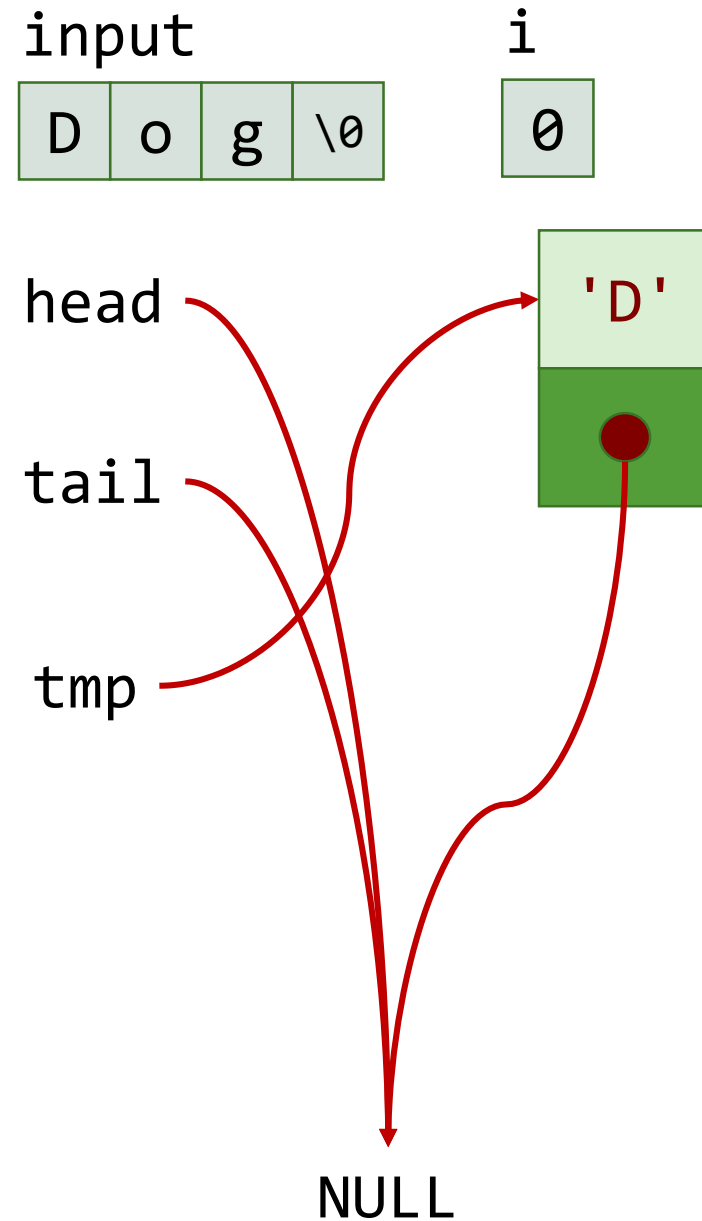
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while(input[i] != '\0') {  
    tmp = (Node *)malloc(sizeof(Node));  
    tmp->data = input[i];  
    tmp->next = NULL;  
    if(head == NULL) {  
        head = tmp;  
        tail = head;  
    } else {  
        tail->next = tmp;  
        tail = tmp;  
    }  
    i++;  
}
```



Walkthrough

- Suppose user input is **Dog**

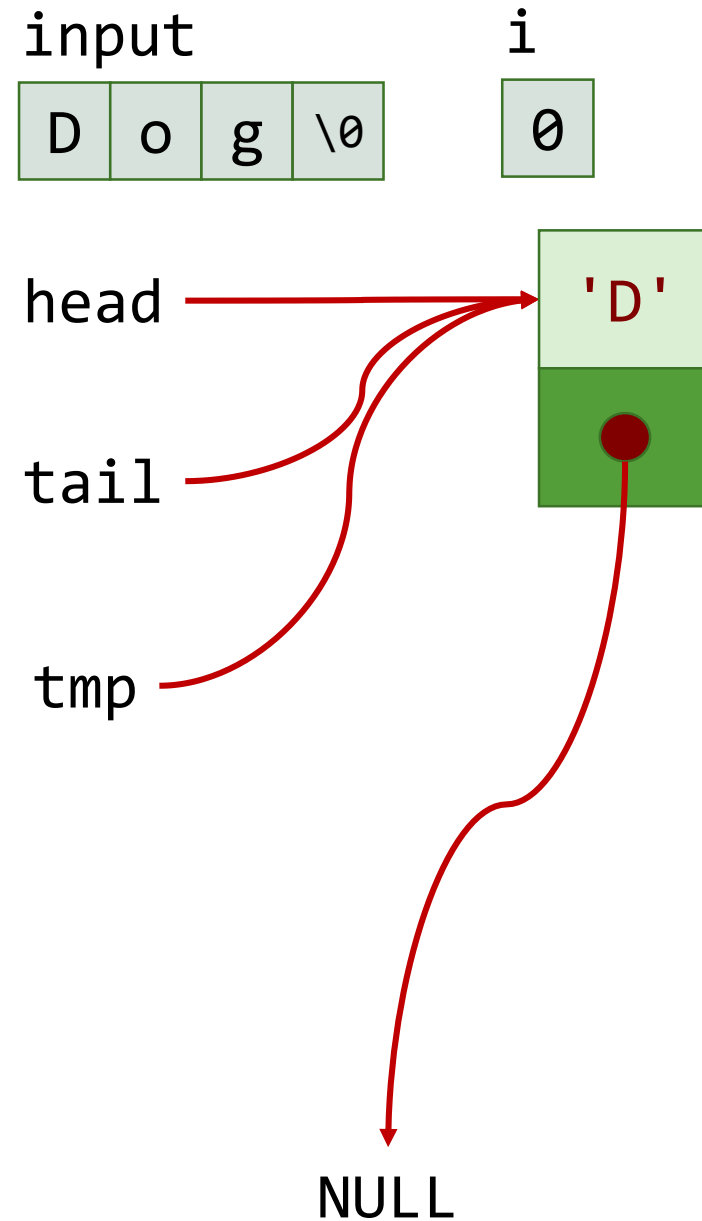
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    tmp->data = input[i];  
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        head = tmp;  
        tail = head;  
    } else {  
        tail->next = tmp;  
        tail = tmp;  
    }  
    i++;  
}
```



Walkthrough

- Suppose user input is **Dog**

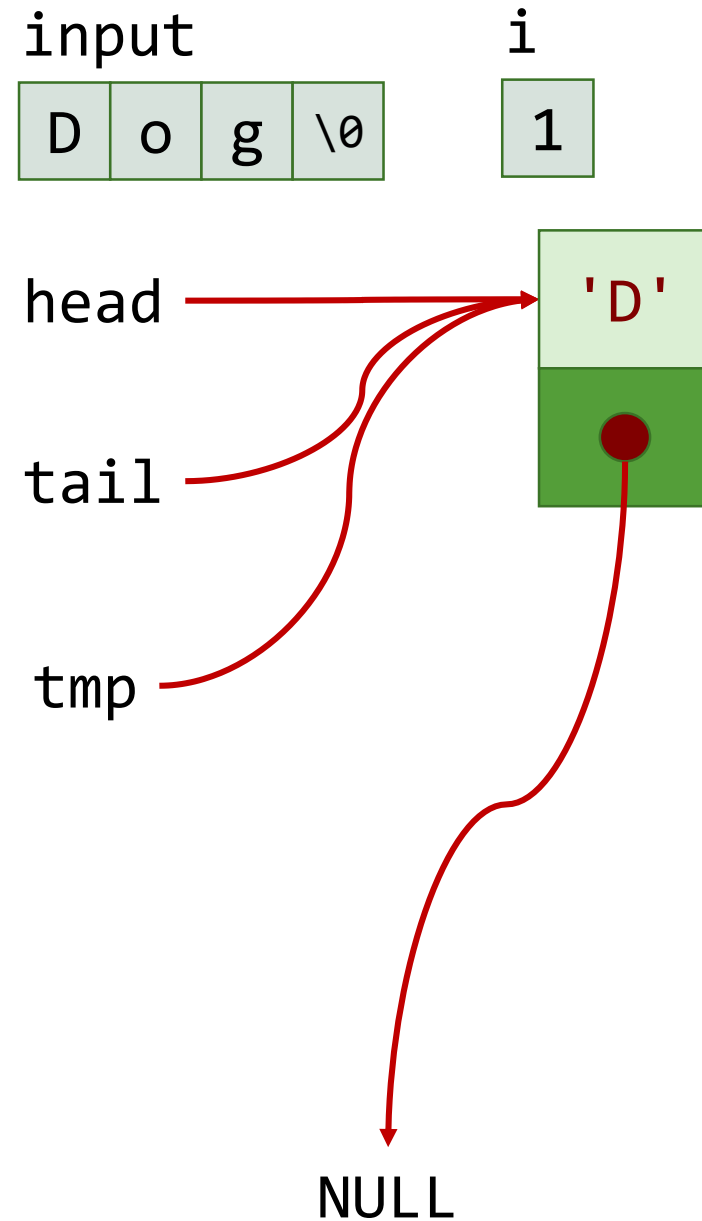
```
while(input[i] != '\0') {  
    tmp = (Node *)malloc(sizeof(Node));  
    tmp->data = input[i];  
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    if(head == NULL) {  
        head = tmp;  
        tail = head;  
    } else {  
        tail->next = tmp;  
        tail = tmp;  
    }  
    i++;  
}
```



Walkthrough

- Suppose user input is **Dog**

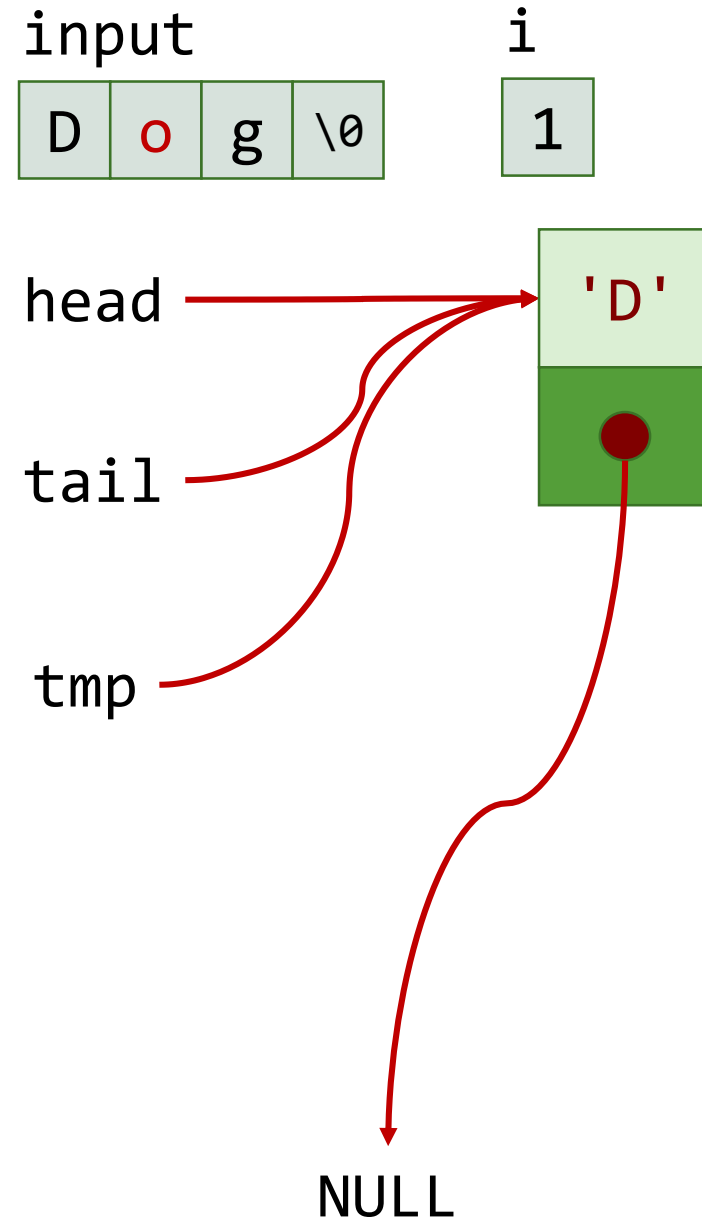
```
while(input[i] != '\0') {  
    tmp = (Node *)malloc(sizeof(Node));  
    tmp->data = input[i];  
    tmp->next = NULL;  
    if(head == NULL) {  
        head = tmp;  
        tail = head;  
    } else {  
        tail->next = tmp;  
        tail = tmp;  
    }  
    i++;  
}
```



Walkthrough

- Suppose user input is **Dog**

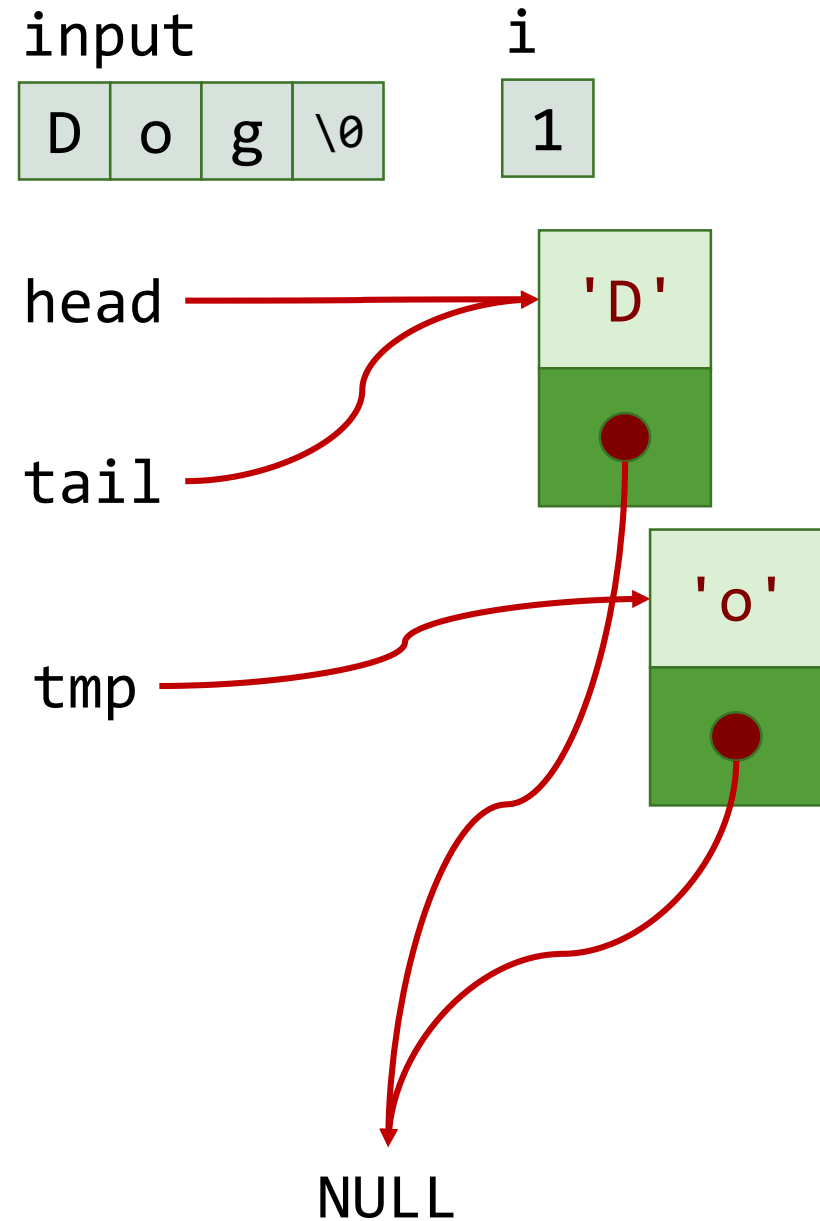
```
while(input[i] != '\0') {  
    tmp = (Node *)malloc(sizeof(Node));  
    tmp->data = input[i];  
    tmp->next = NULL;  
    if(head == NULL) {  
        head = tmp;  
        tail = head;  
    } else {  
        tail->next = tmp;  
        tail = tmp;  
    }  
    i++;  
}
```



Walkthrough

- Suppose user input is **Dog**

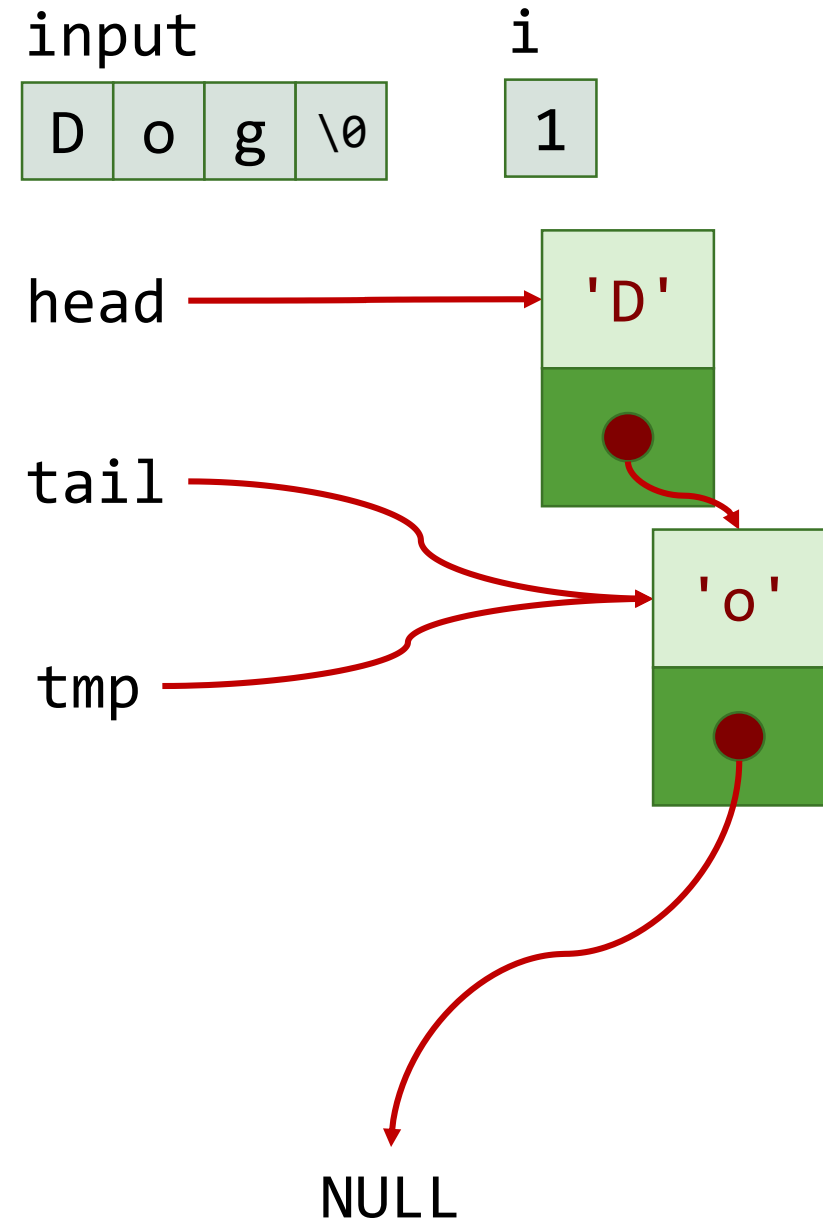
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while(input[i] != '\0') {  
    tmp = (Node *)malloc(sizeof(Node));  
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        head = tmp;  
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    } else {  
        tail->next = tmp;  
        tail = tmp;  
    }  
    i++;  
}
```



Walkthrough

- Suppose user input is **Dog**

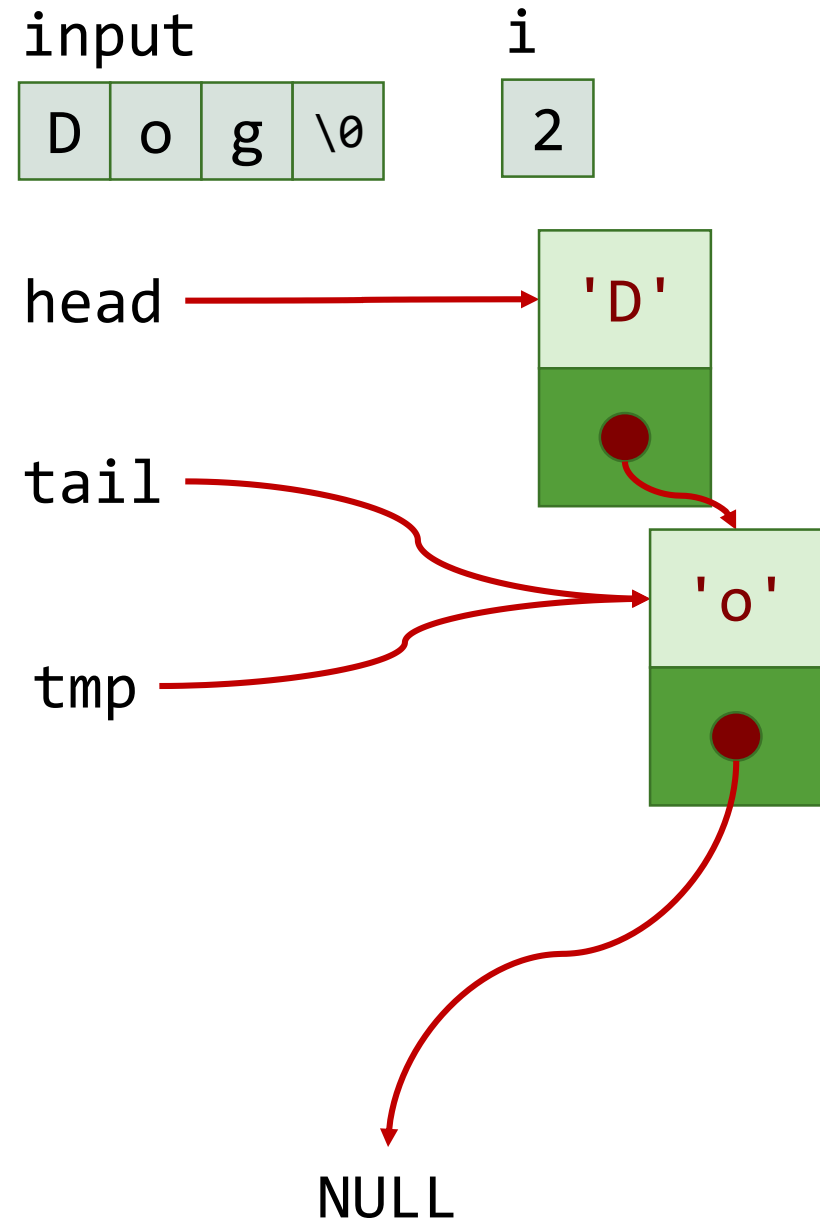
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    if(head == NULL) {  
        head = tmp;  
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    } else {  
        tail->next = tmp;  
        tail = tmp;  
    }  
    i++;  
}
```



Walkthrough

- Suppose user input is **Dog**

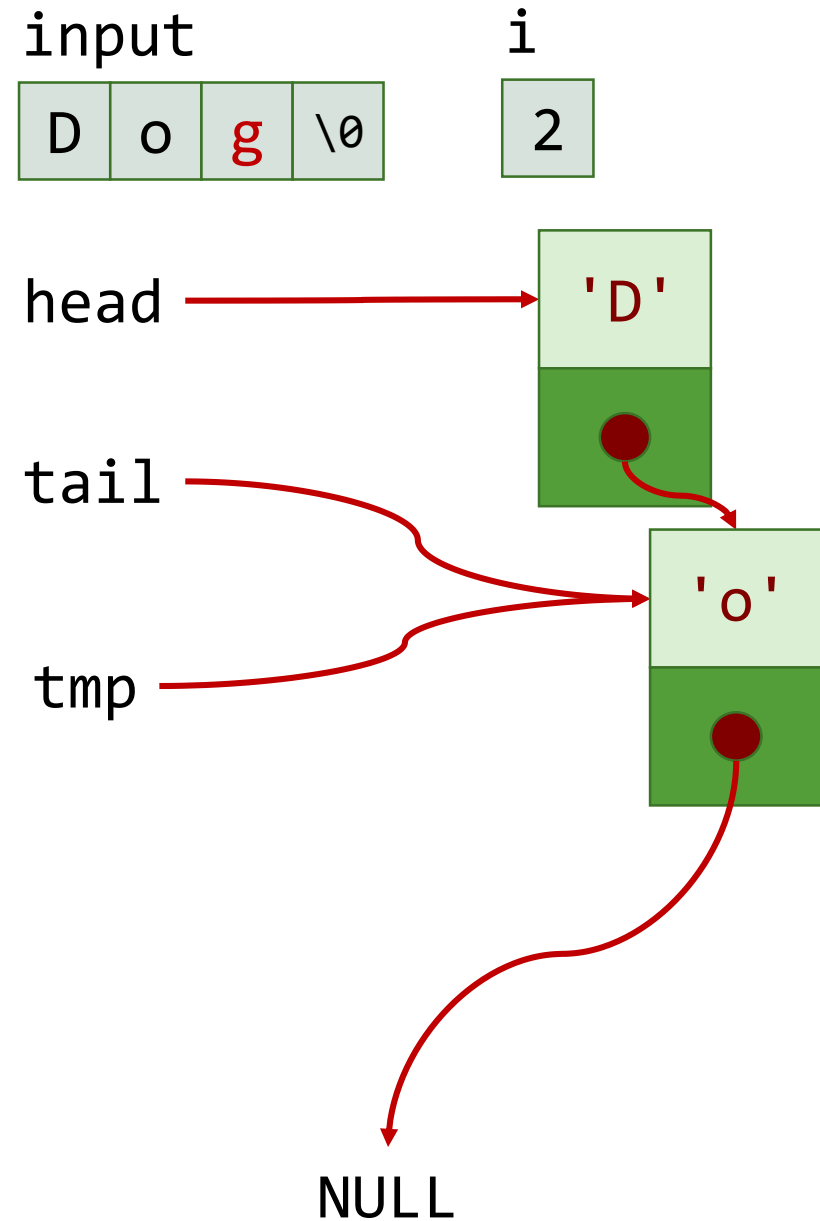
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    tmp = (Node *)malloc(sizeof(Node));  
    tmp->data = input[i];  
    tmp->next = NULL;  
    if(head == NULL) {  
        head = tmp;  
        tail = head;  
    } else {  
        tail->next = tmp;  
        tail = tmp;  
    }  
    i++;  
}
```



Walkthrough

- Suppose user input is **Dog**

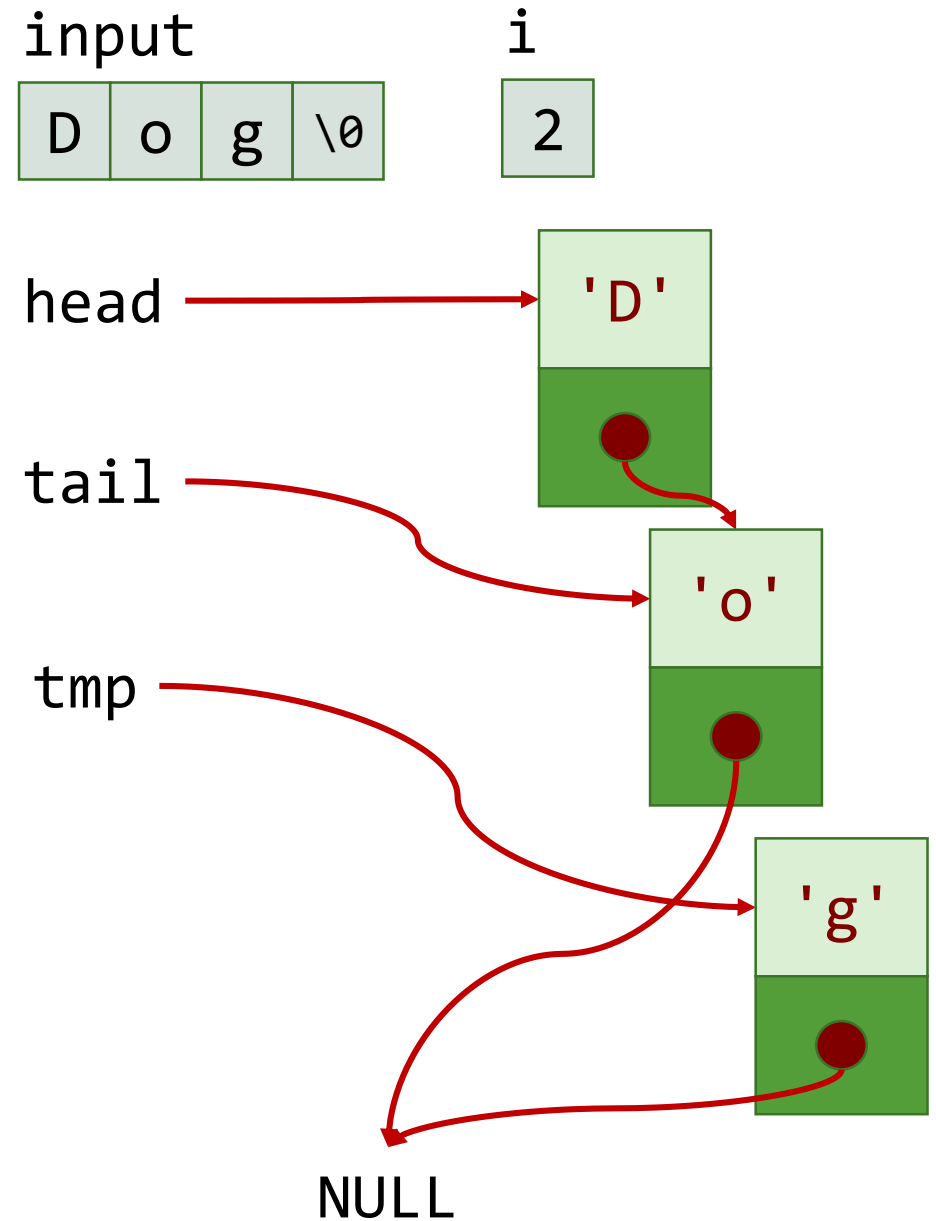
```
while(input[i] != '\0') {  
    tmp = (Node *)malloc(sizeof(Node));  
    tmp->data = input[i];  
    tmp->next = NULL;  
    if(head == NULL) {  
        head = tmp;  
        tail = head;  
    } else {  
        tail->next = tmp;  
        tail = tmp;  
    }  
    i++;  
}
```



Walkthrough

- Suppose user input is **Dog**

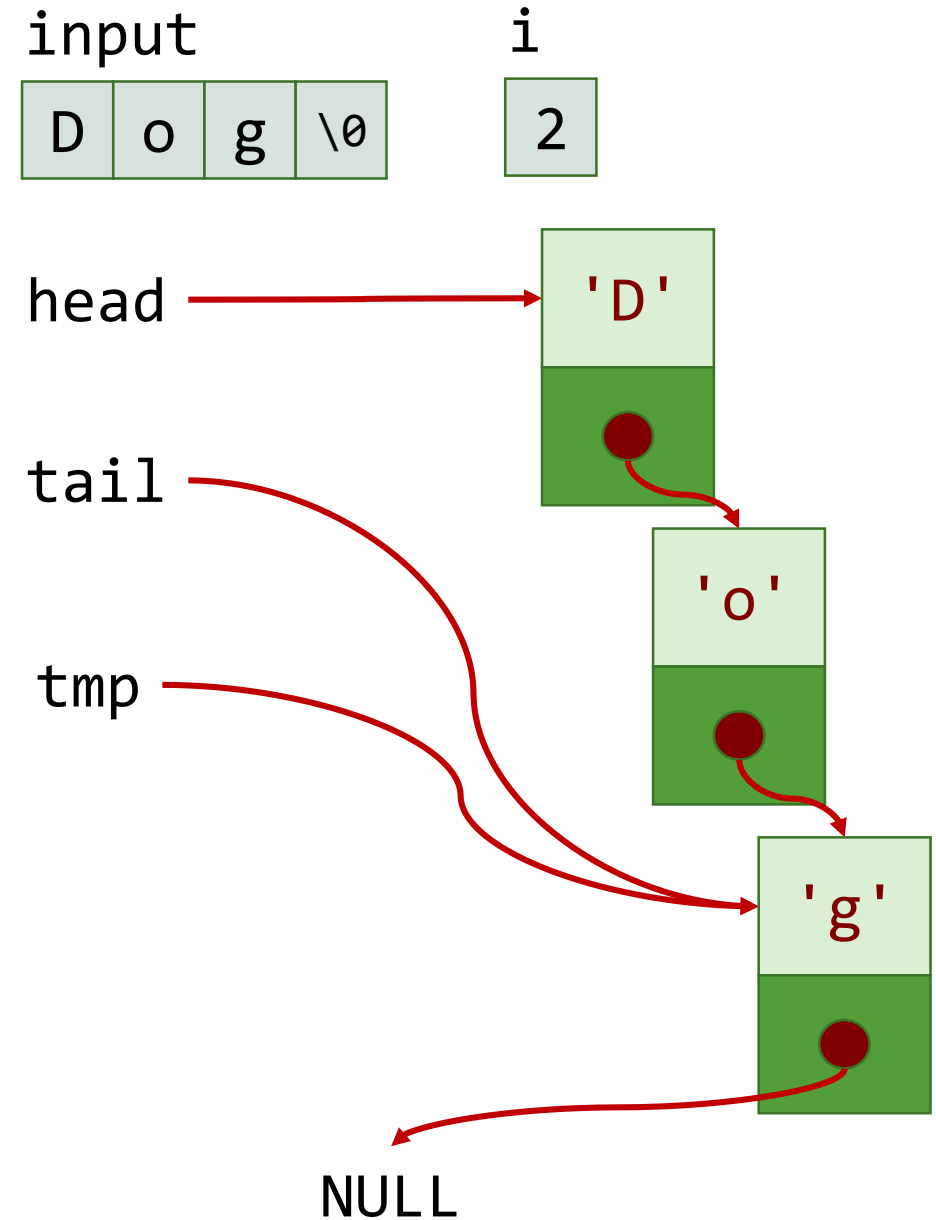
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while(input[i] != '\0') {  
    tmp = (Node *)malloc(sizeof(Node));  
    tmp->data = input[i];  
    tmp->next = NULL;  
    if(head == NULL) {  
        head = tmp;  
        tail = head;  
    } else {  
        tail->next = tmp;  
        tail = tmp;  
    }  
    i++;  
}
```



Walkthrough

- Suppose user input is **Dog**

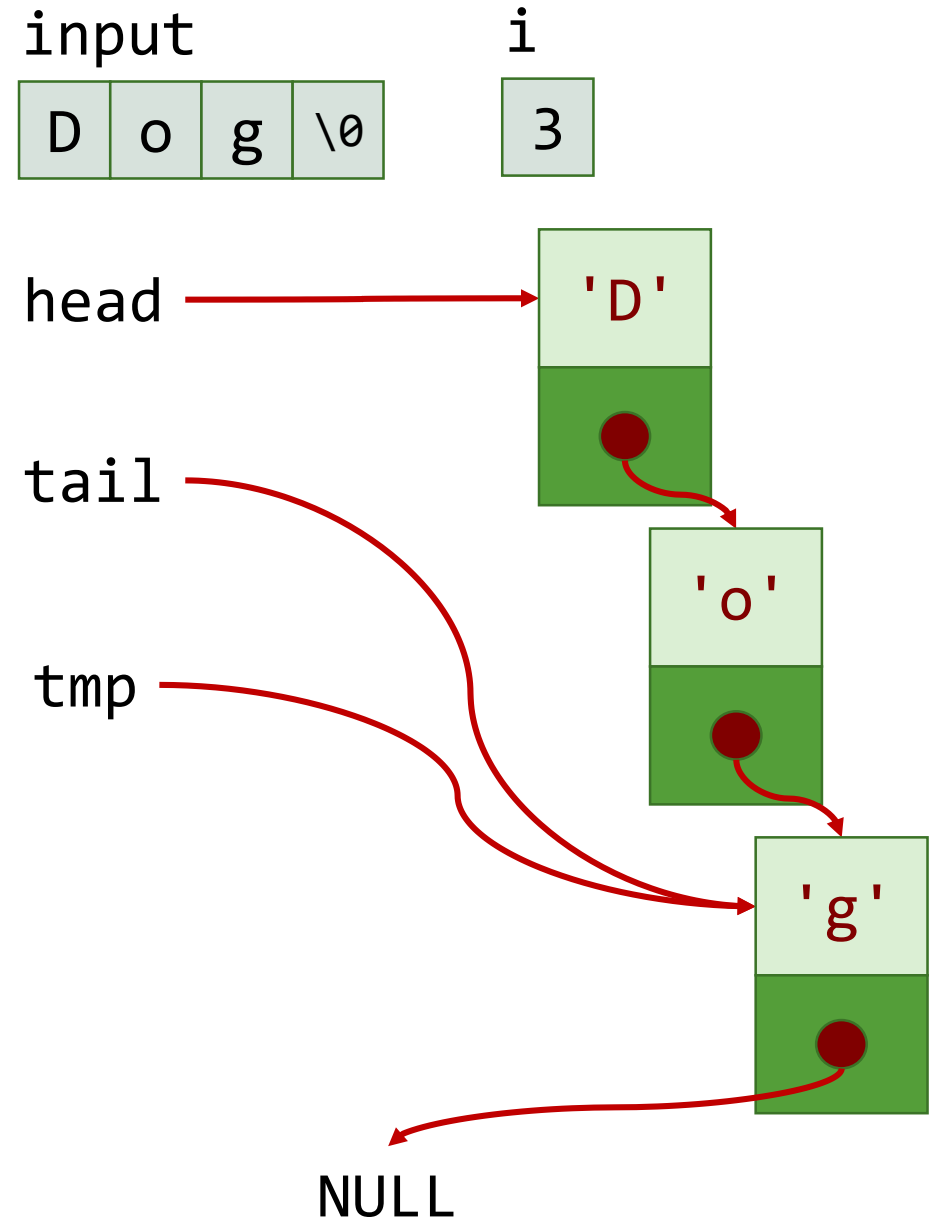
```
while(input[i] != '\0') {  
    tmp = (Node *)malloc(sizeof(Node));  
    tmp->data = input[i];  
    tmp->next = NULL;  
    if(head == NULL) {  
        head = tmp;  
        tail = head;  
    } else {  
        tail->next = tmp;  
        tail = tmp;  
    }  
    i++;  
}
```



Walkthrough

- Suppose user input is **Dog**

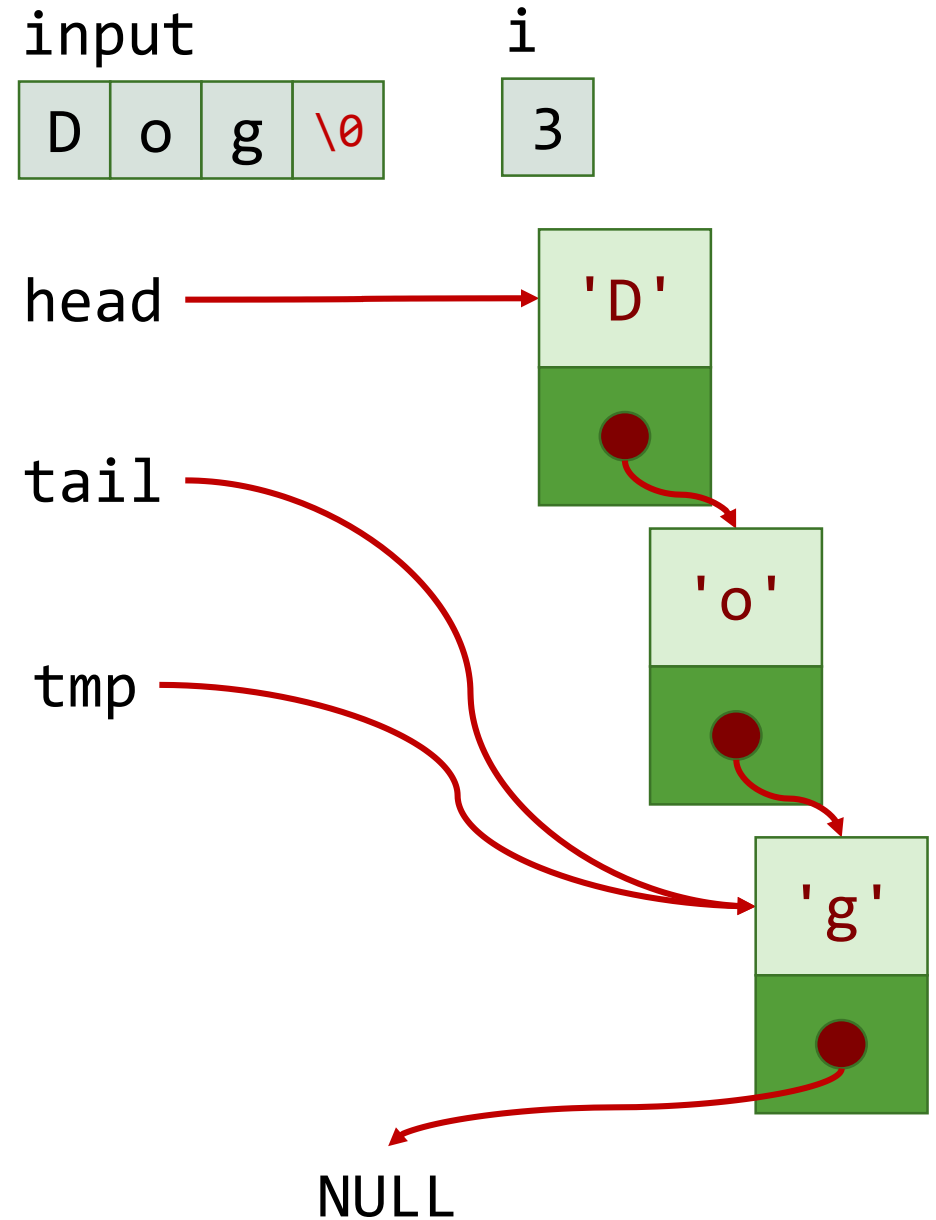
```
while(input[i] != '\0') {  
    tmp = (Node *)malloc(sizeof(Node));  
    tmp->data = input[i];  
    tmp->next = NULL;  
    if(head == NULL) {  
        head = tmp;  
        tail = head;  
    } else {  
        tail->next = tmp;  
        tail = tmp;  
    }  
    i++;  
}
```



Walkthrough

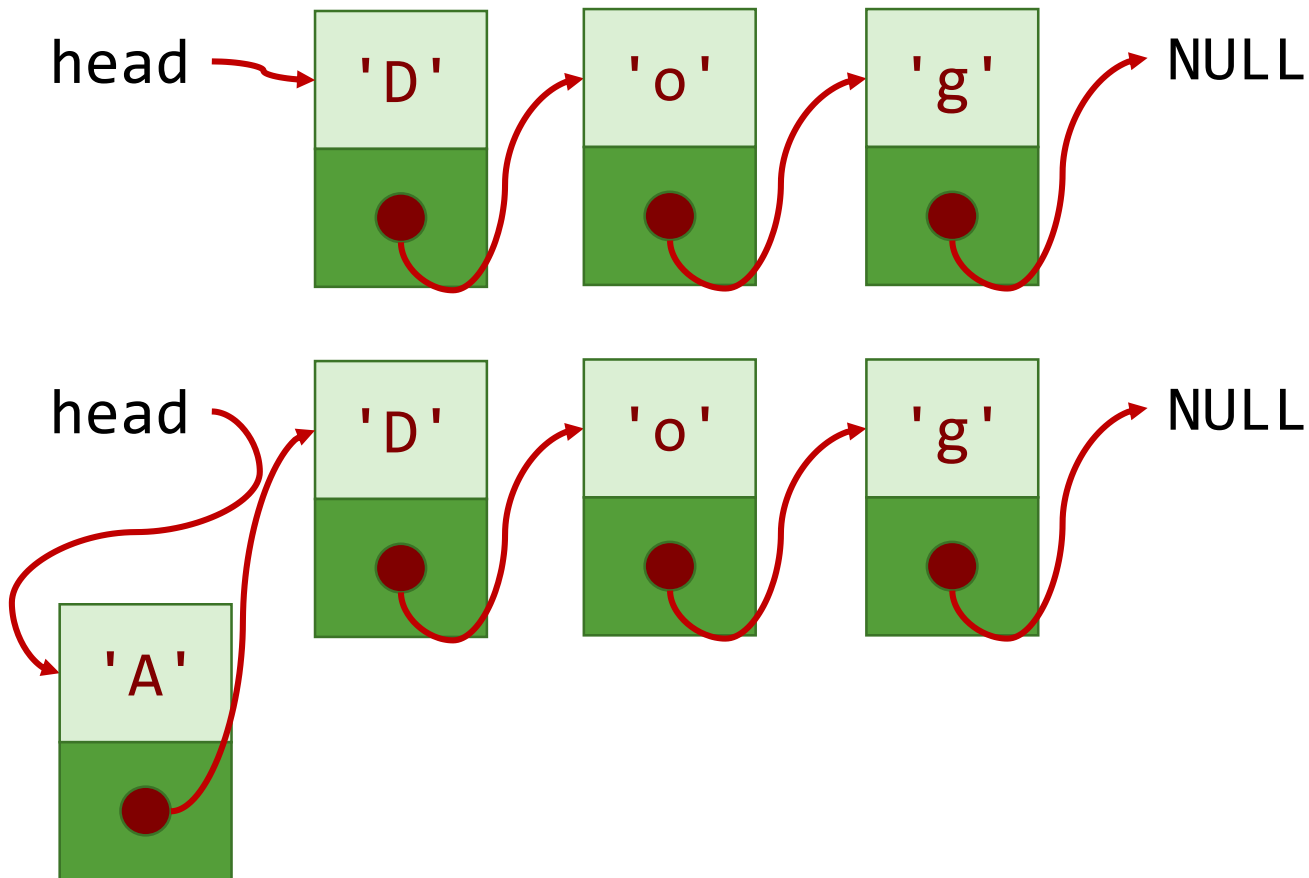
- Suppose user input is **Dog**

```
while(input[i] != '\0') {  
    tmp = (Node *)malloc(sizeof(Node));  
    tmp->data = input[i];  
    tmp->next = NULL;  
    if(head == NULL) {  
        head = tmp;  
        tail = head;  
    } else {  
        tail->next = tmp;  
        tail = tmp;  
    }  
    i++;  
}
```



Inserting a Node (At Head)

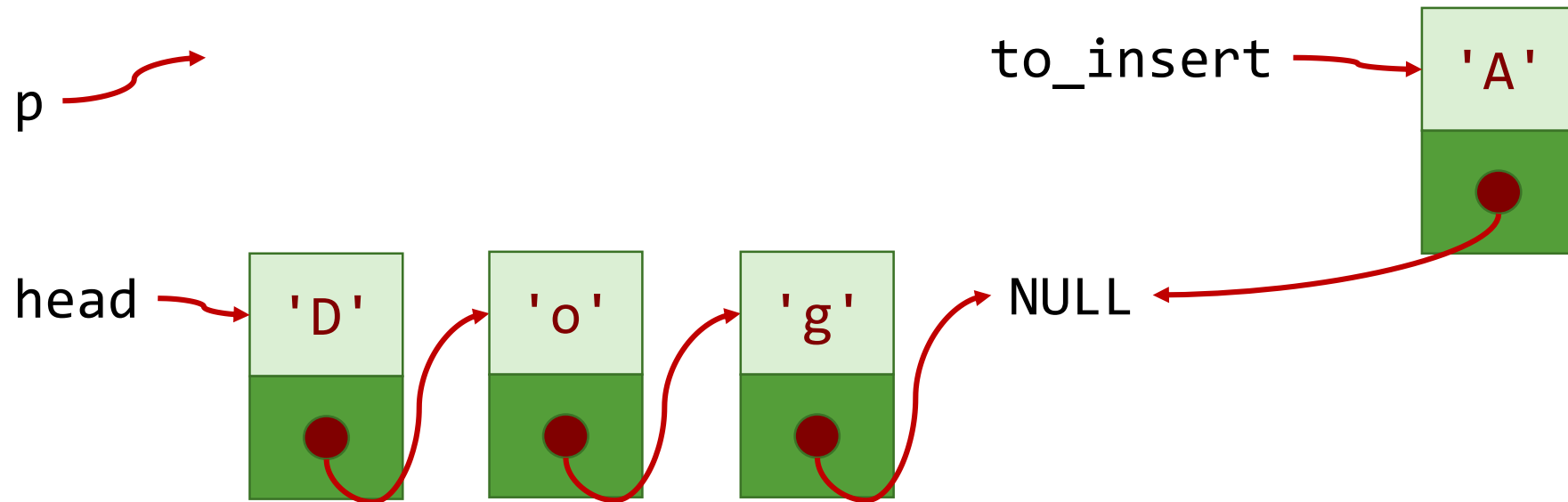
- Easy if insertion is before first node



```
Node *to_insert;  
  
/* Allocate space for  
to_insert and  
initialize */  
  
...  
  
to_insert->next = head;  
head = to_insert;
```

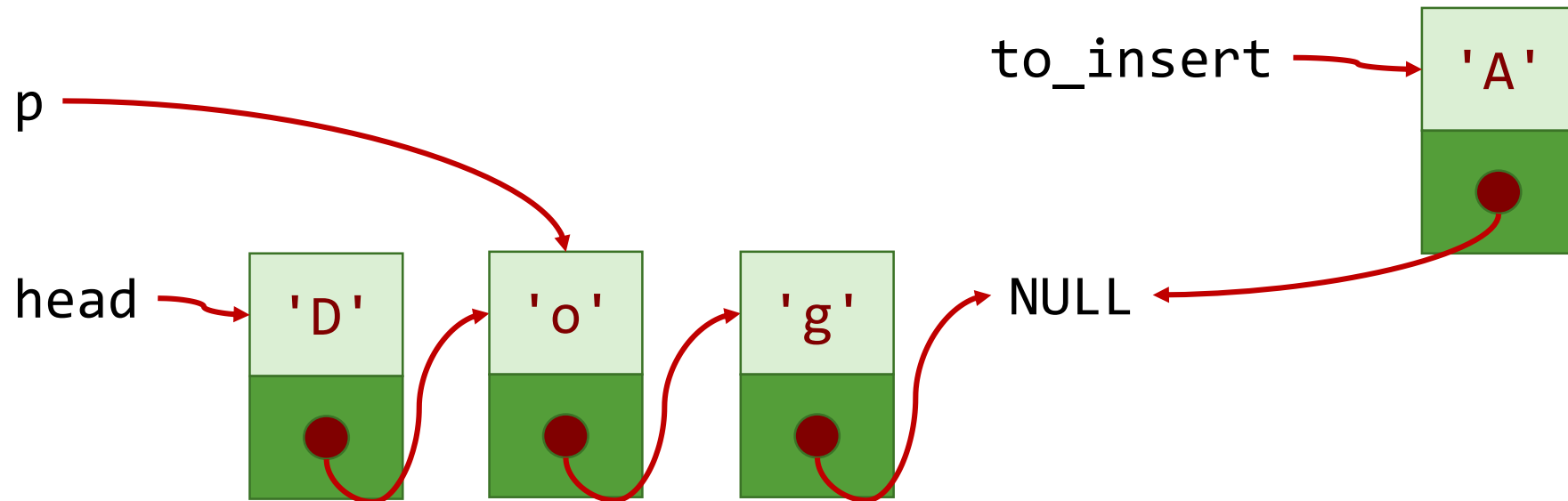
Inserting a Node (Not at Head)

- Need to traverse list until insertion point
- Illustration: Insert 'A' in between 'o' and 'g'.



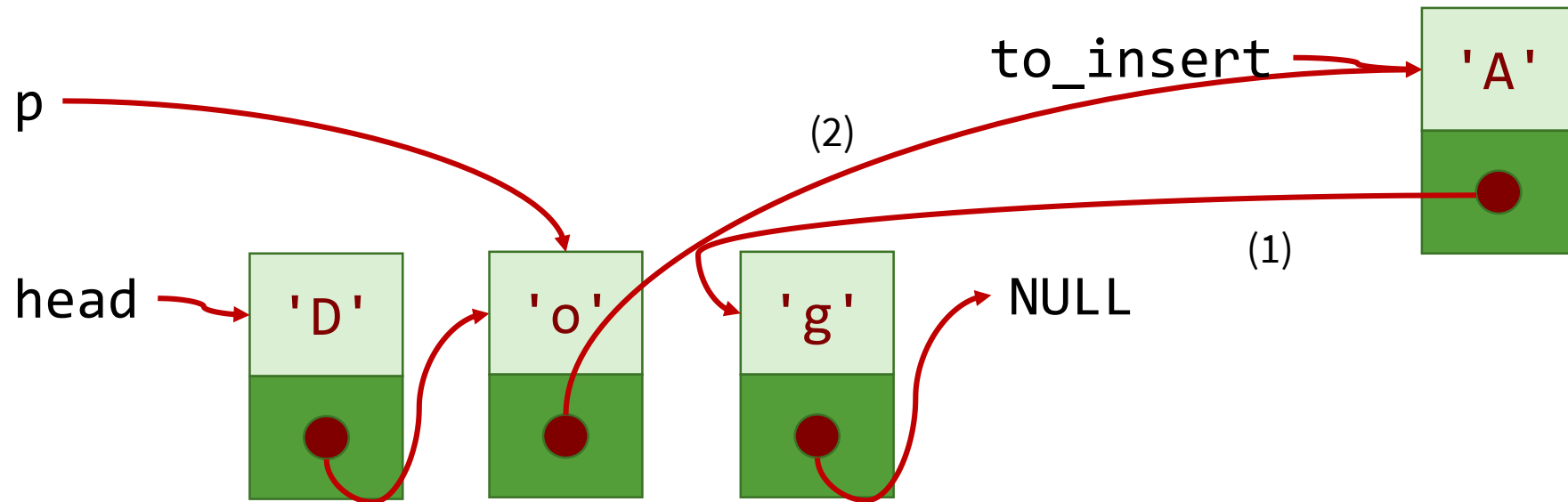
Inserting a Node (Not at Head)

- Illustration: Insert 'A' in between 'o' and 'g'
 - Traverse p until 'o'



Inserting a Node (Not at Head)

- Illustration: Insert 'A' in between 'o' and 'g'
 - Traverse p until 'o'
 - Insert node



Inserting a Node (Not at Head)

```
Node *to_insert;

/* Allocate space for to_insert and initialize */
...

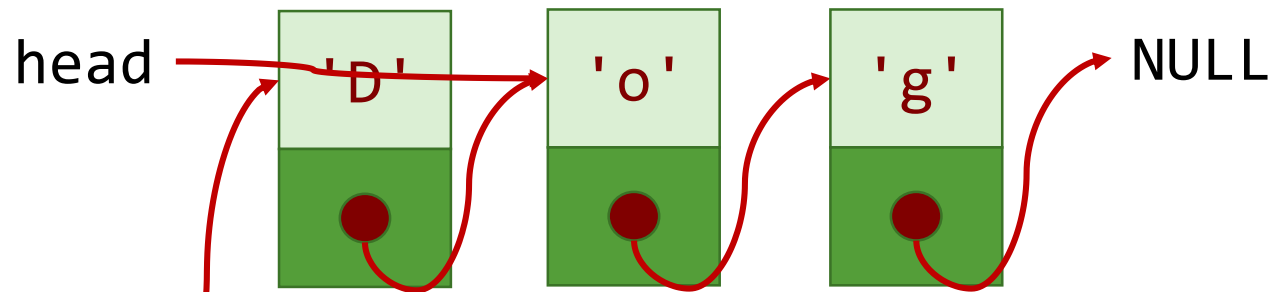
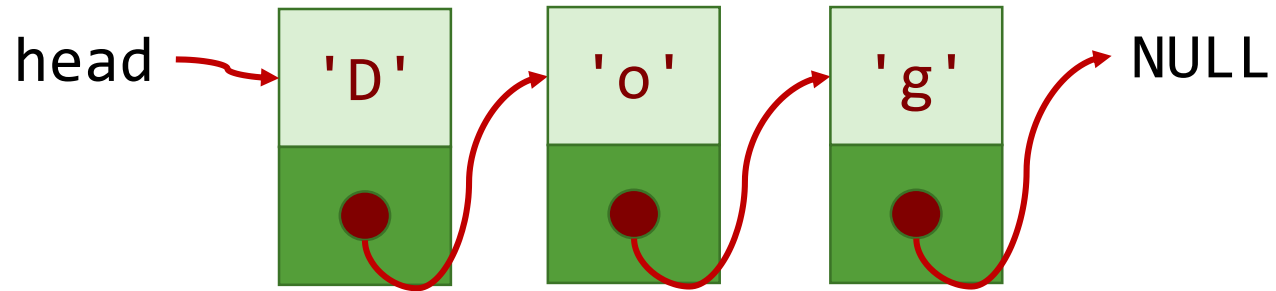
Node *p = head;

/* Traverse until desired node */
while(p != NULL && p->data != 'o')
    p = p->next;

/* Insert */
to_insert->next = p->next
p->next = to_insert;
```

Deleting a Node (At Head)

- Easy if node to delete is first node

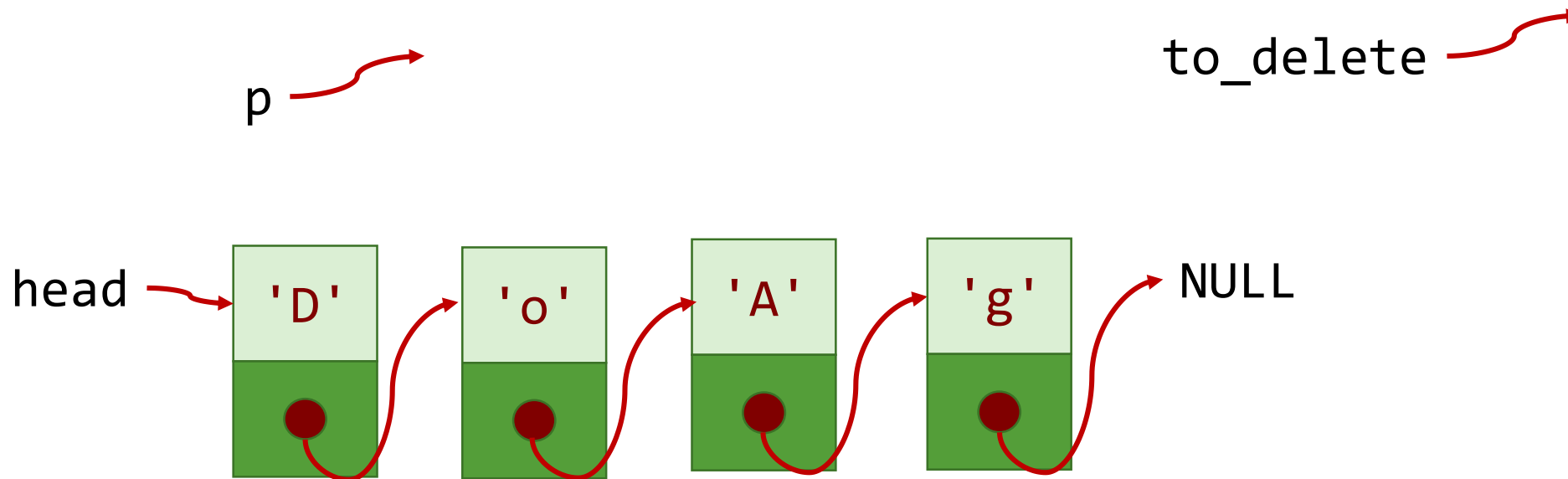


to_delete

```
Node *to_delete;  
  
to_delete = head;  
head = to_delete->next;  
  
free(to_delete);
```

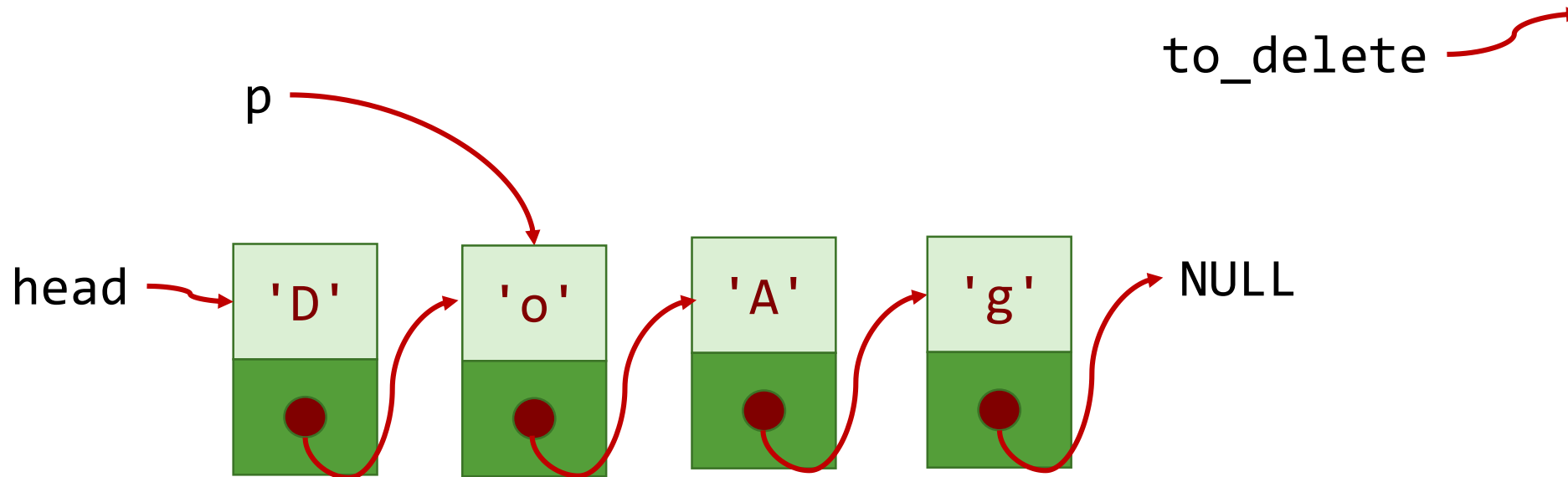
Deleting a Node (Not at Head)

- Need to traverse list until just before the node to be deleted
- Illustration: Delete 'A' in between 'o' and 'g'.



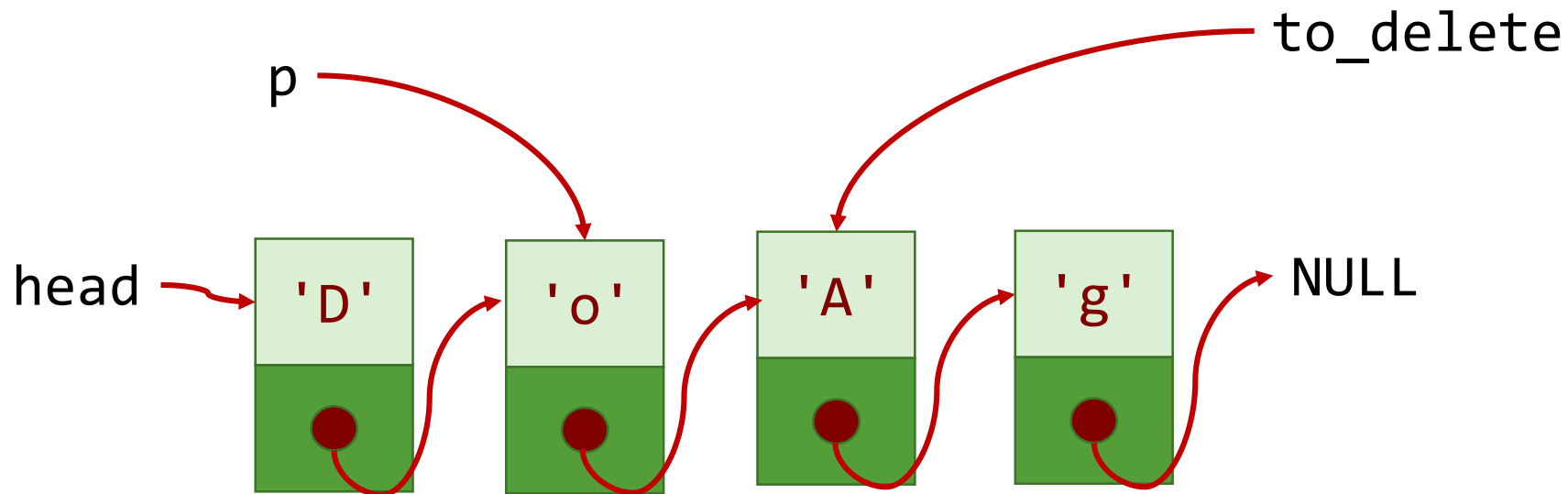
Deleting a Node (Not at Head)

- Illustration: Delete 'A' in between 'o' and 'g'.
 - Traverse p until 'o'



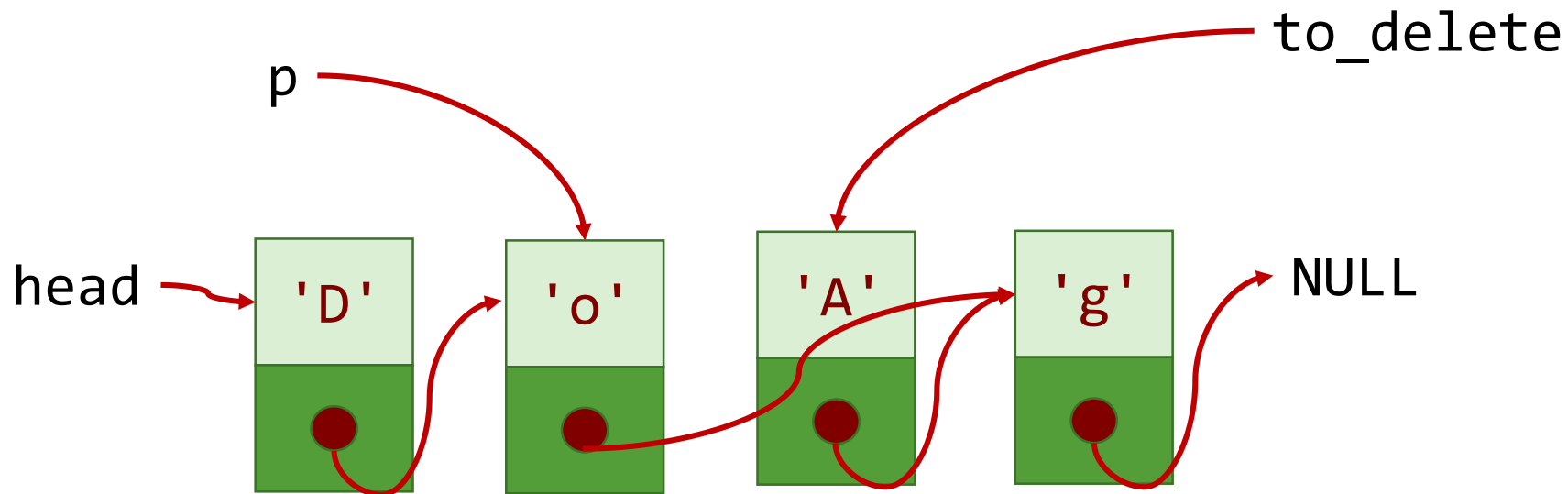
Deleting a Node (Not at Head)

- Illustration: Delete 'A' in between 'o' and 'g'.
 - Traverse p until 'o'
 - Let to_delete point to the next node (the node to be deleted)



Deleting a Node (Not at Head)

- Illustration: Delete 'A' in between 'o' and 'g'.
 - Traverse p until 'o'
 - Let to_delete point to the next node (the node to be deleted)
 - Delete node



Deleting a Node (Not at Head)

```
Node *to_delete;

Node *p = head;

/* Traverse until desired node */
while(p->next != NULL && p->next->data != 'A')
    p = p->next;

/* Delete */
if(p->next != NULL) {
    to_delete = p->next;
    p->next = to_delete->next;
    free(to_delete);
}
```


Things to Consider

- What if list is empty?
- What if traversal reaches end (NULL)?

Next Lecture

- FILE Stream I/O
- Command Line Arguments