Programming and Algorithms

COMP1038.PGA

Week 8 – Lecture 3: Doubly linked list

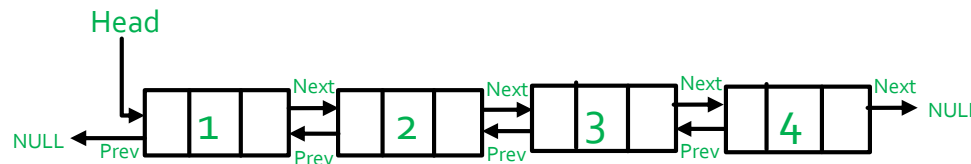Dr. Pushpendu Kar

Outline

- Doubly linked list
  - Introduction
  - Creation
  - Insertion
  - Deletion
  - Printing

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Introduction

- Pointer to next element as with singly-linked list.
- Pointer to previous element as well.
- Can access previous element just by using previous pointer.
- More efficient navigation but more complex algorithms and larger storage requirements

Head

NULL | 1 | Next → | 2 | Next → | 3 | Next → | 4 | Next → NULL
Prev ← Prev ← Prev ← Prev

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Creation

```
/* Node of a doubly linked list */
struct Node {
    int data;
    struct Node* next; // Pointer to next node in DLL
    struct Node* prev; // Pointer to previous node in DLL
};
```

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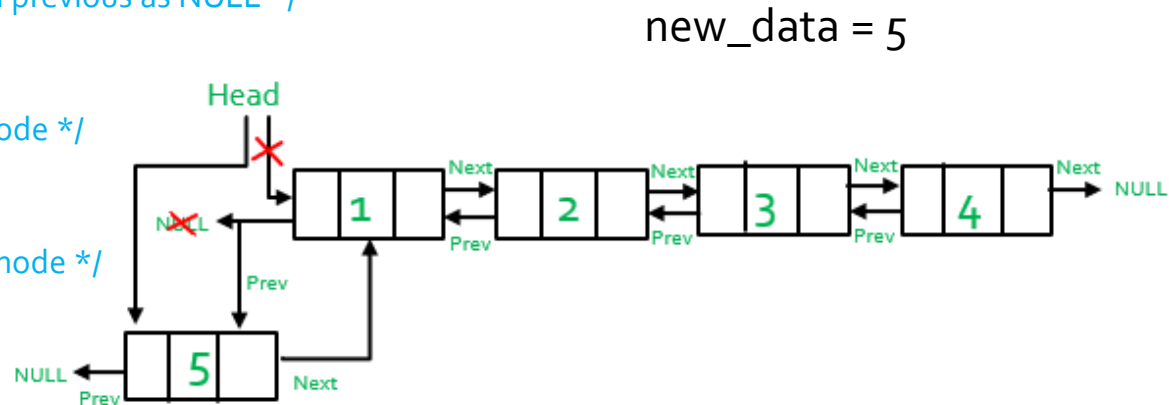
Insertion

- **Add a node at the front:**

void insertAtBegining(struct Node** head_ref, int new_data)
{
  /* 1. allocate node */
  struct Node* new_node = (struct Node*)malloc(sizeof(struct Node));

  /* 2. put in the data */
  new_node->data = new_data;

  /* 3. Make next of new node as head and previous as NULL */
  new_node->next = (*head_ref);
  new_node->prev = NULL;

  /* 4. change prev of head node to new node */
  if ((*head_ref) != NULL)
    (*head_ref)->prev = new_node;

  /* 5. move the head to point to the new node */
  (*head_ref) = new_node;
}

new_data = 5

Insertion cont...

- **Add a node at the end:**

```
void InsertEnd(struct Node** head_ref, int new_data)
{    /* 1. allocate node */
    struct Node* new_node = (struct Node*)malloc(sizeof(struct Node));

    struct Node* last = *head_ref; /* used in step 5*/

    /* 2. put in the data  */
    new_node->data = new_data;

    /* 3. This new node is going to be the last node, so
        make next of it as NULL*/
    new_node->next = NULL;

    /* 4. If the Linked List is empty, then make the new
        node as head */
    if (*head_ref == NULL) {
        new_node->prev = NULL;
        *head_ref = new_node;
        return;
    }
    /* 5. Else traverse till the last node */
    while (last->next != NULL)
        last = last->next;

    /* 6. Change the next of last node */
    last->next = new_node;

    /* 7. Make last node as previous of new node */
    new_node->prev = last;

    return;
}
```
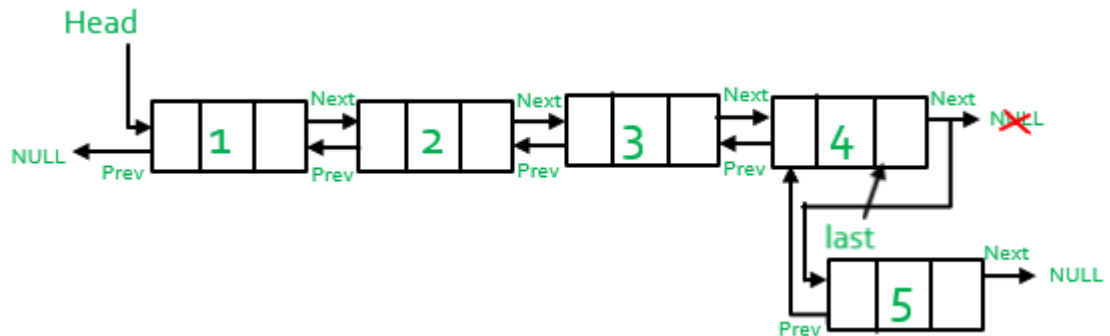
new_data = 5

Insertion cont...

- **Add a node after a given index:**

```
/* Given a reference (pointer to pointer) to the head
of a DLL and an int index, inserts a new node after the index */
void insertAfterIndex(struct Node** head_ref, int new_data, int index)
{
    /* 1. if list in NULL or invalid position is given */
    if (*head_ref== NULL || index < 0)
        return;

    struct Node* tmp = *head_ref;
    int i;

    /* 2. traverse up to the node at position 'index' from the beginning */
    for (i= 0; tmp != NULL && i< index; i++)
        tmp = tmp->next;

    /* 3. if 'index' is greater than the number of nodes in the doubly
            linked list */
    if (tmp == NULL)
        return;

    /* 4. allocate new node */
    struct Node* new_node = (struct Node*)malloc(sizeof(struct Node));

    /* 5. put in the data */
    new_node->data = new_data;

    /* 6. Make next of new node as next of prev_node */
    new_node->next = tmp->next;
}
```
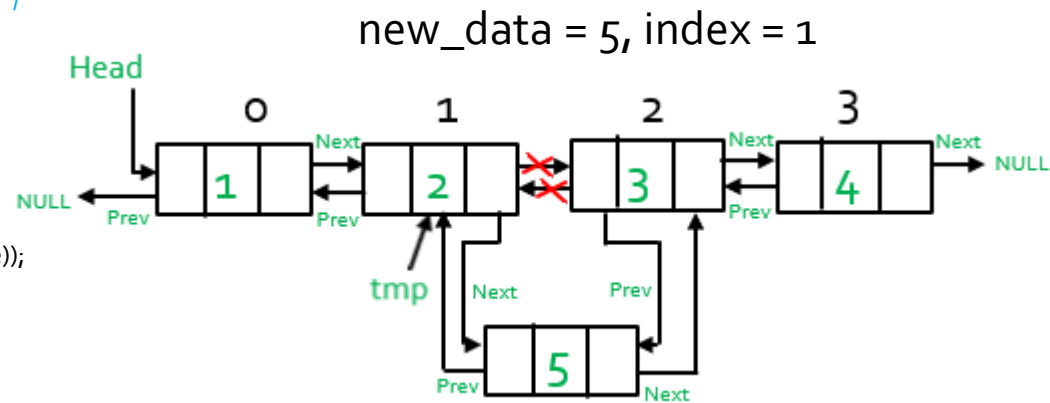
```
/* 7. Make the next of prev_node as new_node */
tmp->next = new_node;

/* 8. Make prev_node as previous of new_node */
new_node->prev = tmp;

/* 9. Change previous of new_node's next node */
if (new_node->next != NULL)
        new_node->next->prev = new_node;
}
```

new_data = 5, index = 1

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Deletion

- **Deletion at the at the given node pointer:**

```
/* Function to delete a node in a Doubly Linked List.
  head_ref --> pointer to head node pointer.
  del  -->  pointer to node to be deleted. */
void deleteNode(struct Node** head_ref, struct Node* del)
{
  /* base case */
  if (*head_ref == NULL || del == NULL)
    return;

  /* If node to be deleted is head node */
  if (*head_ref == del)
    *head_ref = del->next;

  /* Change next only if node to be deleted is NOT the last node */
  if (del->next != NULL)
    del->next->prev = del->prev;

  /* Change prev only if node to be deleted is NOT the first node */
  if (del->prev != NULL)
    del->prev->next = del->next;

  /* Finally, free the memory occupied by del*/
  free(del);
  return;
}
```
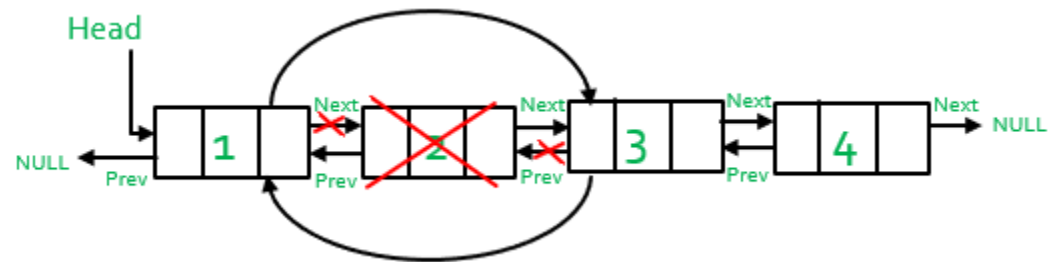
del -> pointing to node 2

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Deletion cont…

- **Deletion at the given node index:**

```
/* Function to delete the node at the given node index
   in the doubly linked list */
void deleteNodeAtGivenIndex(struct Node** head_ref, int index)
{
    /* if list in NULL or invalid index is given */
    if (*head_ref == NULL || index < 0)
        return;

    struct Node* tmp = *head_ref;
    int i;

    /* traverse up to the node at position 'index' from
       the beginning */
    for (int i = 0; tmp != NULL && i < index; i++)
        tmp = tmp ->next;

    /* if 'index' is greater than the number of nodes
       in the doubly linked list */
    if (tmp == NULL)
        return;

    /* delete the node pointed to by 'tmp' */
    deleteNode(head_ref, tmp);
}
```
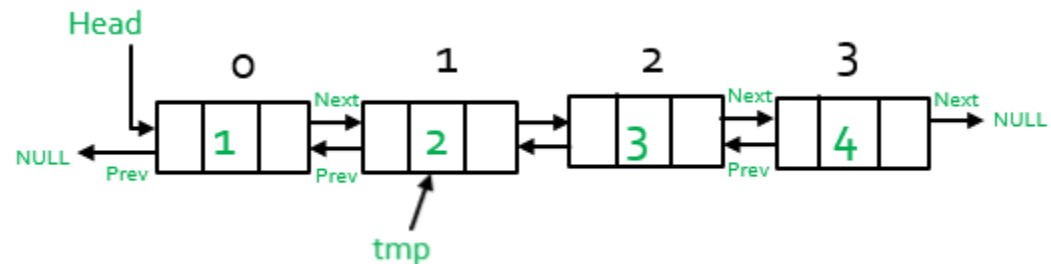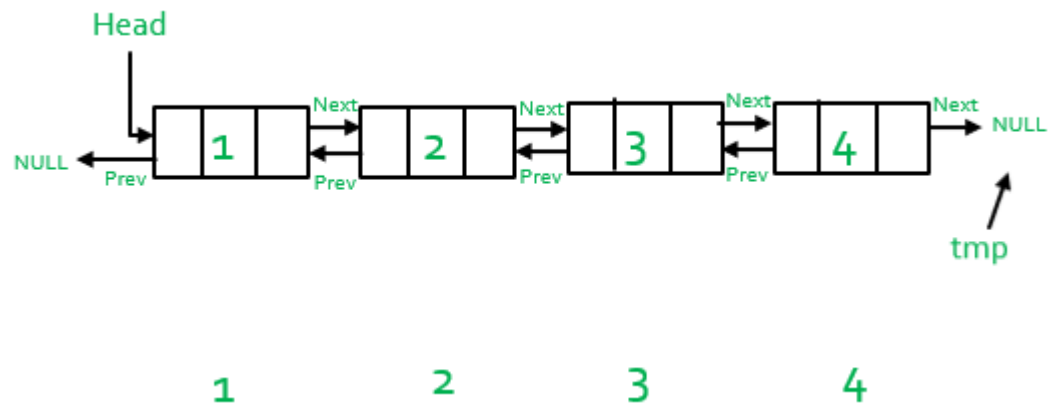
Index = 1

Call the 'deleteNode' function from the last slide where del = tmp

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Printing

```
void printList(struct Node** head_ref)
{   struct Node* tmp = *head_ref;
    while (tmp != NULL) {
        printf ("%d ", tmp->data);
        tmp = tmp->next;
    }
}
```

Applications

- Doubly linked list can be used in navigation systems where both front and back navigation is required.
- It is used by browsers to implement backward and forward navigation of visited web pages i.e. back and forward button.
- It is also used by various application to implement Undo and Redo functionality.

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The End

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