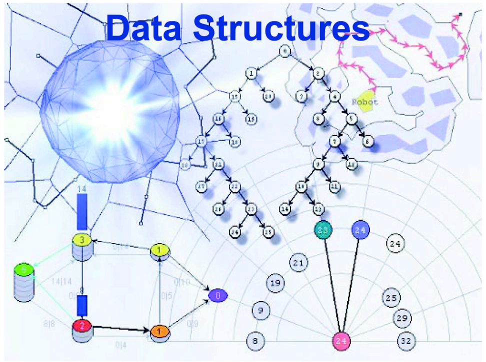
BBM 201
DATA STRUCTURES

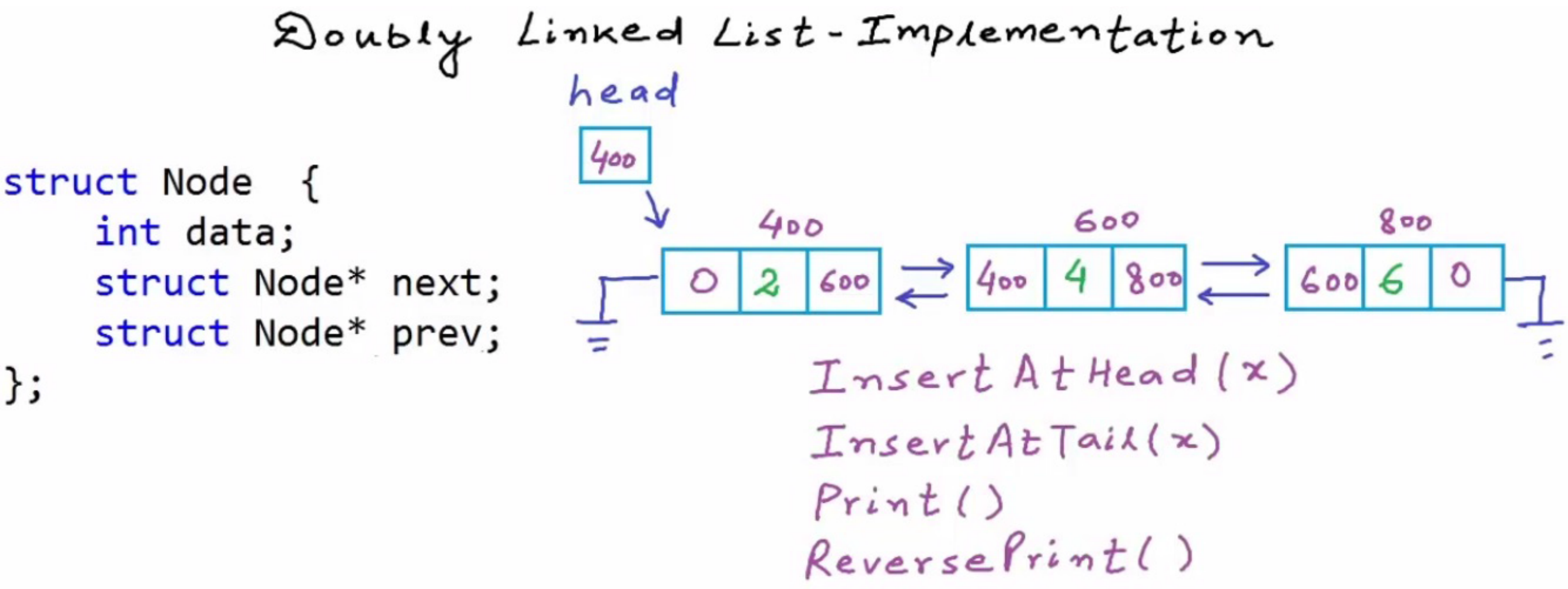
Lecture 10:

Doubly Linked Lists

2017-2018 Fall



Doubly Linked Lists



Each node stores not only the address of the next node, but also the address of the previous node. So, each node stores three fields.

Advantage of doubly linked list: Reverse look-up that we could not do using a linked list. For example, deletion is much faster than for a linked list.

For temp being 600, temp-> next points to the address 800 and temp->prev points to the address 400.

```c
/* Doubly Linked List implementation */
#include<stdio.h>
#include<stdlib.h>
struct Node  {
    int data;
    struct Node* next;
    struct Node* prev;
};
struct Node* head; // global variable - pointer to head node.
void InsertAtHead(int x) {
    // local variable
    // Will be cleared from memory when function call will finish
    struct Node myNode;
    myNode.data = x;
    myNode.prev = NULL;
    myNode.next = NULL;
}
```

Note: head is a global variable. Each node inside the InsertAtHead function is created locally and the node myNode does not exist after the function is executed.

Therefore, local node allocation is NOT preferred.

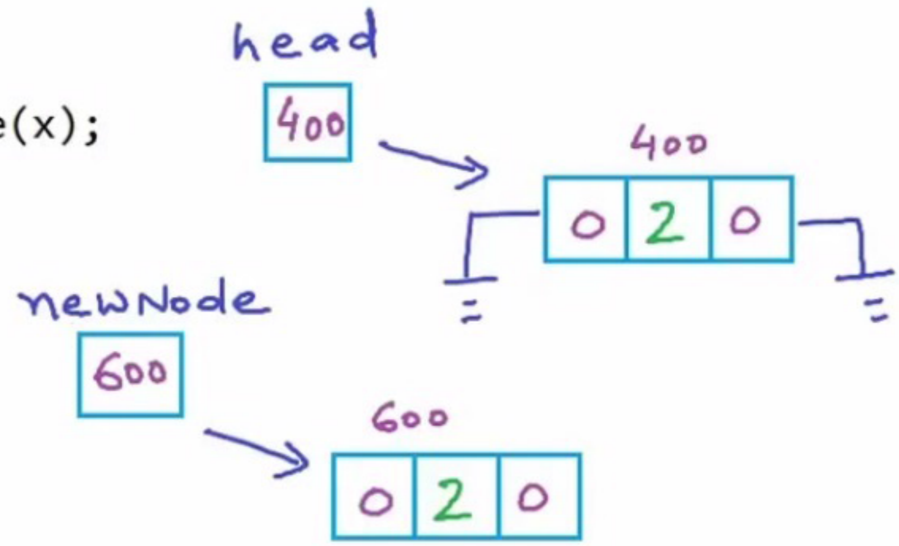
```c
struct Node  {
    int data;
    struct Node* next;
    struct Node* prev;
};
struct Node* head; // global variable - pointer to head node.
struct Node* GetNewNode(int x) {
    struct Node* newNode = (struct Node*)malloc(sizeof(struct Node));
    newNode->data = x;
    newNode->prev = NULL;
    newNode->next = NULL;
    return newNode;
}
void InsertAtHead(int x) {

}
```

Each node "newNode" is created in the dynamic memory and the node exists after the function is executed.
Now, we create a new node in a separate function, called GetNewNode.

Doubly Linked List - Implementation

```
void InsertAtHead(int x) {
    struct Node* newNode = GetNewNode(x);
    if(head == NULL) {
        head = newNode;
        return;
    }
    head->prev = newNode;
    newNode->next = head;
    head = newNode;
}
```



InsertAtHead(2)

InsertAtHead(4)

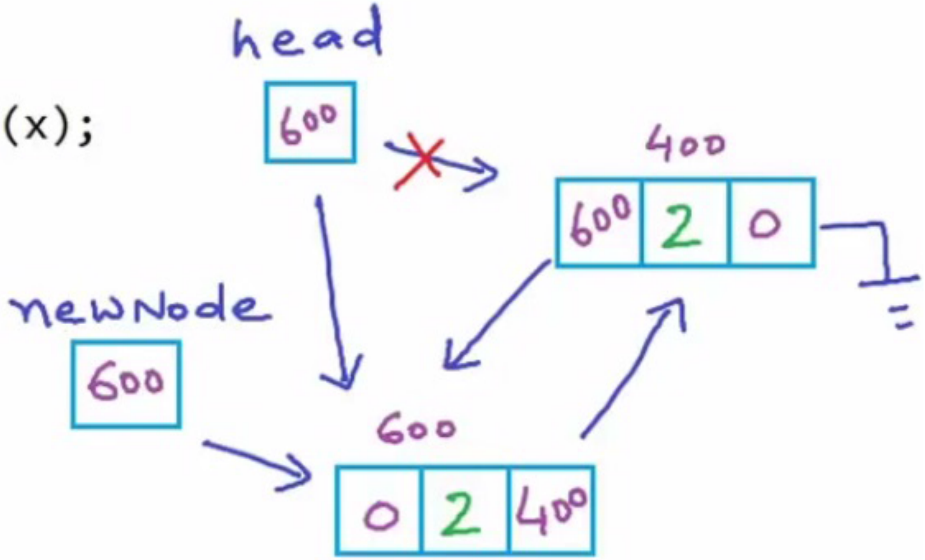
Now, one node is created in the list with head pointing to it using the line head = newNode.

We have two nodes, head is pointing to the node at address 400 and newNode is pointing to the node at address 600.

Typo: The data-field at address 600 has value 4 not 2.

Doubly Linked List - Implementation

```
void InsertAtHead(int x) {
    struct Node* newNode = GetNewNode(x);
    if(head == NULL) {
        head = newNode;
        return;
    }
    head->prev = newNode;
    newNode->next = head;
    head = newNode;
}
```



Insert At Head (2)

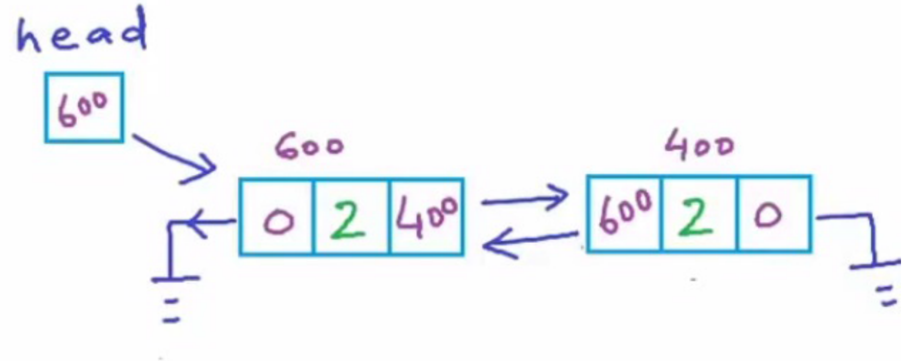
Insert At Head (4)

Set the prev-field of the head node as 600 (address of the new node).
Then, set the next-field of the new node as 400 (the address of the head node).
And now, head can point to 600, that is the address of the final head node.

Typo: The data-field at address 600 has value 4 not 2.

Doubly Linked List - Implementation

```
void InsertAtHead(int x) {
    struct Node* newNode = GetNewNode(x);
    if(head == NULL) {
        head = newNode;
        return;
    }
    head->prev = newNode;
    newNode->next = head;
    head = newNode;
}
```



InsertAtHead(2)

InsertAtHead(4)

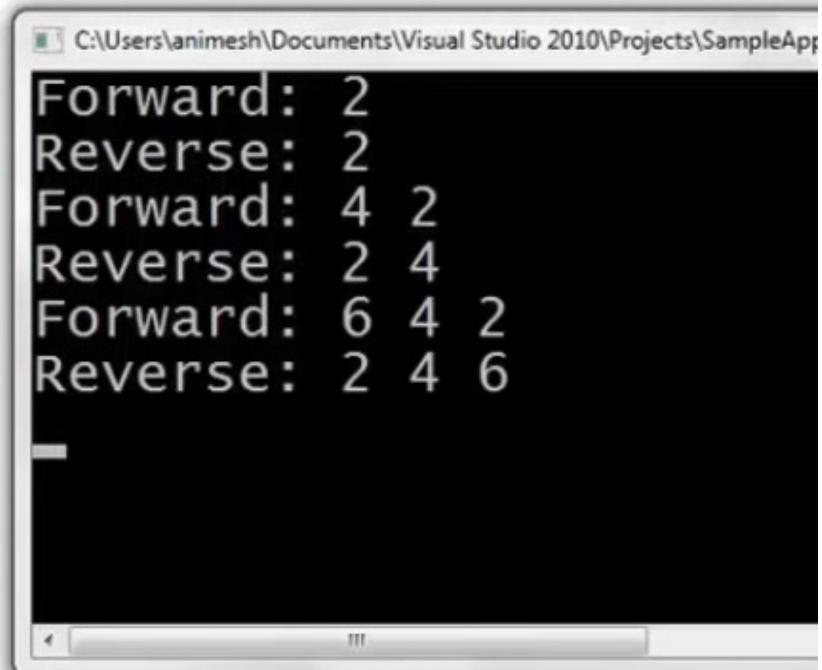
Reverse Printing

```
void ReversePrint() {
    struct Node* temp = head;
    if(temp == NULL) return; // empty list, exit
    // Going to last Node
    while(temp->next != NULL) {
        temp = temp->next;
    }
    // Traversing backward using prev pointer
    printf("Reverse: ");
    while(temp != NULL) {
        printf("%d ",temp->data);
        temp = temp->prev;
    }
    printf("\n");
}
```

In Reverse-printing, the code first goes to the end of the list and then traverses backwards.

```c
void ReversePrint() {
    struct Node* temp = head;
    if(temp == NULL) return; // empty list, exit
    // Going to last Node
    while(temp->next != NULL) {
        temp = temp->next;
    }
    // Traversing backward using prev pointer
    printf("Reverse: ");
    while(temp != NULL) {
        printf("%d ",temp->data);
        temp = temp->prev;
    }
    printf("\n");
}

int main() {
    head = NULL; // empty list.
    InsertAtHead(2); Print(); ReversePrint();
    InsertAtHead(4); Print(); ReversePrint();
    InsertAtHead(6); Print(); ReversePrint();
}
```

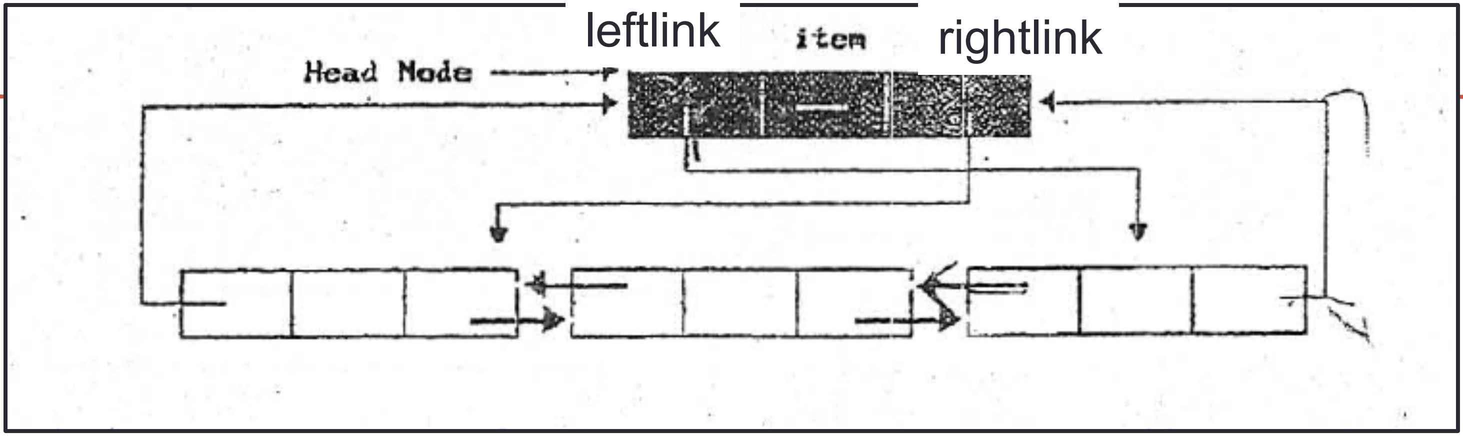


Doubly Circular Linked List

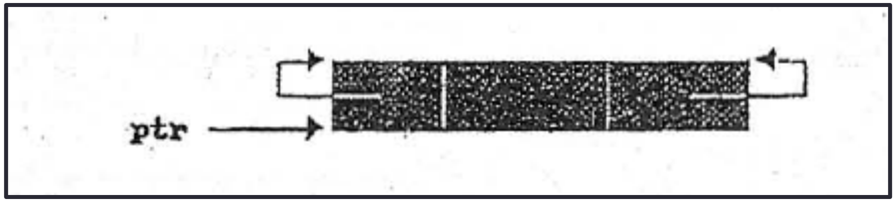
```
typedef struct node *node_pointer;
typedef struct node{
    node_pointer leftlink;
    element item;
    node_pointer rightlink;};
```

```
ptr = ptr->leftlink->rightlink = ptr->rightlink->leftlink
```

Doubly linked circular linked list with head node:



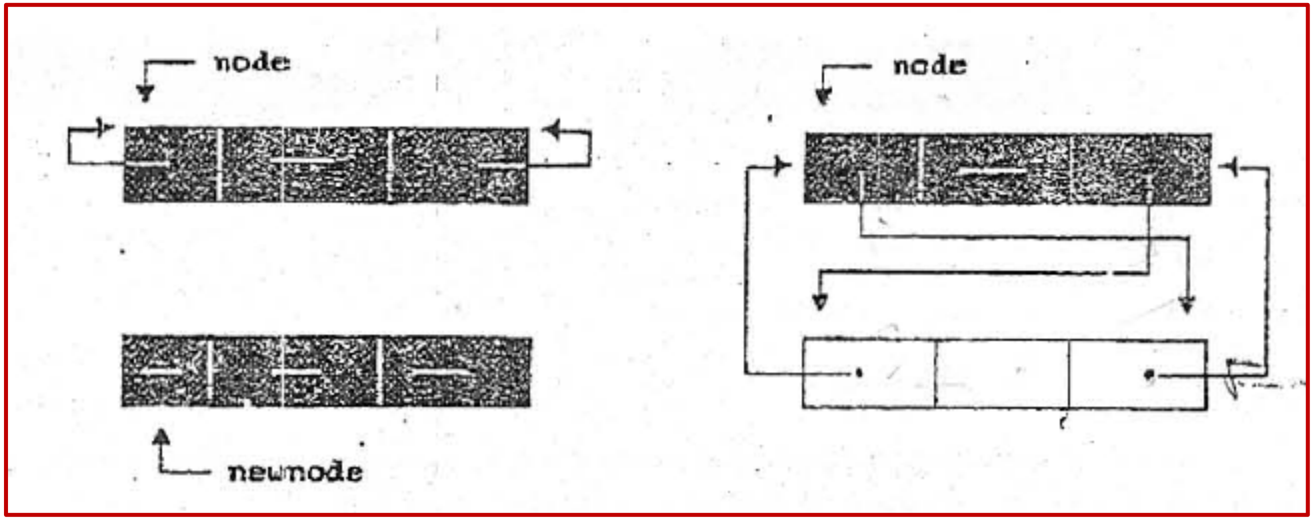
Empty doubly linked circular linked list with head node:



Inserting into a doubly-linked circular list:

```
void dinsert(node_pointer node, node_pointer newnode)
{
/* insert newnode to the right of node */
newnode->leftlink = node;
newnode->rightlink = node->rightlink;
node->rightlink->leftlink = newnode;
node->rightlink = newnode;}
```

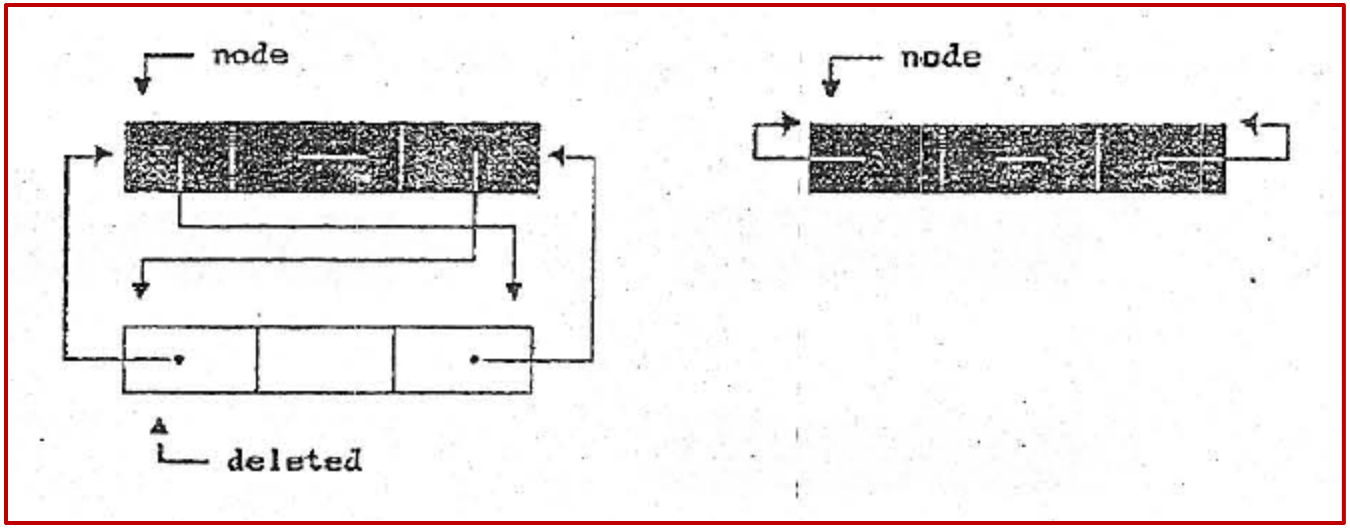
Insertion into an empty doubly linked circular linked list:



Deletion from a doubly-linked circular list:

```
void ddelete(node_pointer node, node_pointer deleted)
{
if(node == deleted)
    printf("Deletion of head node not permitted.\n");
else
    deleted->leftlink->rightlink = deleted->rightlink;
    deleted->rightlink->leftlink = deleted->leftlink;
    free(deleted);}
}
```

Deletion from a doubly linked circular linked list:



Doubly vs. Singly Linked List

Insertion/Deletion has extra work

You have ready access\insert on both ends.

It can work as a Queue and a Stack at the same time.

Node deletion requires no additional pointers.

Reverse a doubly linked list

```
Node reverse(Node head){
    Node n = head, next;
    while(n.next != null){
        next = n.next;
        n.next = n.prev;
        n.prev = next;
        n = next;
    }
    //for the last node
    next=n.next;
    n.next = n.prev;
    n.prev = next;
    // n is the new head.
    return n;
}
```