CS 101: Computer Programming and Utilization

17-Linked Lists

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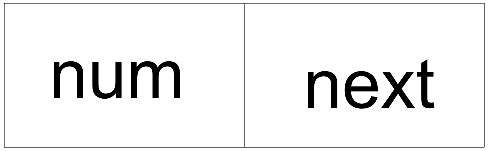
What does this program do?

```
struct node {    //has two items, as below
   int num;        //the data is an int
   node* next;  //pointer to another node
};
int main() {
   struct node a, b, c;
   struct node* head;
      head = &a;
      a.num = 1; a.next = &b;
      b.num = 2; b.next = &c;
      c.num = 3; c.next = 0;
}  //Draw the memory arrangement and their contents
```

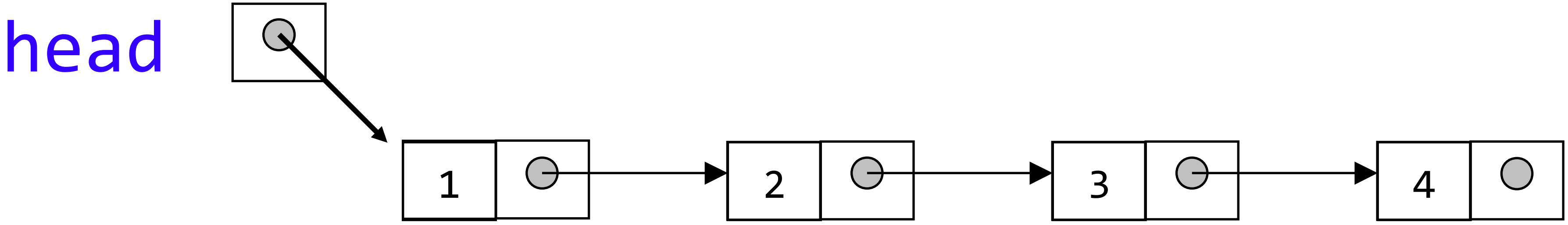


num next

Linked Lists

The structure created by the program is called a Linked List. Its properties are:

- There is a pointer to the *head* (first node) of the list.
- Each node has some data and a pointer to the next node in the list.
- The pointer in the last node is usually NULL (0).



Uses of linked lists

- Items often need to be added or deleted from the “ends” (head or tail).
  - Example: Stack, Queue
- There may be large variation in number of items during program execution
  - Fixed size array may be too small or too large
- Need to insert and delete data at any position
  - Such operations in an array are expensive (Why?)
- Dynamic memory allocation
  - ptr = **new** node; //Creates a new block of memory of size node and assigns its address to ptr
  - **delete** ptr; //Gives back the block of memory to OS

Accessing items in a linked list

- The items in a node are accessed using → operator
  - → involves * (dereference) and . (dot)
  - Recall accessing of values in pointers and structs

- Example: struct node* head;
  - head→num = 5; // sets the value of num in the node pointed to by head, to 5
  - cout << head→num; // prints 5
  - cout << head→next→num; //prints value in node after head
- Given a pointer to the start of a linked list (head), it is possible to access/modify any node in the list

Traversing a linked list

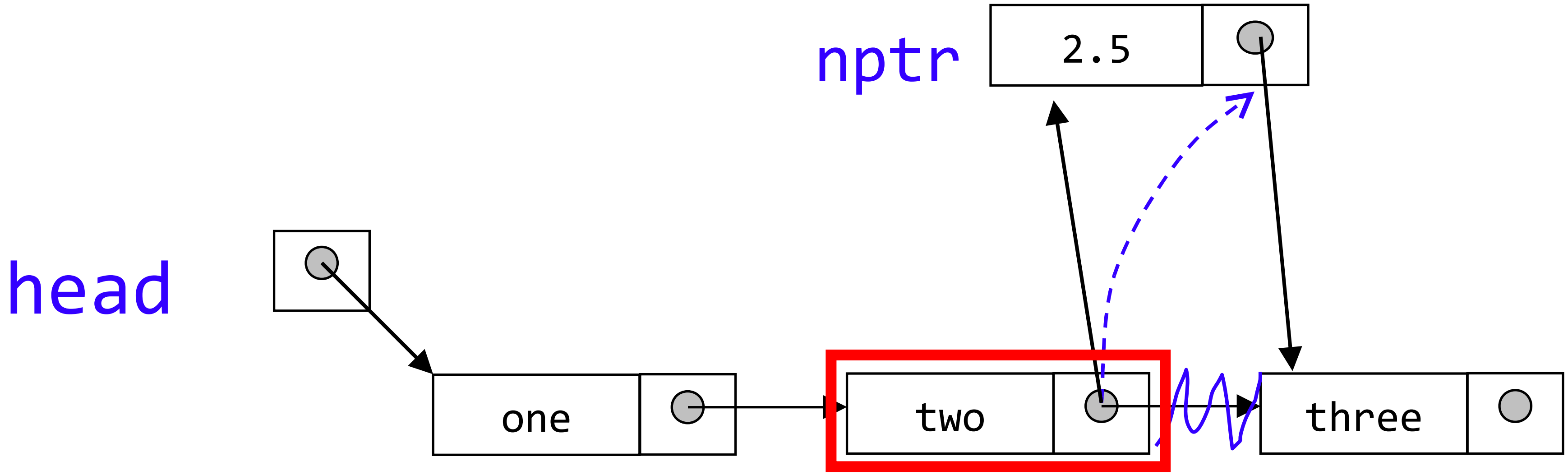
```
void show(node *head); // prints all the items of a list
  node * p = head; // p is a pointer to node, p is initialized to head

  while (p != 0) {     //iterate till you reach the last node of the list
    cout << "[num:" << p→num << ", next:" << p→next << "] -> ";
    p = p→next;    // Move p to the next node in the list
  }
  cout << "NULL" << endl;
}
```

Run demo17-linklist.cpp

Inserting after a node

You can get memory for node from OS by nptr = **new** node;



Find the node you want to insert after

First, copy the link from the node that's already in the list

Then, change the link in the node that's already in the list

See source version for animation

Activity: Think-Pair-Share

Implement a function that inserts an item at the head of a list, and returns a pointer to the new head of list.

node* insert (node *head, int item);

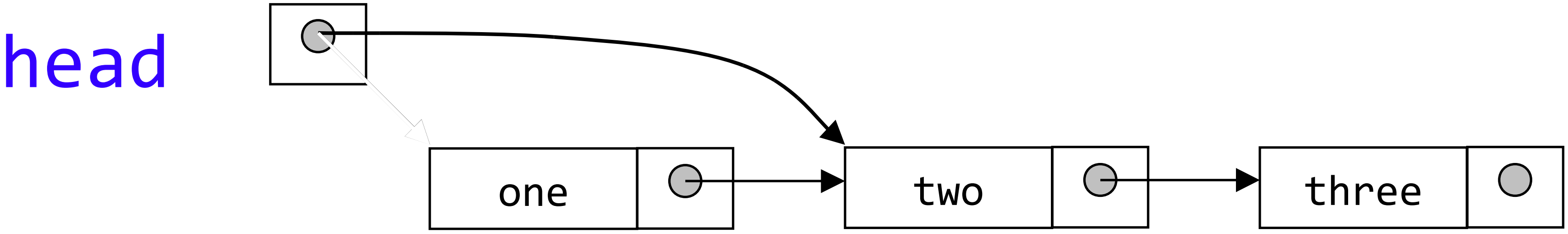
Think (individual): Write the pseudo-code for insert().

Pair: Discuss your pseudo-code with your neighbour. Together, write the C++ code for insert().

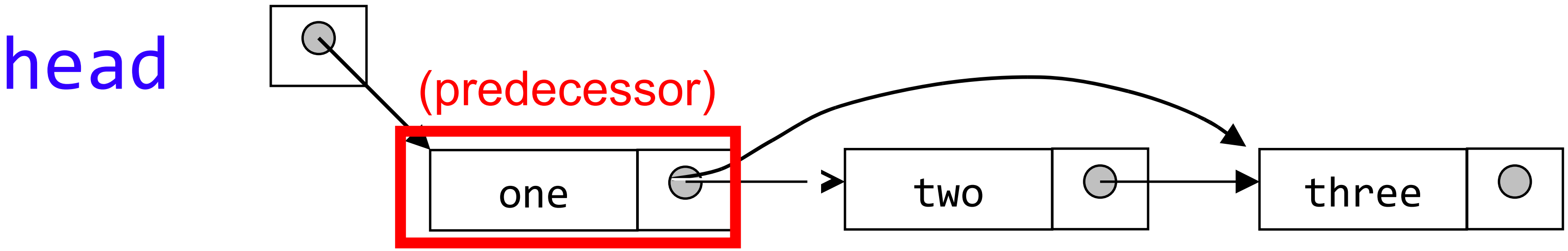
Share: Compare with demo17-linklist.cpp.

Deleting a node

- To delete the first element, change the link in the header



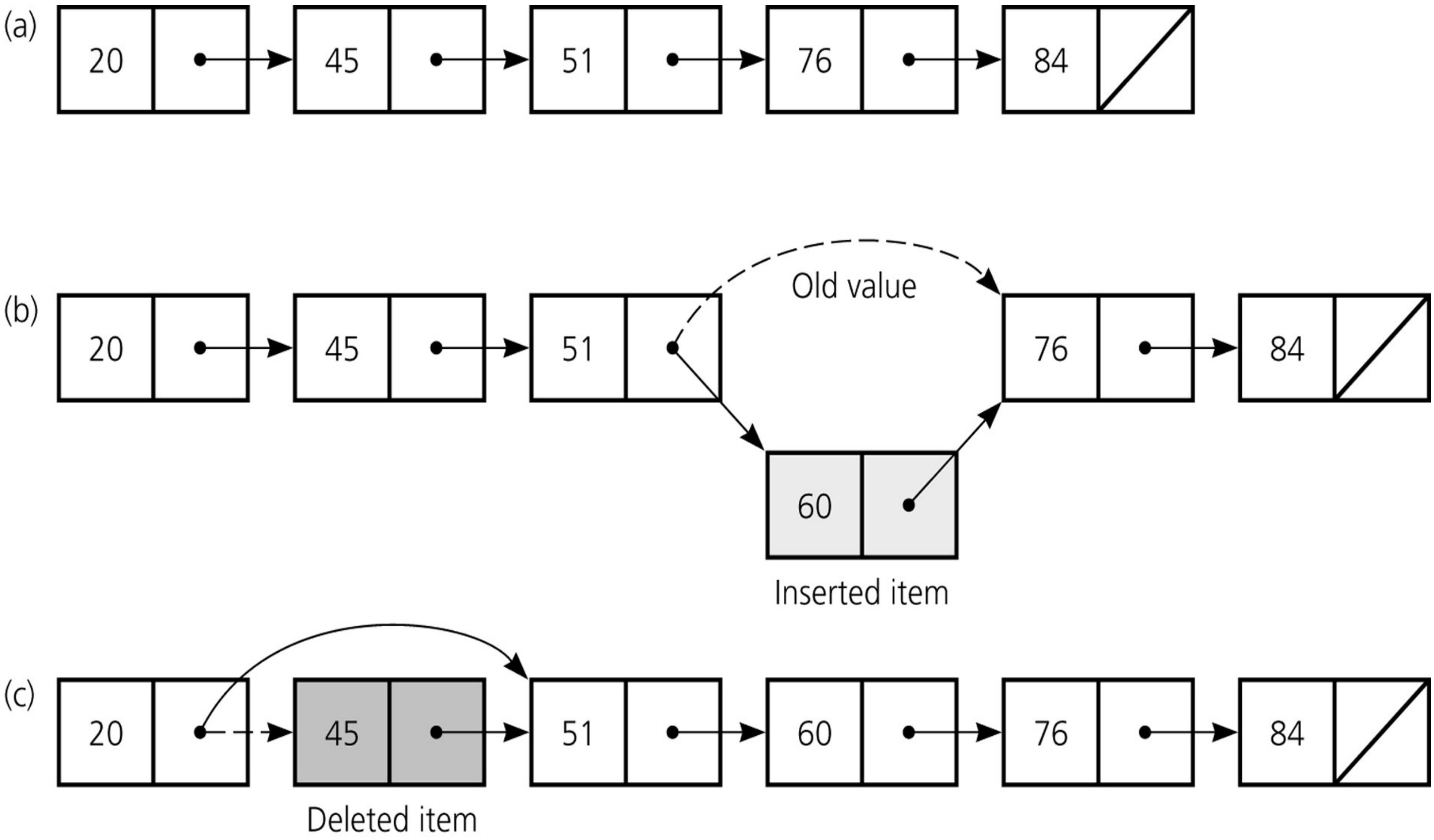
- To delete some other element, change the link in its predecessor



You can release the memory of deleted node by using **delete** nptr;
Memory of deleted nodes will be reclaimed by OS

See source version for animation

Inserting and deleting in a sorted list



a) A sorted linked list of integers; b) Insertion; c) Deletion

Commonly used linked list functions

void show(node *head); // prints all the items of a list

node* insert (node *head, int item); // inserts at the head of the list

void append(node *head, int item); //appends an item at the end of the list

node* remove(node* head, int item); //deletes first occurrence of item from the list

int length (node * head); //returns the number of nodes in a list

node* find(node* head, int item); //returns the address of the item

Run demo17-linklist.cpp

Activity: Think-Pair-Share

You have seen the code for show() and insert(). Use the ideas in them to implement append(), a function that inserts an item at the tail (end) of a list.

Think: Write the pseudo-code for append().

Pair: Discuss your pseudo-code with your neighbour. Together, write the C++ code for append().

Share: Compare with demo17-linklist.cpp.

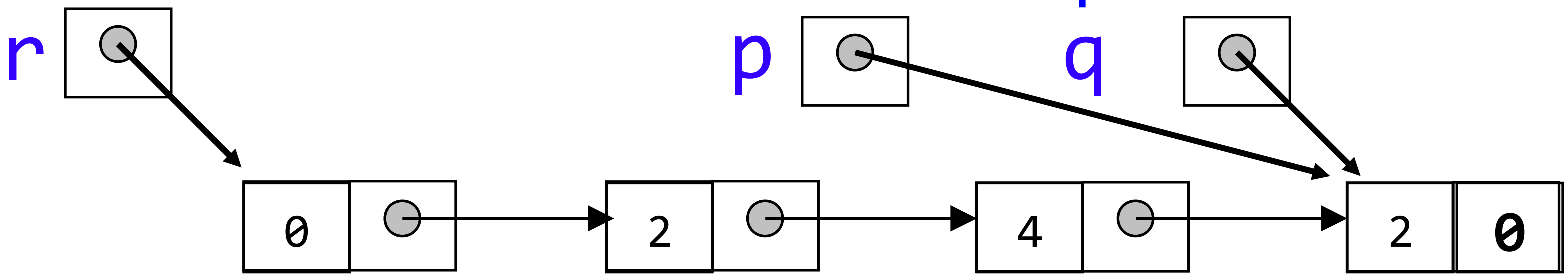
+ code walk-through of other functions in the file.

In-class Tutorial: Question 1

Show the memory configuration and output of this program:

```
struct node { int num;   node * next; };
int main() {
  node *p, *q, *r; p = new node;  r = p;
  for (int i=0; i<3; i++) { q = new node;
    q→num = i; q→next = 0;
    p→num = i*2;  p→next = q;  p = q;
  } cout << p→num << q→num << r→num;
}
```

Answer: Values output are: 2 2 0



In-class Tutorial: Question 2

Function below to find the smallest 'num' in a linked list, is not working correctly. Identify the bug and fix it.

```
int findSmallest(node* head) {
   int smallest = head→num;
   node* curr = head→next;
   while (curr != 0) {
      if (curr→num < head→num) smallest = curr→num;
      else curr = curr→next;
   }
   return smallest;
}
```

Answer:
This should be smallest
instead of head→num

Should we keep / remove this else?

In-class Tutorial: Question 3

Write a function that finds a given item in a linked list and returns the address of that item.

Answer:

```
node* find(node* head, int item) {
   node* curr = head;           // address of the current list node
   while (curr != 0) {                    // end not reached
      if (curr→num == item) break;       // item found
      else curr = curr→next;        // move curr to the next node
   }
   return curr;          // If item is not found, curr will be NULL
}
```