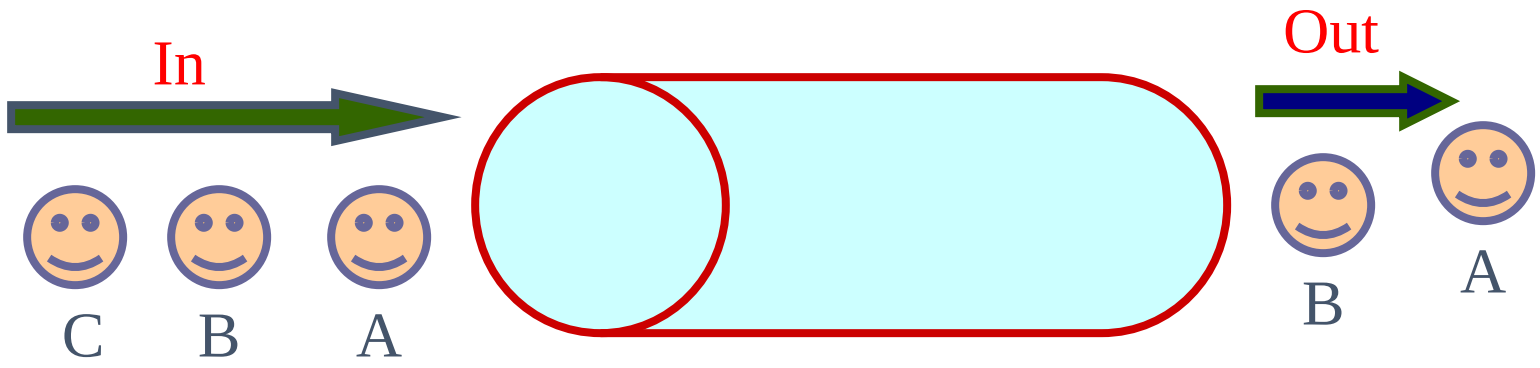
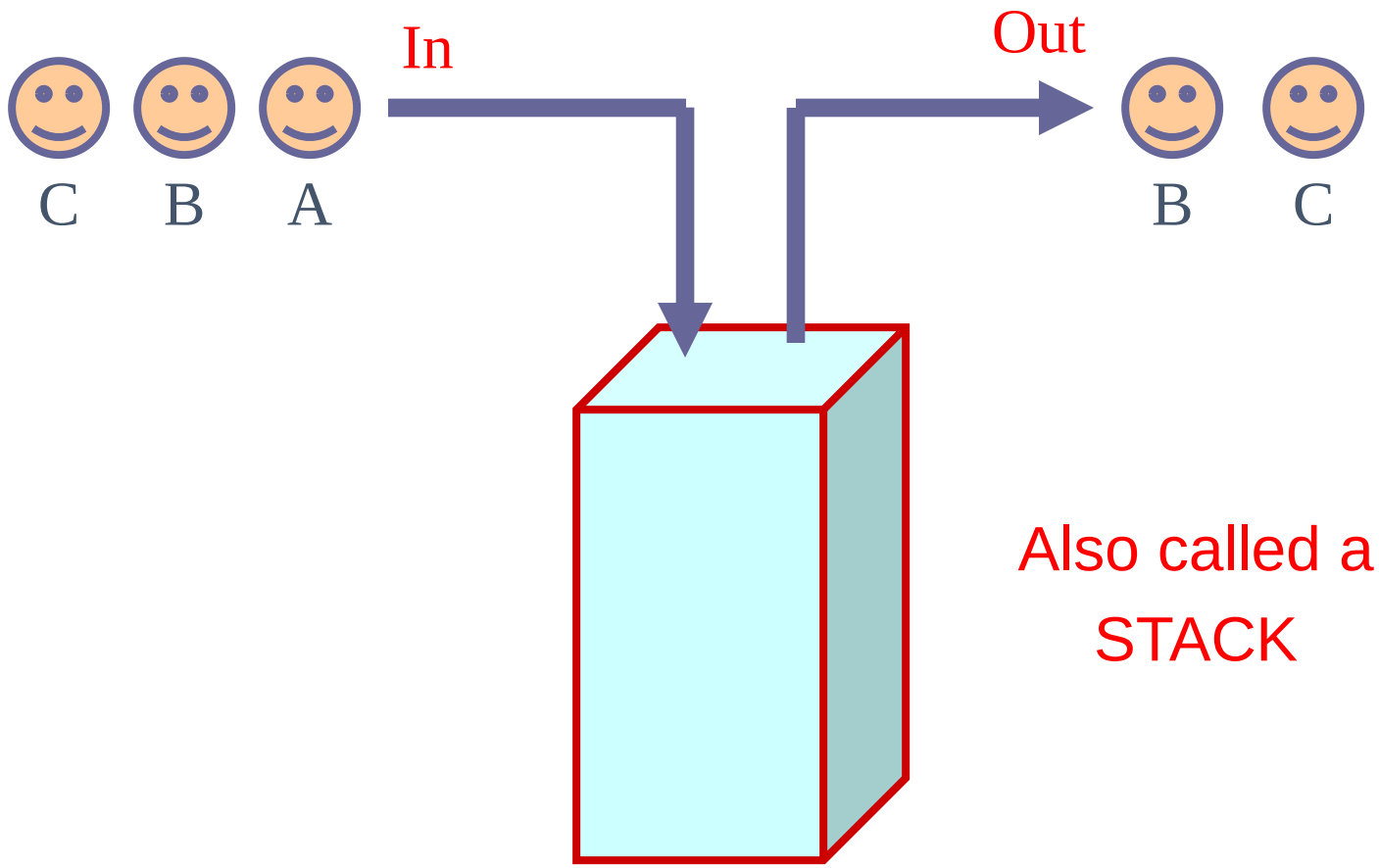
A First-in First-out (FIFO) List



Also called a QUEUE

A Last-in First-out (LIFO) List



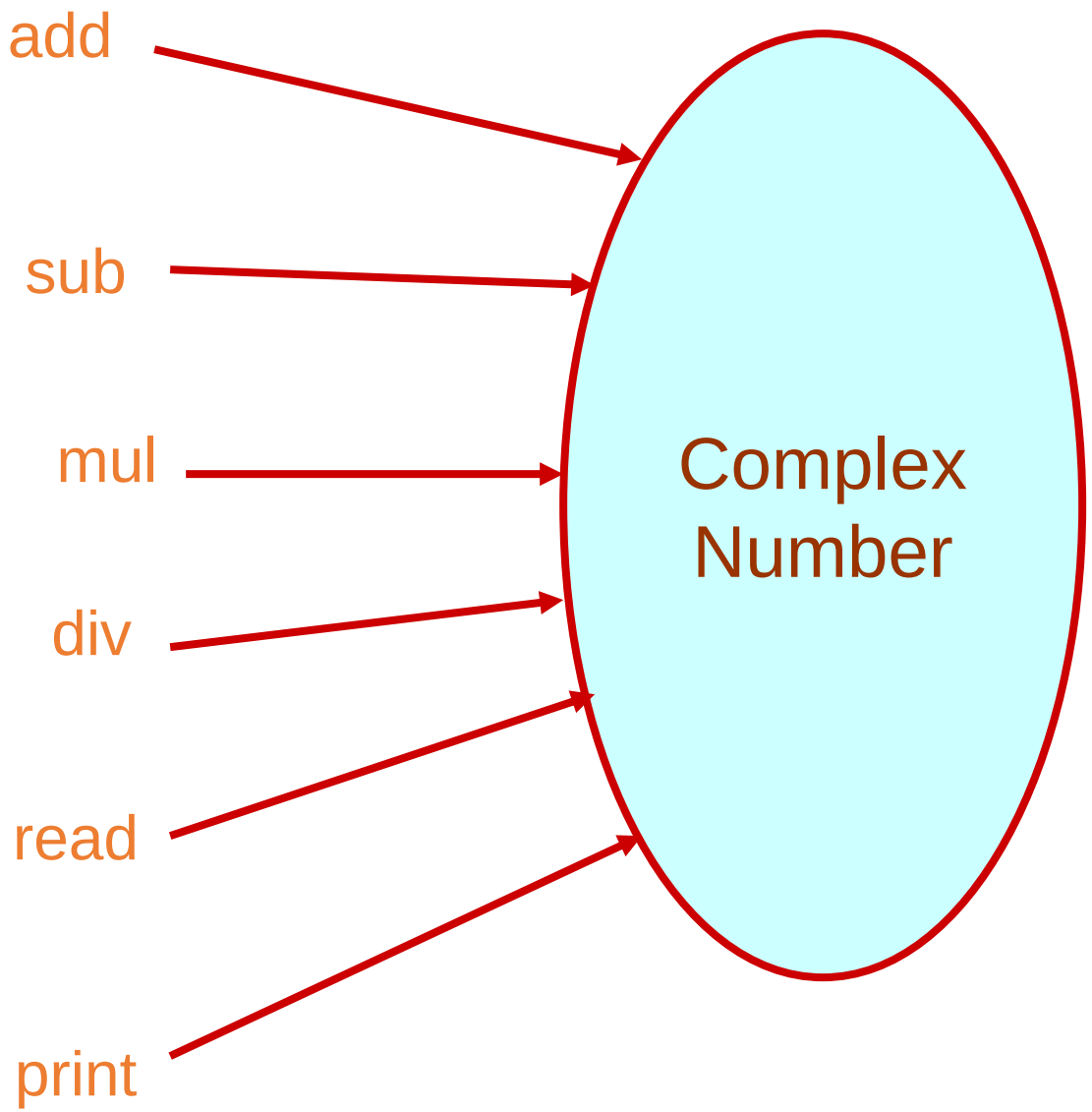
Abstract Data Types

Example 1 :: Complex numbers

```
struct cplx {
              float  re;
              float  im;
            }
typedef struct cplx complex;

complex *add (complex a, complex b);
complex *sub (complex a, complex b);
complex *mul (complex a, complex b);
complex *div (complex a, complex b);
complex *read();
void print (complex a);
```

Structure definition

Function prototypes

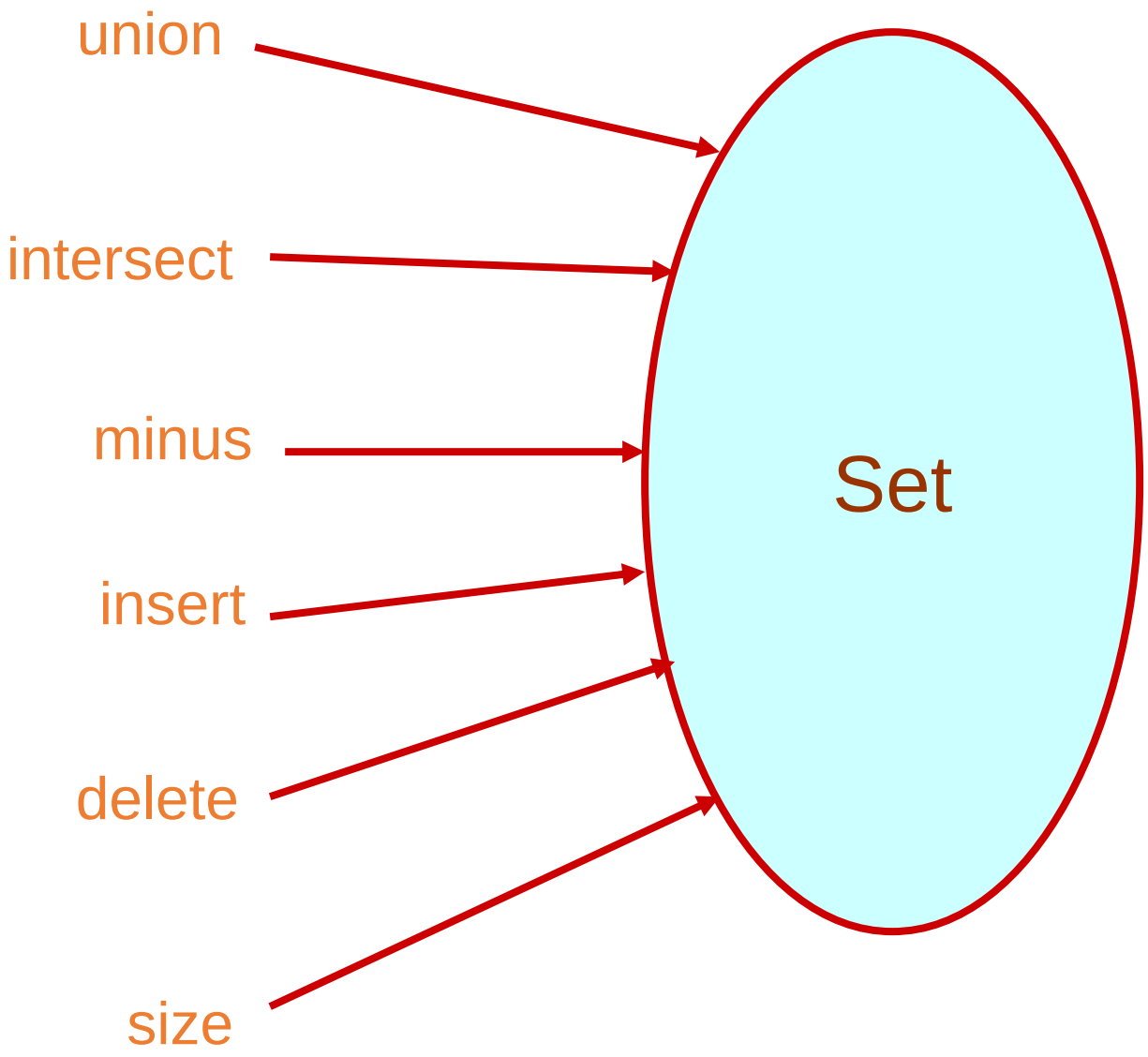

add
sub
mul
div
read
print
Complex
Number

Example 2 :: Set manipulation

```
struct node {
              int element;
              struct node *next;
            }
typedef struct node set;

set *union (set a, set b);
set *intersect (set a, set b);
set *minus (set a, set b);
void insert (set a, int x);
void delete (set a, int x);
int size (set a);
```

Structure definition

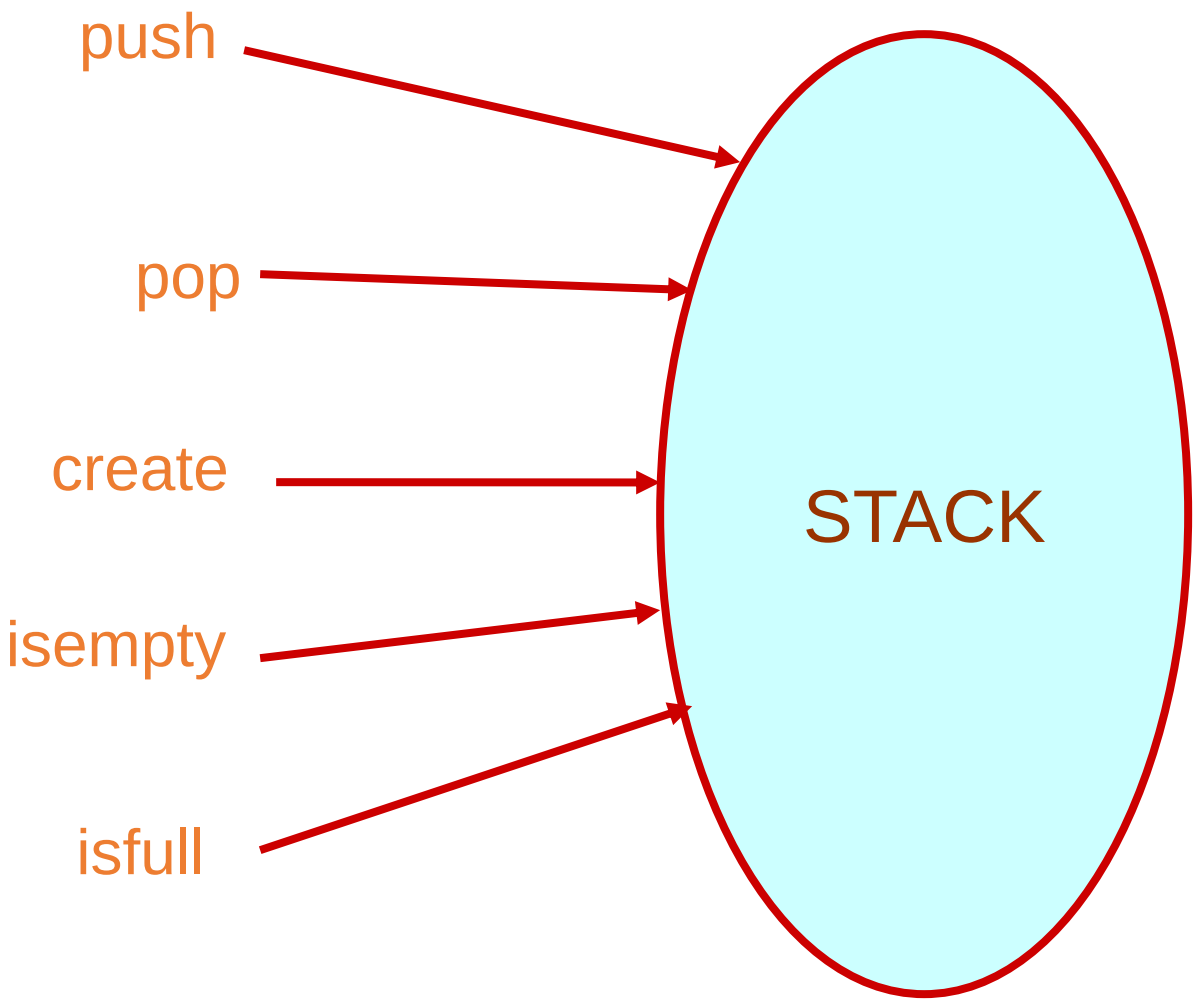
Function prototypes


union
intersect
minus
insert
delete
size
Set

Example 3 :: Last-In-First-Out STACK

Assume:: stack contains integer elements

```
void push (stack *s, int element);
                    /* Insert an element in the stack */
int pop (stack *s);
                    /* Remove and return the top element */
void create (stack  *s);
                    /* Create a new stack */
int isempty (stack *s);
                    /* Check if stack is empty */
int isfull (stack *s);
                    /* Check if stack is full */
```


push
pop
create
isempty
isfull
STACK

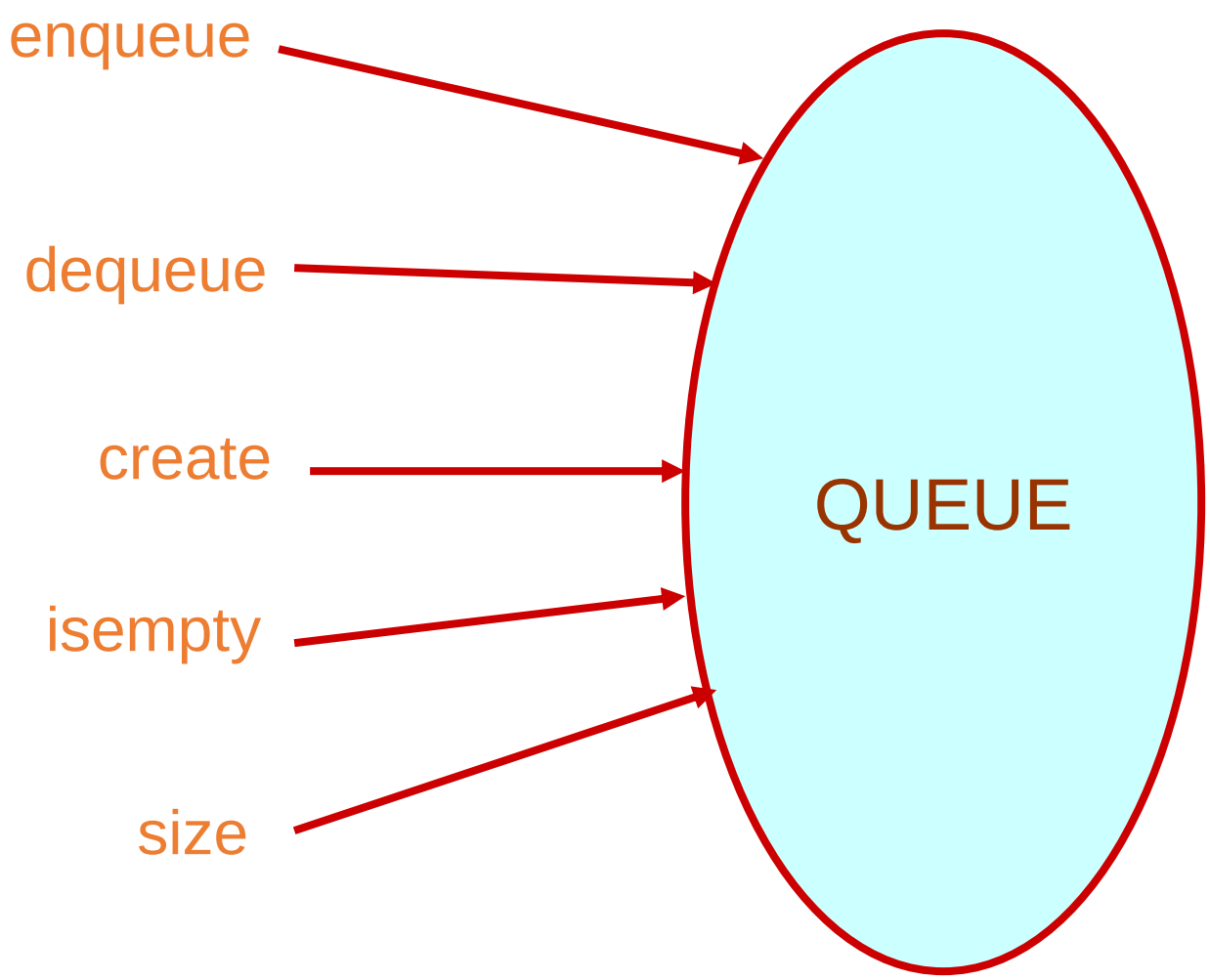
Contd.

- We shall look into two different ways of implementing stack:
  - Using arrays
  - Using linked list

Example 4 :: First-In-First-Out QUEUE

Assume:: queue contains integer elements

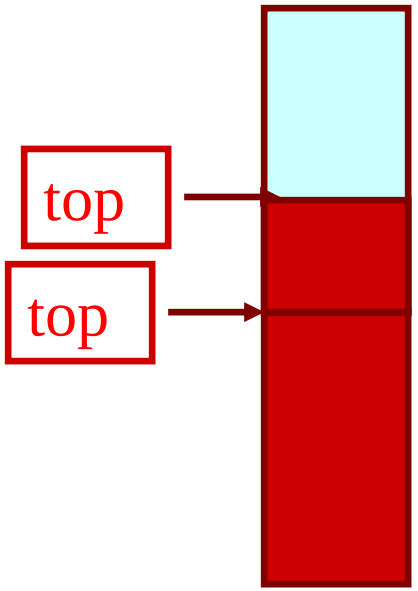
```
void enqueue (queue *q, int element);
                    /* Insert an element in the queue */
int dequeue (queue *q);
                    /* Remove an element from the queue */
queue *create();
                    /* Create a new queue */
int isempty (queue *q);
                    /* Check if queue is empty */
int size (queue *q);
                    /* Return the no. of elements in queue */
```


enqueue
dequeue
create
isempty
size
QUEUE

Stack Implementations: Using Array and Linked List

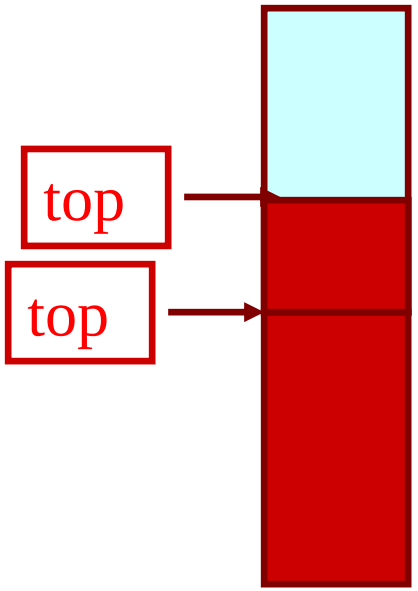
STACK USING ARRAY

PUSH



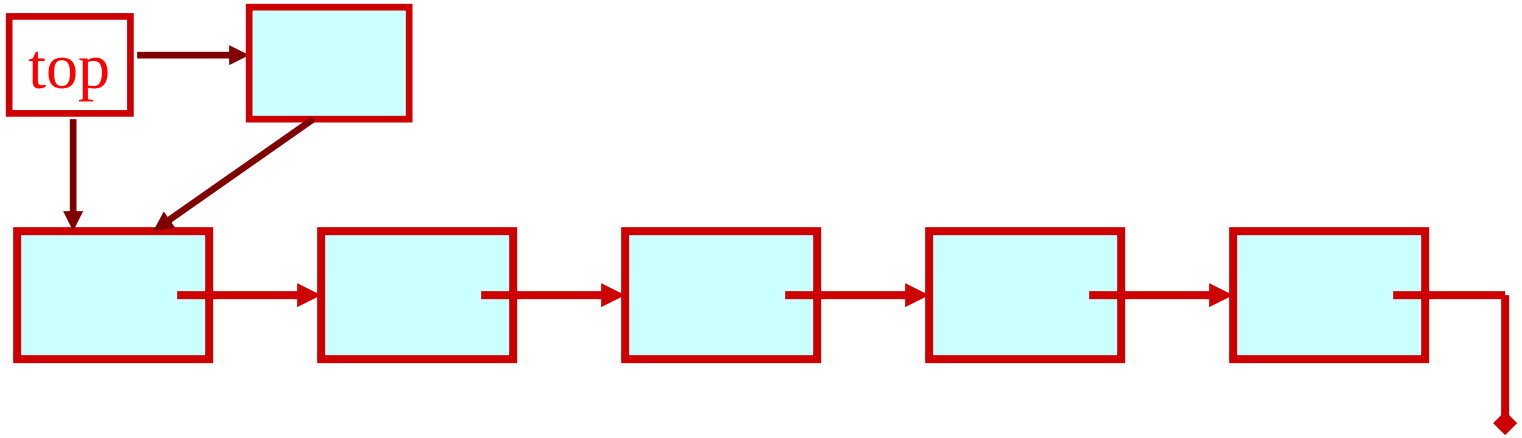
STACK USING ARRAY

POP



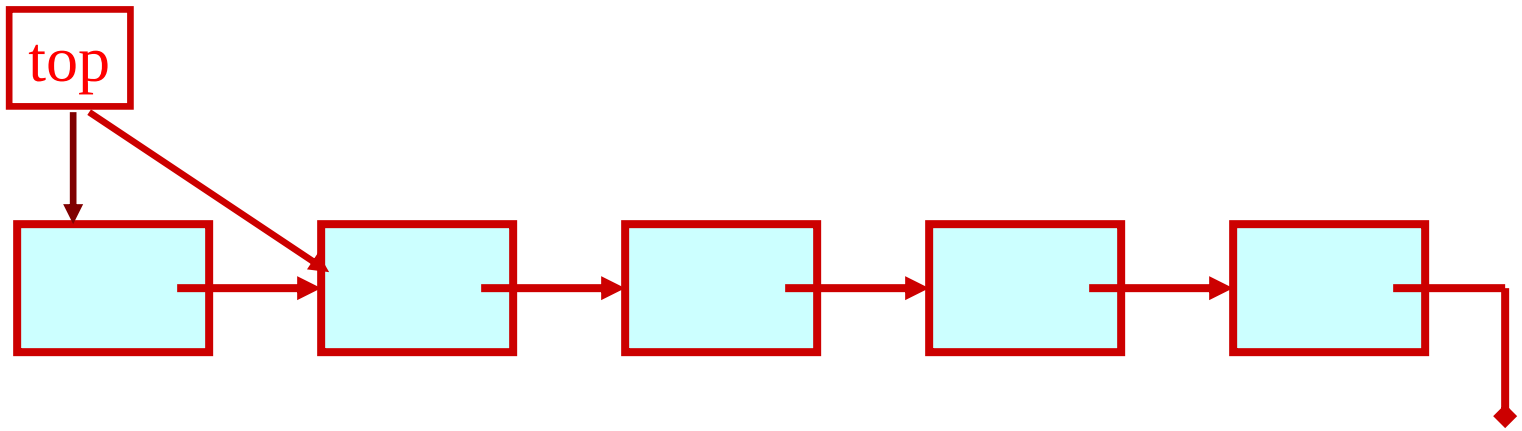
Stack: Linked List Structure

PUSH OPERATION



Stack: Linked List Structure

POP OPERATION



Basic Idea

- In the array implementation, we would:
  - Declare an array of fixed size (which determines the maximum size of the stack).
  - Keep a variable which always points to the “top” of the stack.
    - Contains the array index of the “top” element.
- In the linked list implementation, we would:
  - Maintain the stack as a linked list.
  - A pointer variable `top` points to the start of the list.
  - The first element of the linked list is considered as the stack top.

Declaration

```
#define MAXSIZE 100

struct lifo
{
   int st[MAXSIZE];
   int  top;
};
typedef struct lifo
                  stack;
stack s;
```

ARRAY

```
struct lifo
{
   int value;
   struct lifo *next;
};
typedef struct lifo
                   stack;

stack *top;
```

LINKED LIST

Stack Creation

```
void create (stack *s)
{
   s->top = -1;

   /* s->top points to
      last element
      pushed in;
      initially -1 */
}
```

ARRAY

```
void create (stack **top)
{
   *top = NULL;

   /* top points to NULL,
      indicating empty
      stack              */
}
```

LINKED LIST

Pushing an element into the stack

```
void push (stack *s, int element)
  {
     if (s->top == (MAXSIZE-1))
     {
         printf ("\n Stack overflow");
         exit(-1);
     }
     else
     {
         s->top ++;
         s->st[s->top] = element;
     }
  }
```

ARRAY

```
void push (stack **top, int element)
{
    stack *new;

    new = (stack *) malloc(sizeof(stack));
    if (new == NULL)
    {
       printf ("\n Stack is full");
       exit(-1);
    }

    new->value = element;
    new->next = *top;
    *top = new;
}
```

LINKED LIST

Popping an element from the stack

```
int pop (stack *s)
  {
     if (s->top == -1)
     {
        printf ("\n Stack underflow");
        exit(-1);
     }
     else
     {
        return (s->st[s->top--]);
     }
  }
```

ARRAY

```
int pop (stack **top)
{
    int t;
    stack *p;

    if (*top == NULL)
    {
        printf ("\n Stack is empty");
        exit(-1);
    }
    else
    {
        t = (*top)->value;
        p = *top;
        *top = (*top)->next;
        free (p);
        return t;
    }
}
```

LINKED LIST

Checking for stack empty

```
int isempty (stack *s)
{
   if (s->top == -1)
          return 1;
   else
          return (0);
}
```

ARRAY

```
int isempty (stack *top)
{
   if (top == NULL)
         return (1);
    else
         return (0);
}
```

LINKED LIST

Checking for stack full

```
int isfull (stack *s)
{
   if (s->top ==
            (MAXSIZE-1))
        return 1;
   else
        return (0);
}
```

ARRAY

- Not required for linked list implementation.
- In the `push()` function, we can check the return value of `malloc()`.
  - If -1, then memory cannot be allocated.

LINKED LIST

Example main function :: array

```
#include <stdio.h>
#define MAXSIZE 100

struct lifo
{
   int st[MAXSIZE];
   int  top;
};
typedef struct lifo stack;
```

```
main()
{
  stack A, B;
  create(&A);  create(&B);
  push(&A,10);
  push(&A,20);
  push(&A,30);
  push(&B,100);  push(&B,5);

  printf ("%d %d", pop(&A),
                   pop(&B));

  push (&A, pop(&B));

  if (isempty(&B))
    printf ("\n B is empty");
}
```

Example main function :: linked list

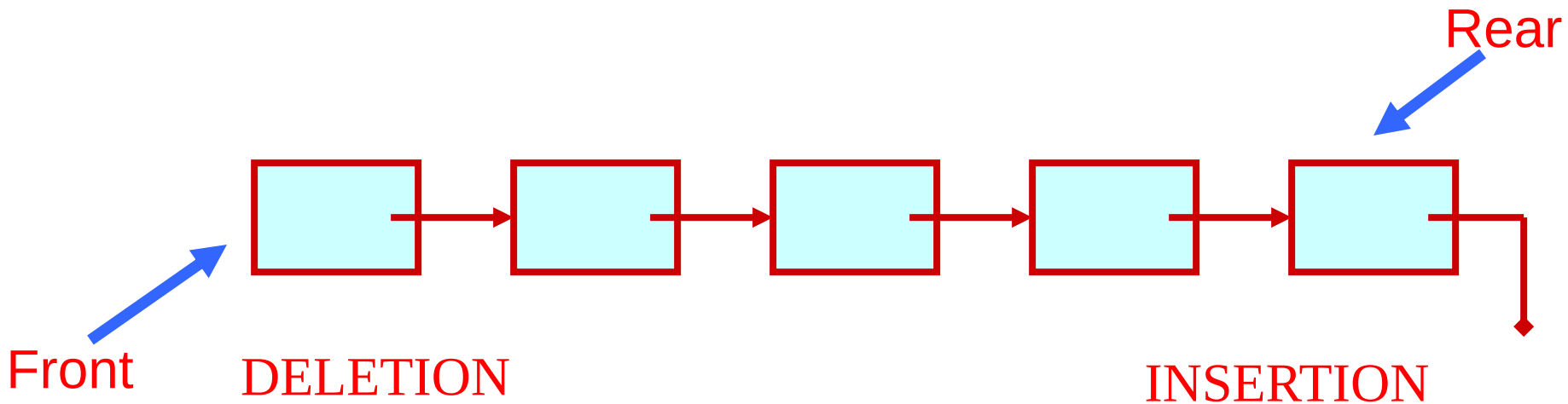
```
#include <stdio.h>
struct lifo
{
    int value;
    struct lifo *next;
};
typedef struct lifo stack;
```

```
main()
{
  stack *A, *B;
  create(&A); create(&B);
  push(&A,10);
  push(&A,20);
  push(&A,30);
  push(&B,100);
  push(&B,5);

  printf ("%d %d",
        pop(&A), pop(&B));

  push (&A, pop(&B));

  if (isempty(B))
    printf ("\n B is
  empty");
}
```

Queue Implementation using Linked List

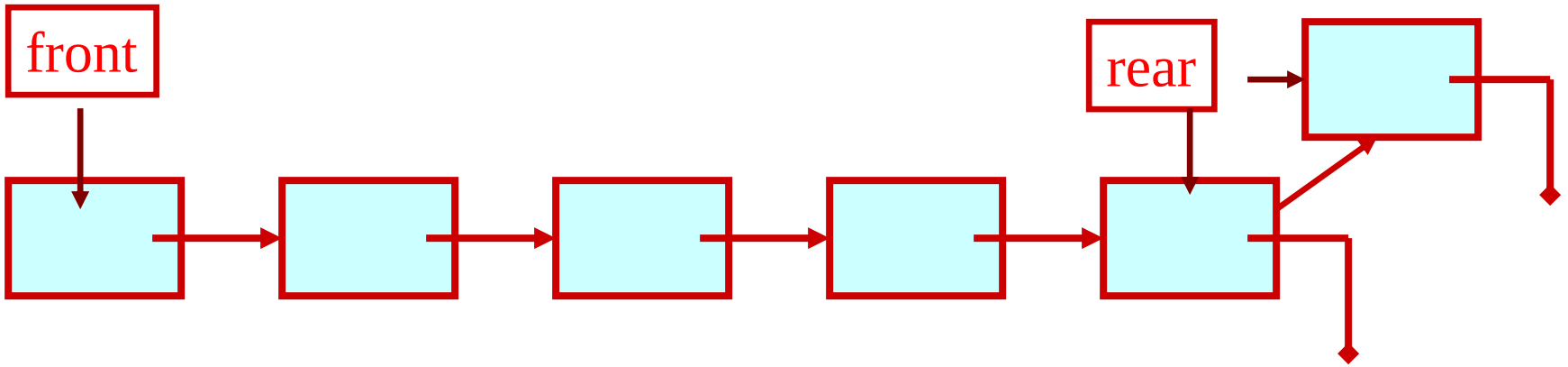
Basic Idea

- Basic idea:
  - Create a linked list to which items would be added to one end and deleted from the other end.
  - Two pointers will be maintained:
    - One pointing to the beginning of the list (point from where elements will be deleted).
    - Another pointing to the end of the list (point where new elements will be inserted).



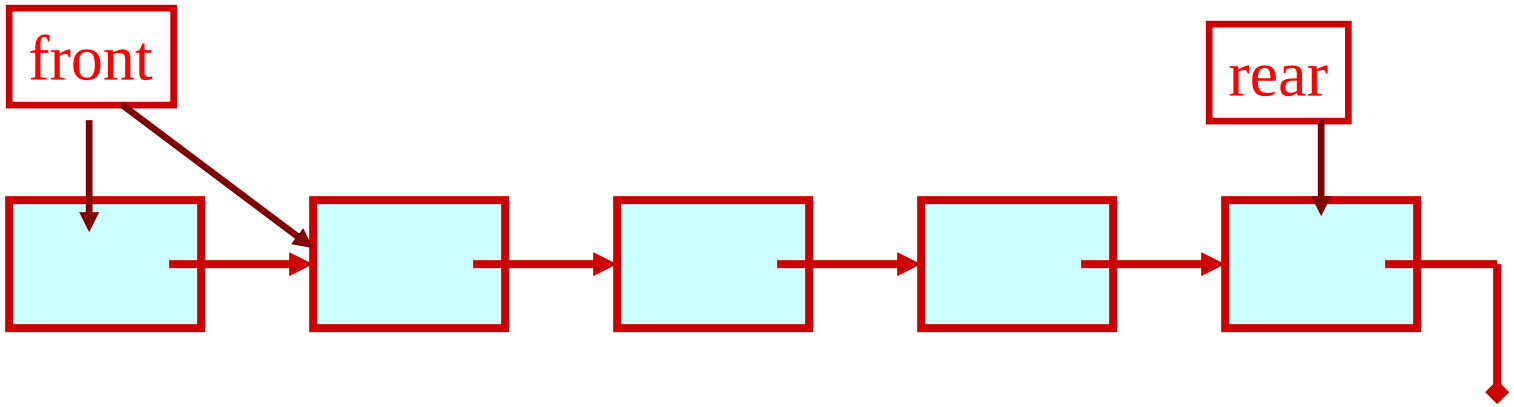
QUEUE: LINKED LIST STRUCTURE

ENQUEUE



QUEUE: LINKED LIST STRUCTURE

DEQUEUE



QUEUE using Linked List

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

struct node{
        char name[30];
        struct node *next;
    };

typedef struct node _QNODE;

typedef struct {
    _QNODE *queue_front, *queue_rear;
     } _QUEUE;
```

```
_QNODE *enqueue (_QUEUE *q, char x[])
{
_QNODE *temp;
temp= (_QNODE *)
        malloc (sizeof(_QNODE));
if (temp==NULL){
printf("Bad allocation \n");
return NULL;
}
strcpy(temp->name,x);
temp->next=NULL;
```

```
if(q->queue_rear==NULL)
{
q->queue_rear=temp;
q->queue_front=
     q->queue_rear;
}
else
{
q->queue_rear->next=temp;
q->queue_rear=temp;
}
return(q->queue_rear);
}
```

```
char  *dequeue(_QUEUE *q,char x[])
{
_QNODE *temp_pnt;

if(q->queue_front==NULL){
q->queue_rear=NULL;
printf("Queue is empty \n");
return(NULL);
}
```

```
else{
strcpy(x,q->queue_front->name);
temp_pnt=q->queue_front;
q->queue_front=
        q->queue_front->next;
free(temp_pnt);
if(q->queue_front==NULL)
q->queue_rear=NULL;
return(x);
  }
}
```

```
void init_queue(_QUEUE *q)
{
 q->queue_front= q->queue_rear=NULL;
}

int isEmpty(_QUEUE *q)
{
 if(q==NULL) return 1;
 else return 0;
}
```

```
main()
{
int i,j;
char command[5],val[30];
_QUEUE q;

 init_queue(&q);

command[0]='\0';
printf("For entering a name use 'enter <name>'\n");
printf("For  deleting  use 'delete' \n");
printf("To end the session use 'bye' \n");
while(strcmp(command,"bye")){
scanf("%s",command);
```

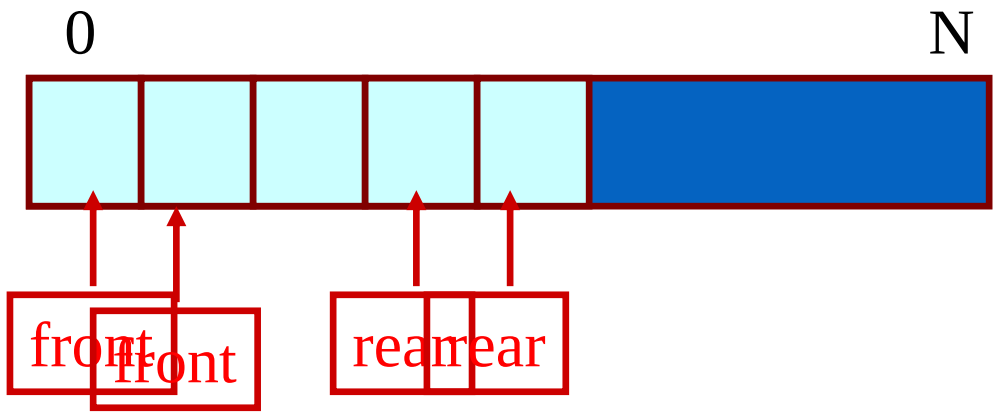
```
if(!strcmp(command,"enter")) {
scanf("%s",val);
if((enqueue(&q,val)==NULL))
printf("No more pushing please \n");
else printf("Name entered %s \n",val);
}
```

```
if(!strcmp(command,"delete")) {
if(!isEmpty(&q))
printf("%s \n",dequeue(&q,val));
else printf("Name deleted %s \n",val);
}
} /* while */
printf("End session \n");
}
```

Problem With Array Implementation

ENQUEUE DEQUEUE

Effective queuing storage area of array gets reduced.



Use of circular array indexing

Queue: Example with Array Implementation

```
#define MAX_SIZE  100

typedef struct { char name[30];
        } _ELEMENT;

typedef struct {
        _ELEMENT q_elem[MAX_SIZE];
         int rear;
         int front;
         int full,empty;
         } _QUEUE;
```

Queue Example: Contd.

```
void init_queue(_QUEUE *q)
{q->rear= q->front= 0;
 q->full=0; q->empty=1;
}

 int  IsFull(_QUEUE *q)
{return(q->full);}

 int  IsEmpty(_QUEUE *q)
{return(q->empty);}
```

Queue Example: Contd.

```
void AddQ(_QUEUE *q, _ELEMENT ob)
{
  if(IsFull(q)) {printf("Queue is Full \n"); return;}

  q->rear=(q->rear+1)%(MAX_SIZE);
  q->q_elem[q->rear]=ob;

  if(q->front==q->rear) q->full=1; else q->full=0;
  q->empty=0;

 return;
}
```

Queue Example: Contd.

```
_ELEMENT DeleteQ(_QUEUE *q)
 {
  _ELEMENT temp;
   temp.name[0]='\0';

     if(IsEmpty(q)) {printf("Queue is EMPTY\n");return(temp);}

     q->front=(q->front+1)%(MAX_SIZE);
     temp=q->q_elem[q->front];

     if(q->rear==q->front) q->empty=1; else q->empty=0;
     q->full=0;

   return(temp);
 }
```

Queue Example: Contd.

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
```

```
main()
{
int i,j;
char command[5];
_ELEMENT ob;
_QUEUE A;

  init_queue(&A);

  command[0]='\0';
  printf("For adding a name use 'add [name]'\n");
  printf("For deleting  use 'delete' \n");
  printf("To end the session use 'bye' \n");
```

Queue Example: Contd.

```
while (strcmp(command,"bye")!=0){
    scanf("%s",command);

      if(strcmp(command,"add")==0) {
       scanf("%s",ob.name);
       if (IsFull(&A))
      printf("No more insertion please \n");
      else {
       AddQ(&A,ob);
        printf("Name inserted %s \n",ob.name);
            }
                                          }
```

Queue Example: Contd.

```
        if (strcmp(command,"delete")==0) {
            if (IsEmpty(&A))
                printf("Queue is empty \n");
                else {
                        ob=DeleteQ(&A);
                         printf("Name deleted %s \n",ob.name);
                        }
                                                    }
        }  /* End of while */
  printf("End session \n");
}
```