Computer Programming

Dr. Deepak B Phatak
Dr. Supratik Chakraborty
Department of Computer Science and Engineering
IIT Bombay

Session: Pointers and Dynamic Memory – Part 2

Quick Recap of Relevant Topics

- Variables and pointers to variables in C++
- “Address of” operator: &
- “Content of” operator: *
- Storage on stack segment and data segment (heap)
- “new” construct in C++

Overview of This Lecture

- Persistence of dynamically allocated memory
- Explicitly de-allocating dynamically allocated memory
- Good programming practices when de-allocating dynamic memory

Dynamically Allocating Memory in a Function


```
int * readQuizMarks(int n);
int main()
{ int numStudents; int * qMarks;
  cout << "Given student count: " << endl;
  cin >> numStudents;
  cout << "Give marks of students" << endl;
  qMarks = readQuizMarks(numStudents);
  //  Print max and min marks
  return 0;
}
```

Dynamically Allocating Memory in a Function

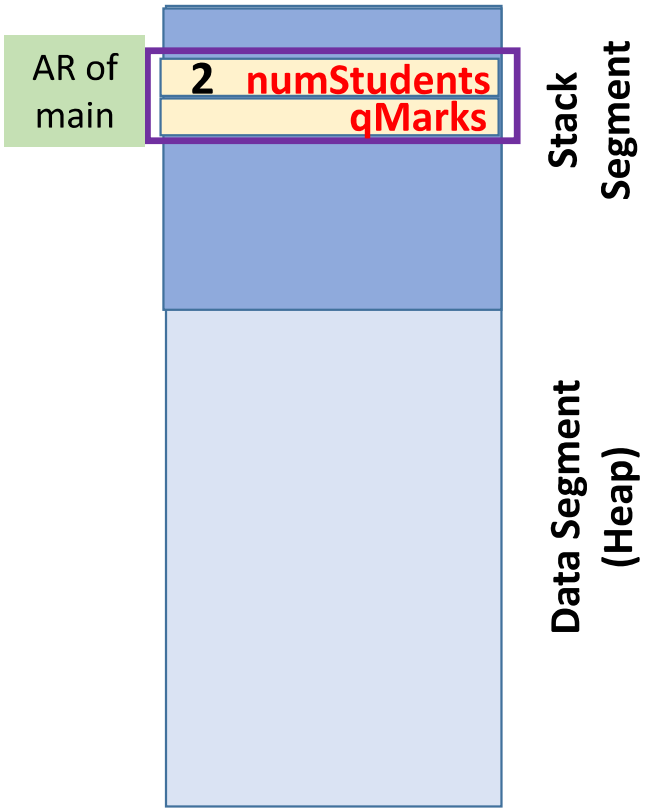

```
int * readQuizMarks(int n);
int main()
{ int numStudents; int * qMarks;
  cout << "Given student count: " << endl;
  cin >> numStudents;
  cout << "Give marks of students" << endl;
  qMarks = readQuizMarks(numStudents);
  //  Print max and min marks
  return 0;
}
```

```
// PRECONDITION: n > 0
int * readQuizMarks(int n)
{ int * marks, i;
  marks = new int[n];
  if (marks == NULL) {return NULL;}
  for (i = 0; i<n; i++) {cin >> marks[i];}
  return marks;
}
// POSTCONDITION: Marks stored
// in dynamic array that is returned
```

Dynamically Allocating Memory in a Function

IIT Bombay

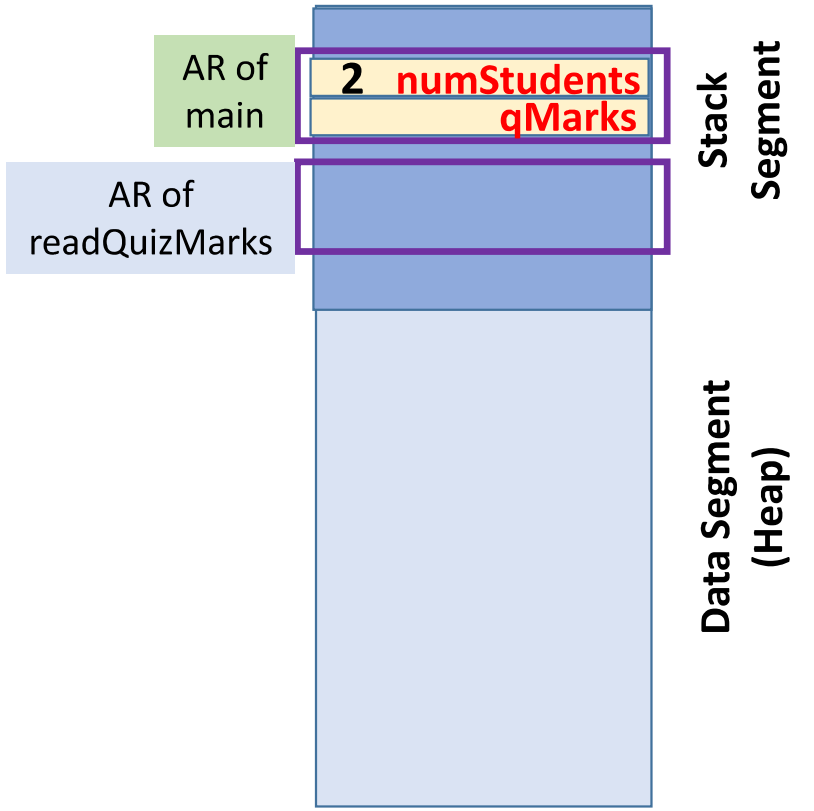
```
int main()
{ int numStudents; int * qMarks;
  cout << "Given student count: " << endl;
  cin >> numStudents;
  cout << "Give marks of students" << endl;
  qMarks = readQuizMarks(numStudents);
  //  Print max and min marks
  return 0;
}
```



Dynamically Allocating Memory in a Function

IIT Bombay

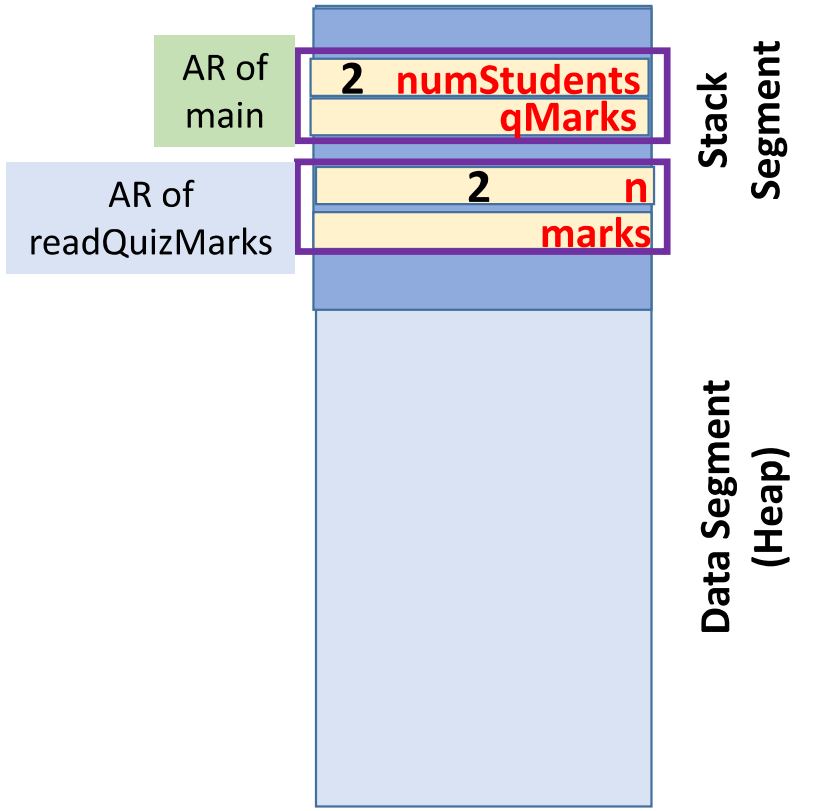
```
int * readQuizMarks(int n)
{ int * marks, i;
  marks = new int[n];
  if (marks == NULL) {
    return NULL;
  }
  for (i = 0; i < n; i++) {
    cin >> marks[i];
  }
  return marks;
}
```



Dynamically Allocating Memory in a Function

IIT Bombay

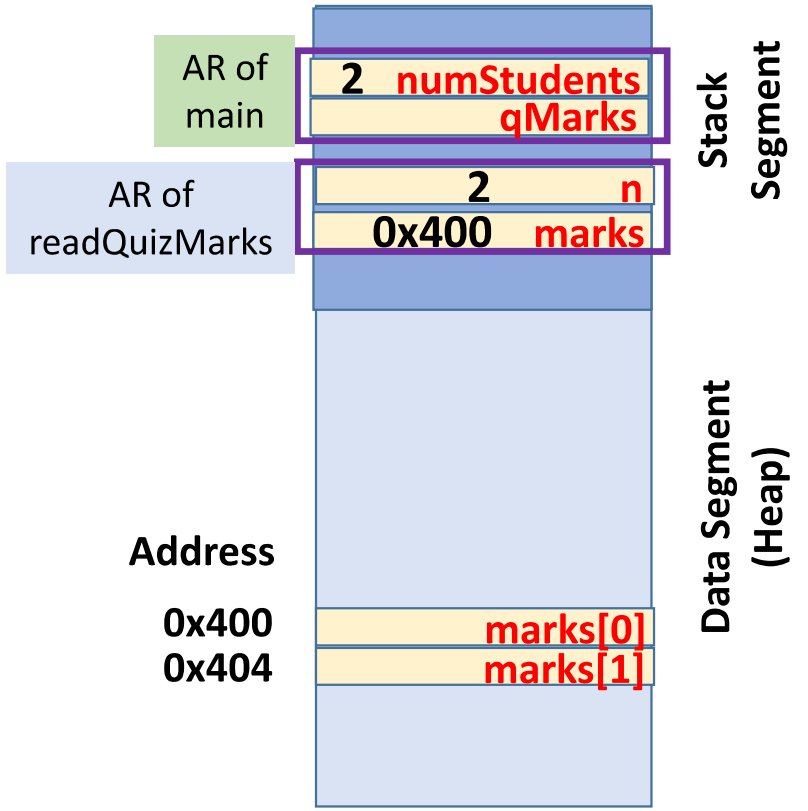
```
int * readQuizMarks(int n)
{ int * marks, i;
  marks = new int[n];
  if (marks == NULL) {
    return NULL;
  }
  for (i = 0; i < n; i++) {
    cin >> marks[i];
  }
  return marks;
}
```



Dynamically Allocating Memory in a Function

IIT Bombay

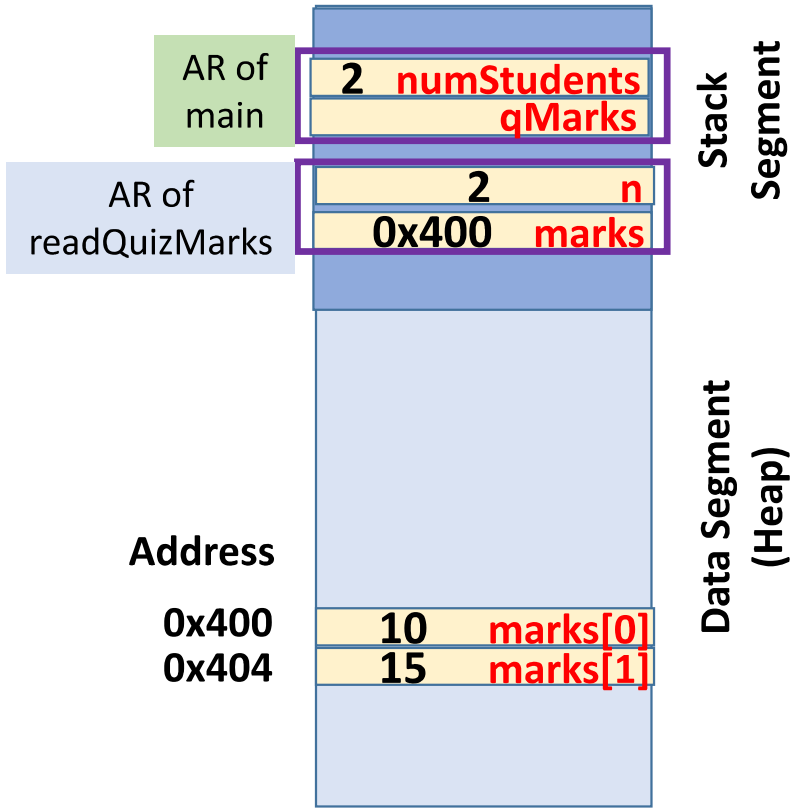
```
int * readQuizMarks(int n)
{ int * marks, i;
  marks = new int[n];
  if (marks == NULL) {
    return NULL;
  }
  for (i = 0; i < n; i++) {
    cin >> marks[i];
  }
  return marks;
}
```



Dynamically Allocating Memory in a Function

IIT Bombay

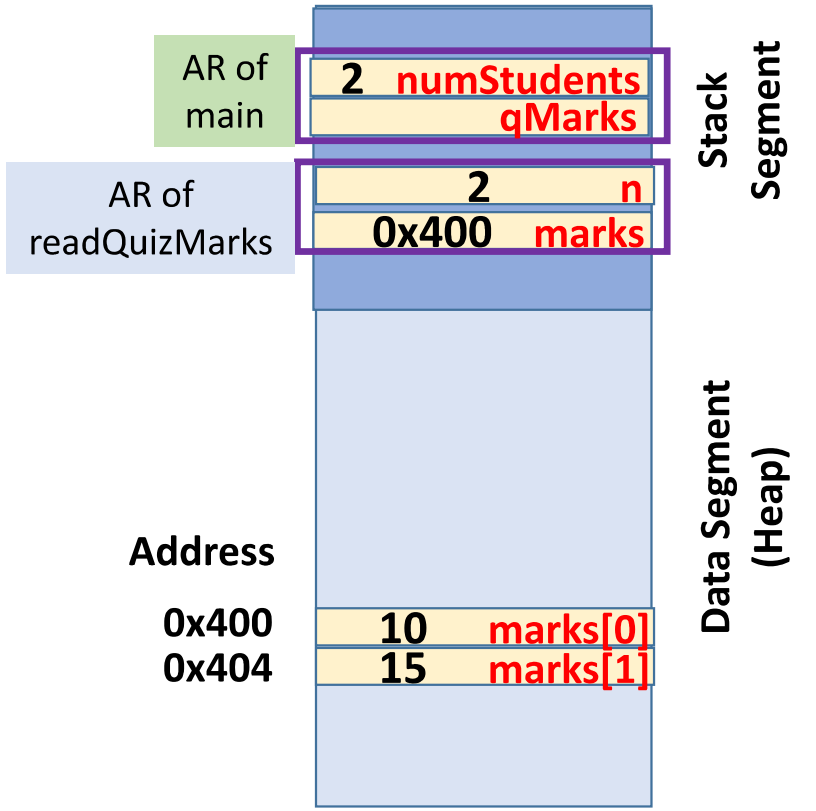
```
int * readQuizMarks(int n)
{ int * marks, i;
  marks = new int[n];
  if (marks == NULL) {
    return NULL;
  }
  for (i = 0; i < n; i++) {
    cin >> marks[i];
  }
  return marks;
}
```



Dynamically Allocating Memory in a Function

IIT Bombay

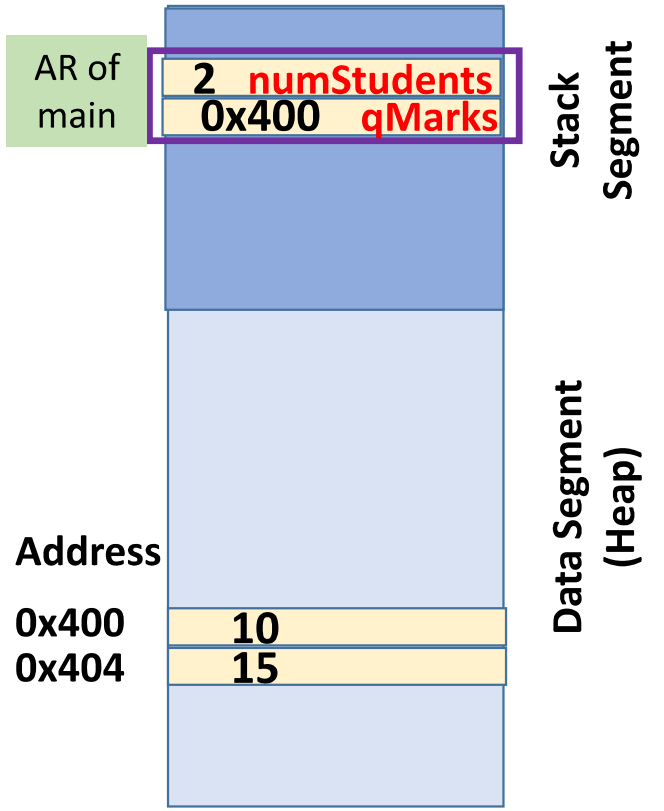
```
int * readQuizMarks(int n)
{ int * marks, i;
  marks = new int[n];
  if (marks == NULL) {
    return NULL;
  }
  for (i = 0; i < n; i++) {
    cin >> marks[i];
  }
  return marks;
}
```



Can Caller Access Memory Allocated by Callee?

IIT Bombay

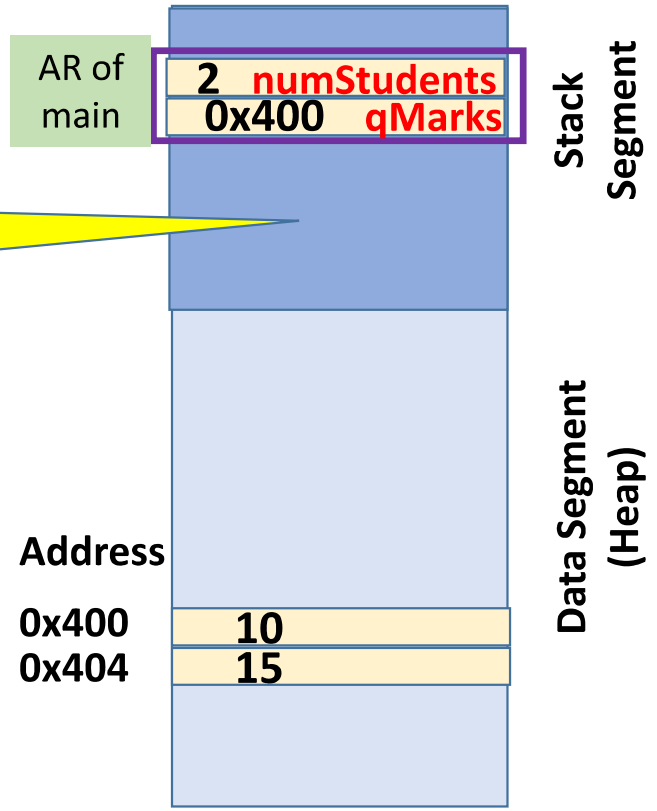
```
int main()
{ int numStudents; int *qMarks;
  cout << "Given student count: " << endl;
  cin >> numStudents;
  cout << "Give marks of students" << endl;
  qMarks = readQuizMarks(numStudents);
  //  Print max and min marks
  return 0;
}
```



Can Caller Access Memory Allocated by Callee?

IIT Bombay

```
int main()
{
  Activation record of
  readQuizMarks non-existent in
  stack segment
ndl;
  cout << "Give marks of students" << endl;
  qMarks = readQuizMarks(numStudents);
  //  Print max and min marks
  return 0;
}
```



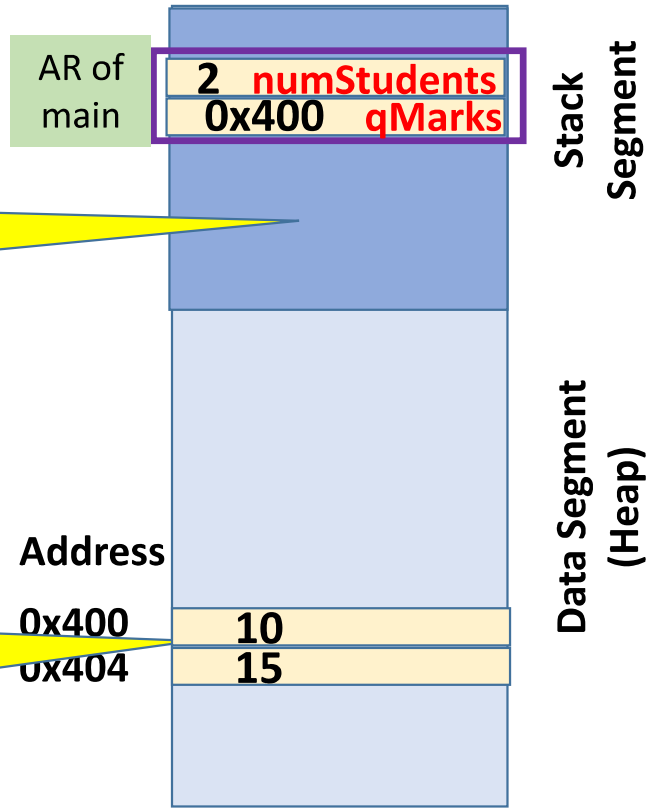
Can Caller Access Memory Allocated by Callee?

IIT Bombay

```
int main()
{
    ...
    ndl;
    cout << "Give marks of students" << endl;
    qMarks = readQuizMarks(numStudents);
    ...
}
```

Activation record of readQuizMarks non-existent in stack segment

Memory dynamically allocated in readQuizMarks persists

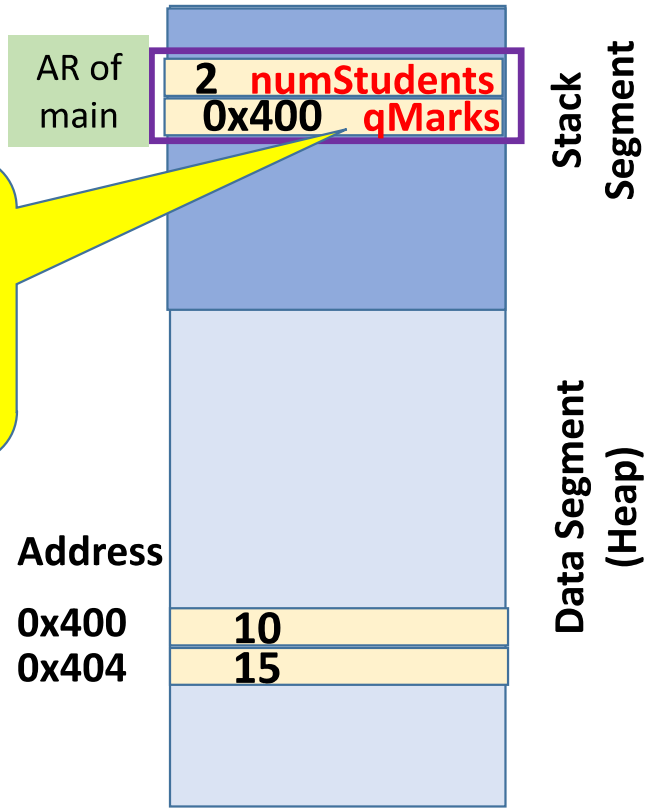


Can Caller Access Memory Allocated by Callee?

IIT Bombay

```
int main()
{
  qMarks = readQuizMarks(numStudents);
  // Print max and min marks
  return 0;
}
```

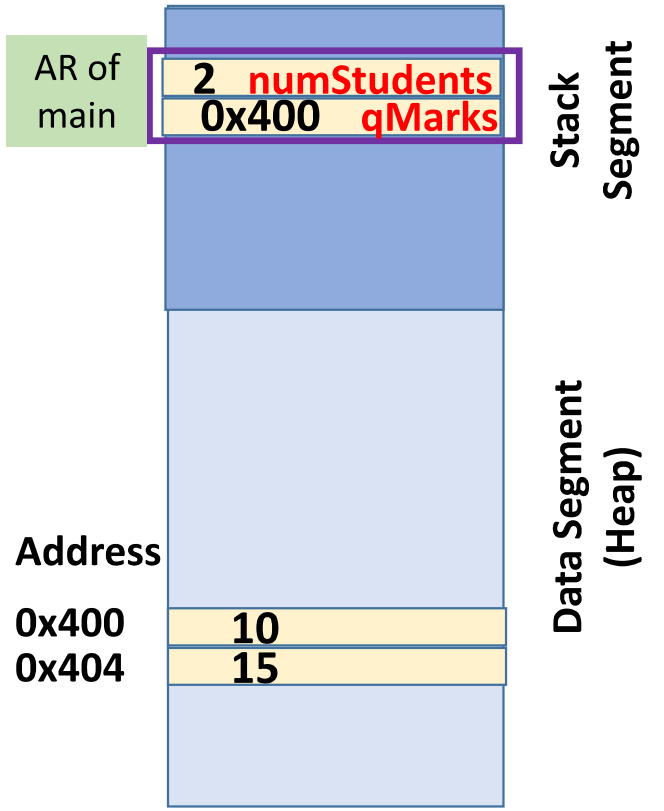
"main" has address of memory dynamically allocated in readQuizMarks.
Can access this memory from "main"



Accessing Memory Allocated by Callee

IIT Bombay

```
int main()  { …  … …
  if (qMarks == NULL) { return -1; }
  int i, min = qMarks[0], max = qMarks[0];
  for (i = 1; i < numStudents; i++) {
    if (qMarks[i] < min) { min = qMarks[i];}
    if (qMarks[i] > max) {max = qMarks[i];}
  }
  cout << "Min: " << min << endl;
  cout << " Max: " << max << endl;
  return 0;}
```

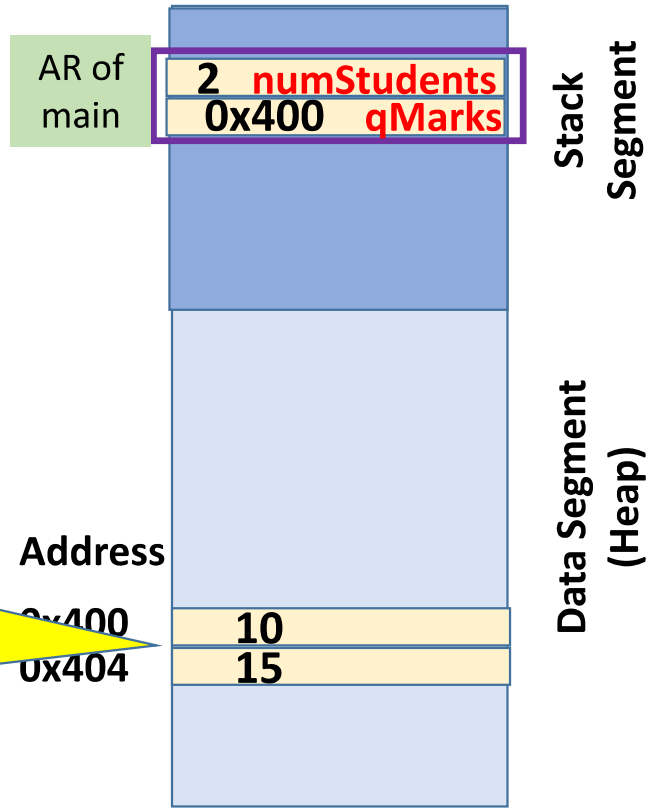


Accessing Memory Allocated by Callee

IIT Bombay

```
int main()  { …  … …
  if (qMarks == NULL) { return -1; }
  int i, min = qMarks[0], max = qMarks[0];
  for (i = 1; i < numStudents; i++) {
    if (qMarks[i] < min) { min = qMarks[i];}
    if (qMarks[i] > max) {max = qMarks[i];}
  }
  return 0;}
```

When is this memory freed (de-allocated) ?



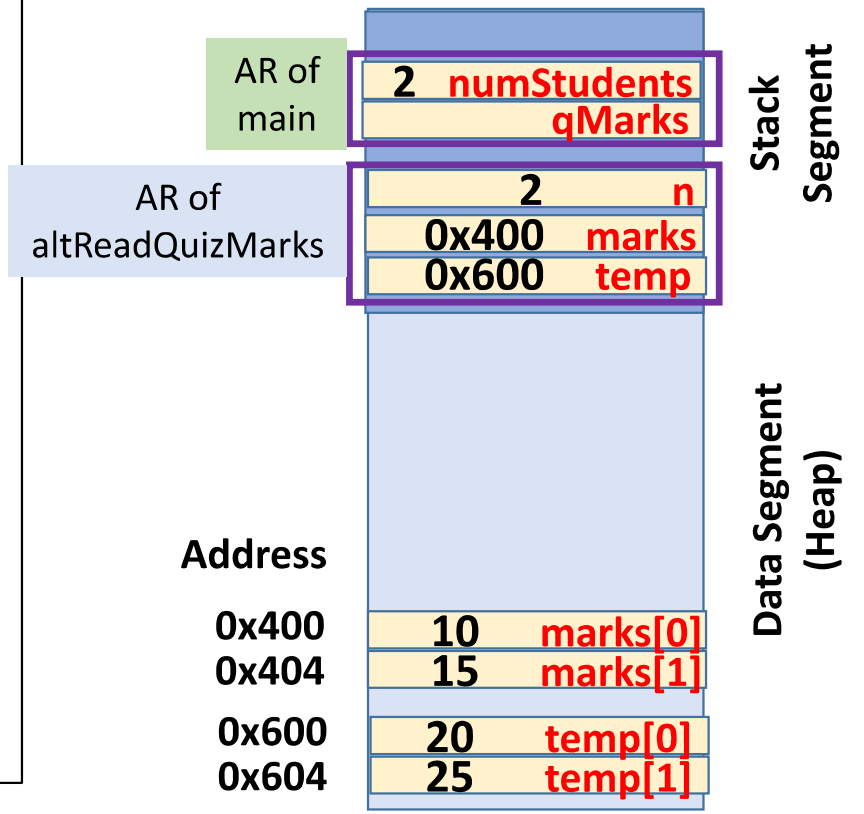
Freeing Dynamically Allocated Memory

- Memory dynamically allocated by a function **not automatically de-allocated (freed)** when the function returns
- Unless explicitly de-allocated, dynamically allocated memory persists until program ends execution
  - Can be very wasteful of memory

Persistence of Dynamically Allocated Memory

IIT Bombay

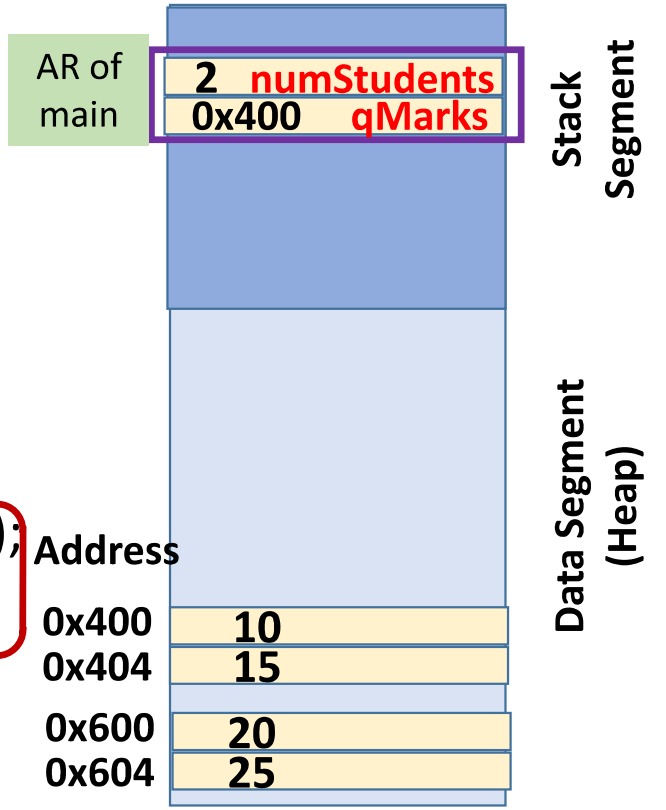
```
int * altReadQuizMarks(int n)
{ int * marks, * temp,  i;
  marks = new int[n];
  temp =  new int[n];
  if ((marks == NULL) || (temp == NULL))
    {  return NULL; }
  for (i = 0; i < n; i++) {
     cin >> marks[i];
     temp[i] = marks[i] + 10;
  }
  // Some computation with temp
  return marks;
}
```



Persistence of Dynamically Allocated Memory

IIT Bombay

```
int main()
{ int numStudents; int *qMarks;
  cout << "Given student count: " << endl;
  cin >> numStudents;
  cout << "Give marks of students" << endl;
  qMarks = altReadQuizMarks(numStudents);
  //  Print max and min marks from qMarks
  return 0;
}
```

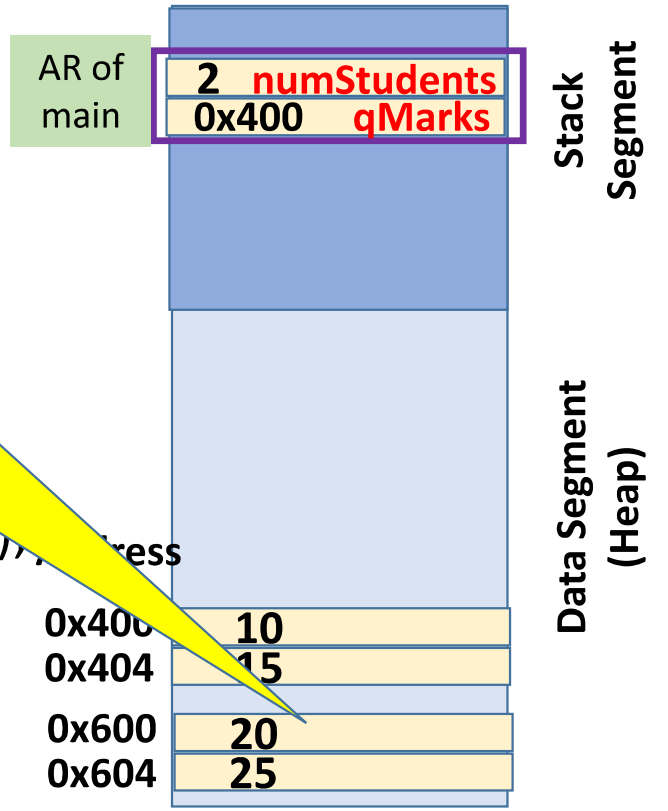


Persistence of Dynamically Allocated Memory

IIT Bombay

```
int mai
{ int nu
  cout <
  cin >> numStudents;
  cout << "Give marks of students" << e
  qMarks = altReadQuizMarks(numStudents), /*
  // Print max and min marks from qMarks
  return 0;
}
```

Array temp of no use, but persists in heap. Wasted memory space.



Explicitly De-allocating Dynamic Memory

- C++ provides a special construct to explicitly de-allocate dynamically allocated memory

Allocation: T * myVar; De-allocation: delete myVar;

myVar = new T;

Allocation: T * myArray; De-allocation: delete[] myArray;

myArray = new T[n];

Explicitly De-allocating Dynamic Memory

IIT Bombay

- C++ p… …o explicitly de-allocate dyna…

Note slightly different usage for dynamically allocated variables and arrays

Alloc… …ion: delete myVar;

myVar = new T;

Allocation: T * myArray;
myArray = new T[n];

De-allocation: delete[] myArray;

Good Programming Practice

- Always de-allocate dynamically allocated memory once you have no further use of it
- Check for valid address before de-allocating memory

if (myArray != NULL) { delete[] myArray;}

preferred over

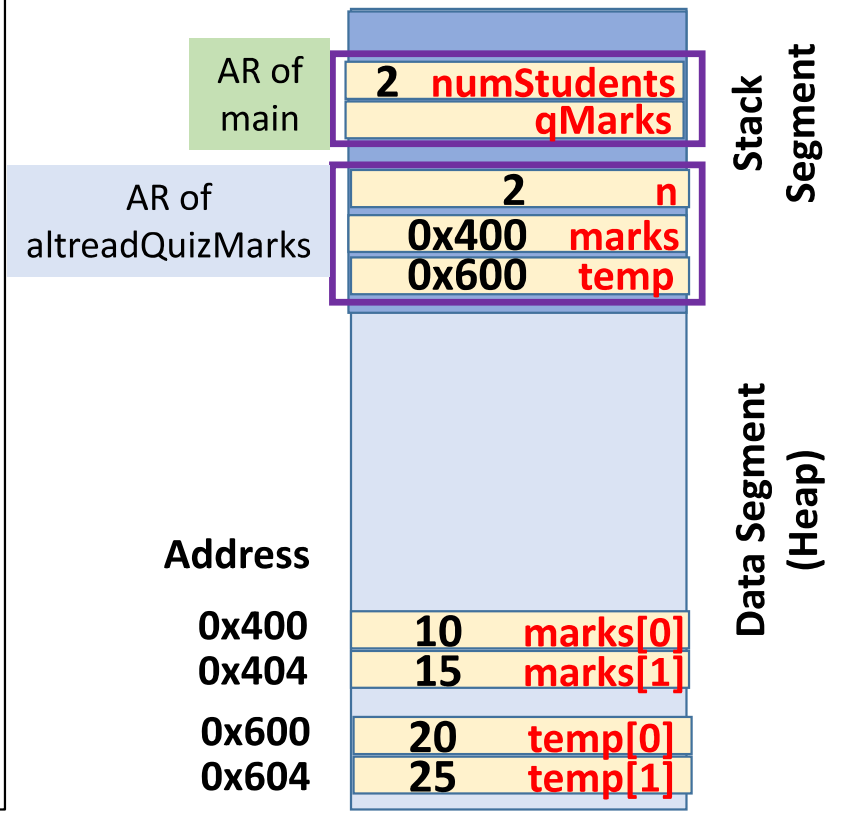
delete[] myArray;

- De-allocating memory at address 0x0 (NULL pointer) will cause program to crash

De-allocating Dynamically Allocated Memory

IIT Bombay

```
int * altReadQuizMarks(int n)
{ int * marks, * temp,  i;
  marks = new int[n];
  temp =  new int[n];
  if ((marks == NULL) || (temp == NULL)) {
    return NULL; }
  for (i = 0; i < n; i++) {
     cin >> marks[i];
     temp[i] = marks[i] + 10;
  }
  // Some computation with temp
  if (temp != NULL) {delete[] temp; }
   return marks;
}
```

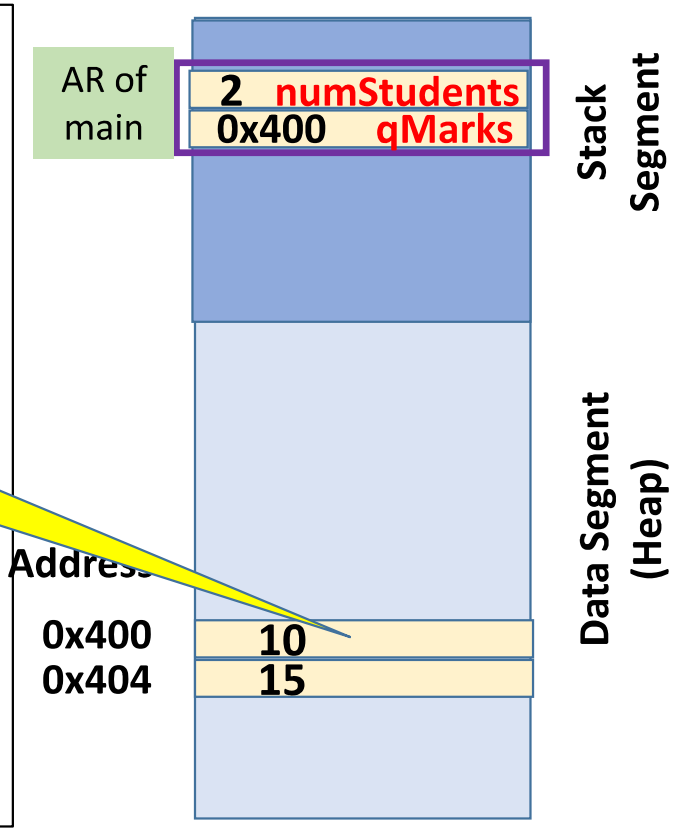


De-allocating Dynamically Allocated Memory

IIT Bombay

```
int ma
{ int nu
  cout <                                  ndl;
  cin >>
  cout << "Give marks of students "       ndl;
  qMarks = readQuizMarks(numStudents);
  // Print max and min marks from qMarks
  return 0;
}
```

Only persisting dynamically allocated memory is something that is needed in "main"

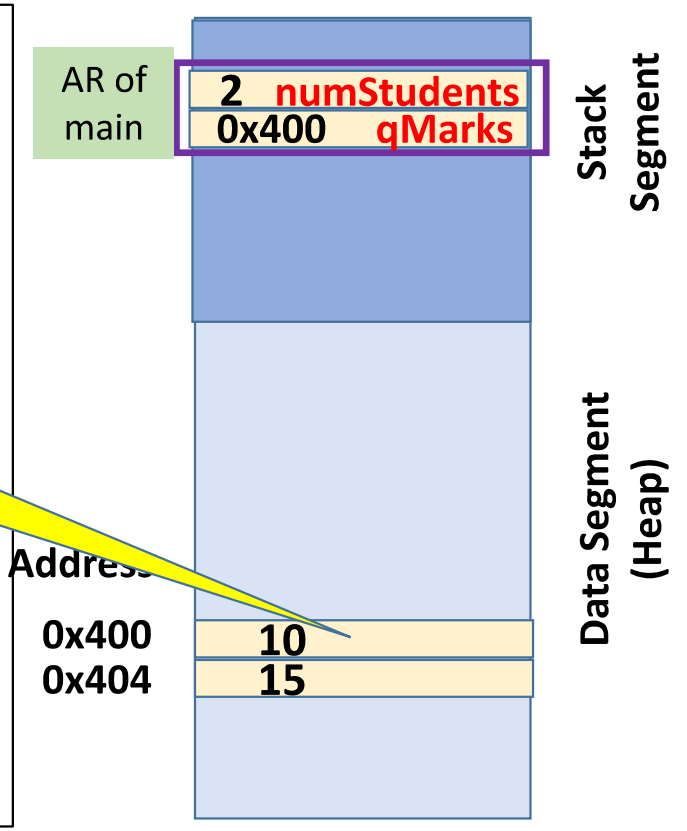


De-allocating Dynamically Allocated Memory

IIT Bombay

```
int ma
{ int nu
  cout <                                  ndl;
  cin >>
  cout << "Give marks of students "      ndl;
  qMarks = readQuizMarks(numStudents);
  // Print max and min marks from qMarks
  if (qMarks != NULL) { delete[] qMarks;}
return 0;}
```

"main" must now de-allocate this memory dynamically allocated by altReadQuizMarks



Summary

IIT Bombay

- Persistence of dynamically allocated memory
- Need for explicit de-allocation of dynamically allocated memory
- “delete” construct in C++
- Good programming practices when de-allocating dynamic memory