

Michael Nowak

Texas A&M University

Overview

Passing arrays to functions

Creating a one-dimensional array on the free store

Creating a two-dimensional array on the free store

Creating arrays in functions

What's problematic about this?

How's this any different

"Resizing" an array

Shallow vs deep copy

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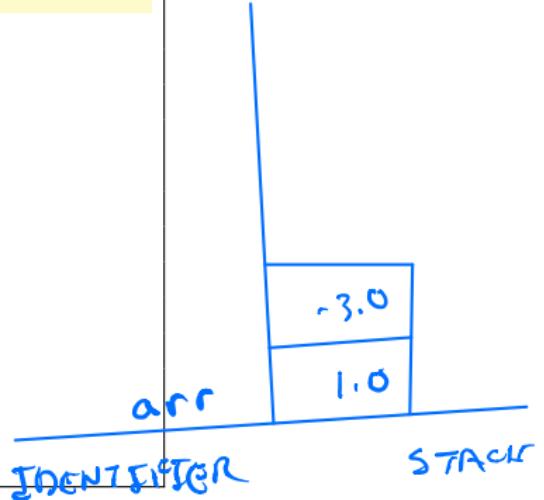
Shallow vs deep copy

Passing arrays to functions

```
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2 int amax(const double *, const unsigned int);
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4 int main()
5 {
6     double arr[] {1.0, -3.0};
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8     return 0;
9 }
10
11 int amax(const double *x, const unsigned int len)
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13     int maxidx = 0;
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16             maxidx = i;
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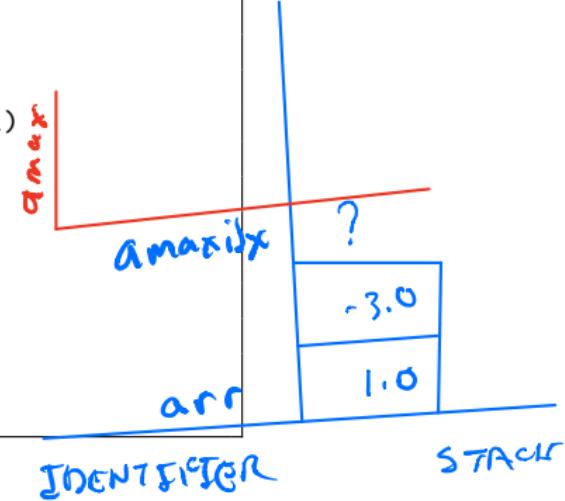
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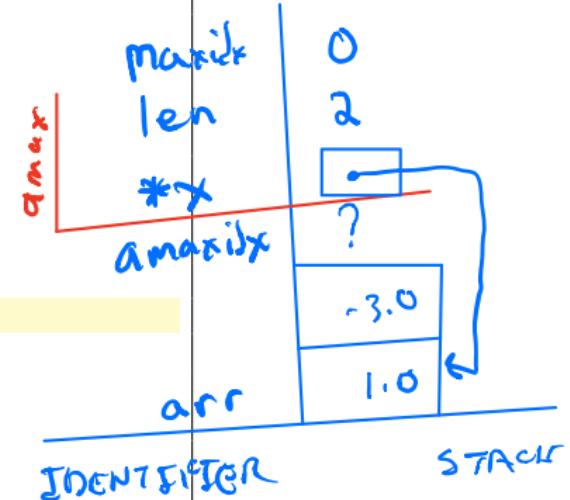
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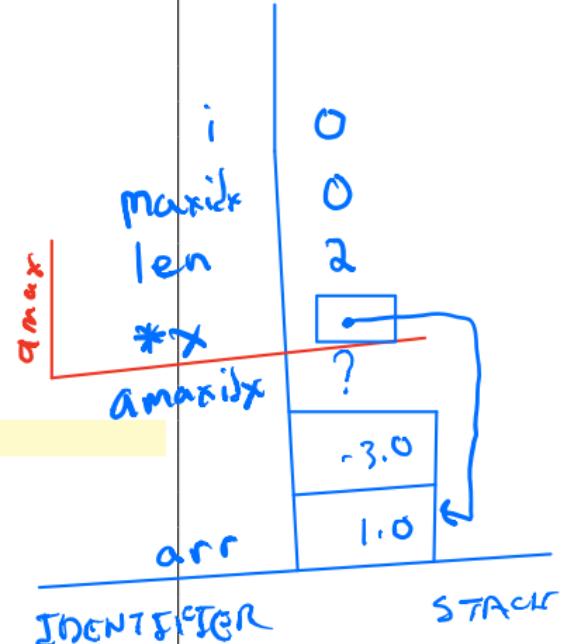
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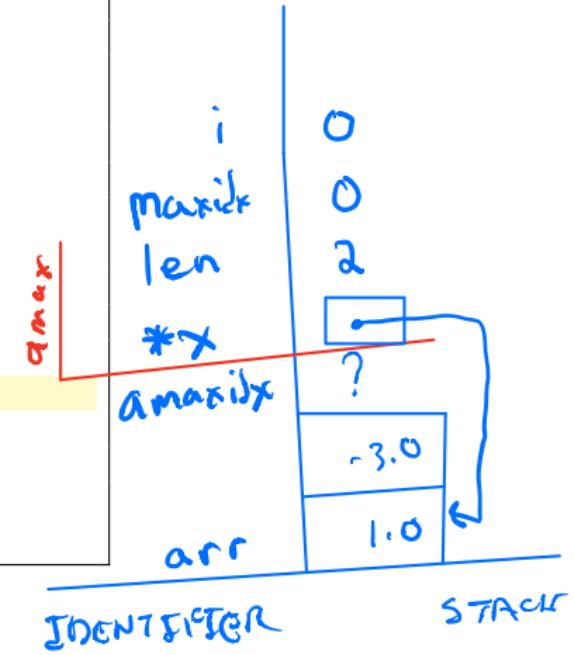
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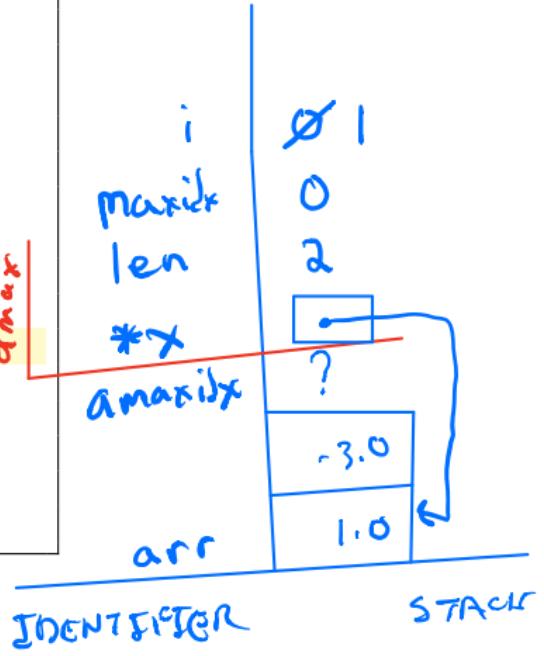
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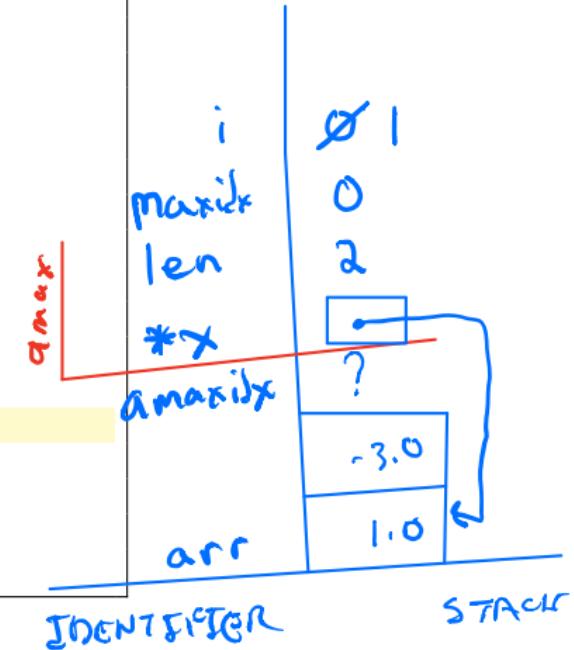
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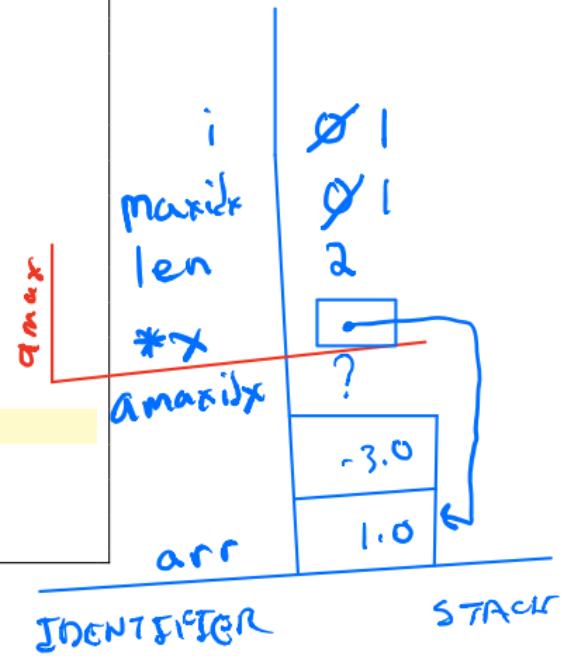
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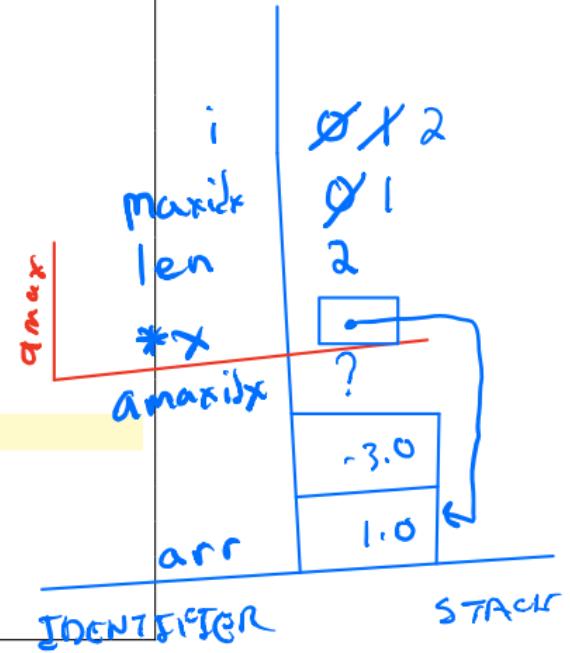
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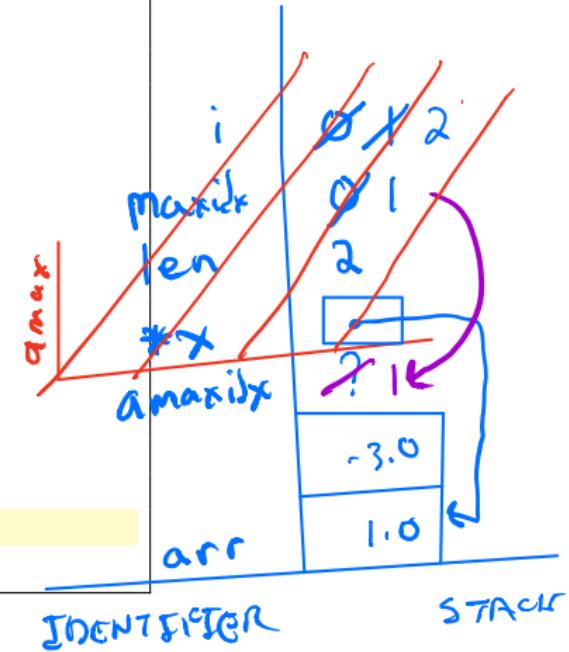
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Shallow vs deep copy

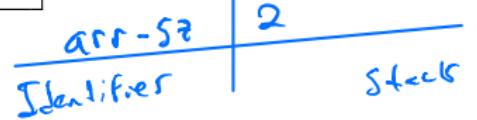
Creating a one-dimensional array on the free store

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1 int main()
2 {
3     unsigned int arr_sz = 2;
4     int *arr = new int[arr_sz];
5     for (unsigned int i = 0; i < arr_sz; ++i)
6         arr[i] = i;
7     /* does something interesting */
8     delete [] arr;
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10    return 0;
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Creating a one-dimensional array on the free store

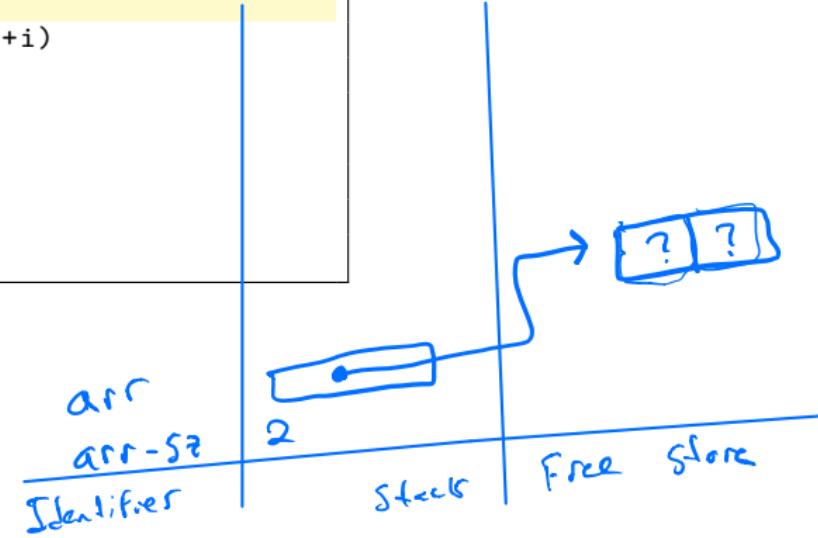
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Creating a one-dimensional array on the free store

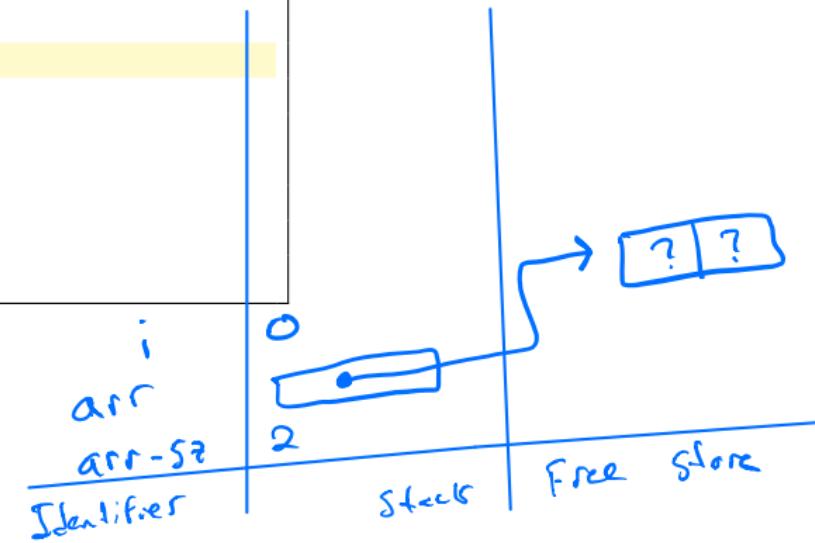
arr is a pointer to an integer object

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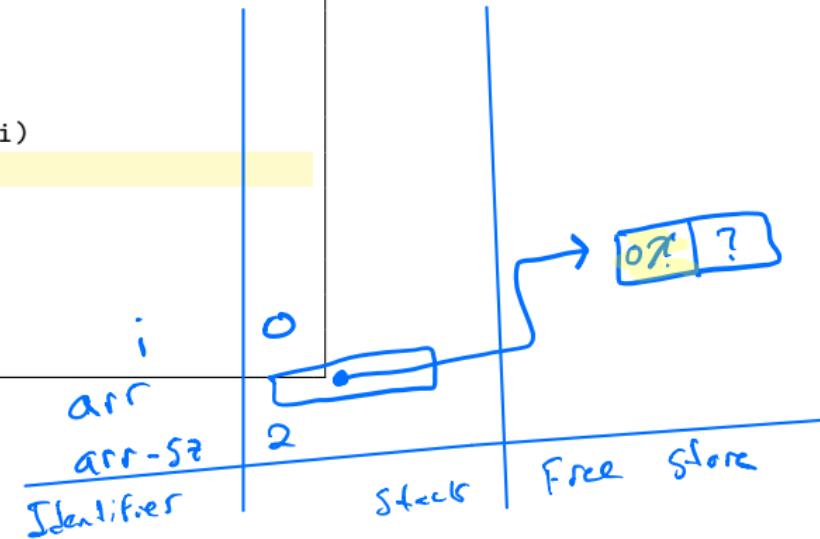
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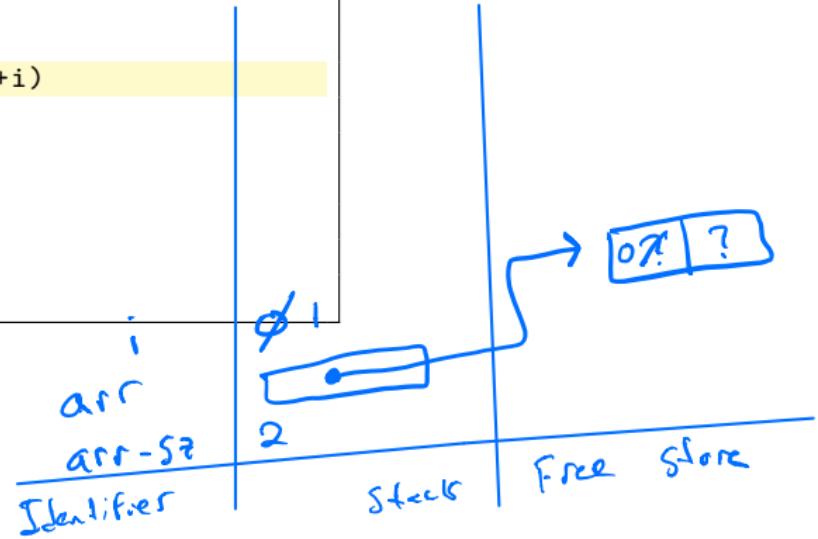
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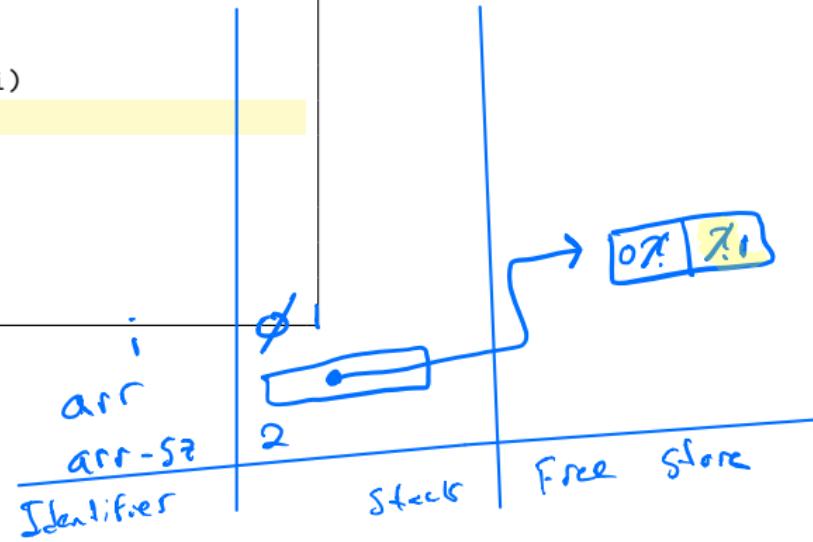
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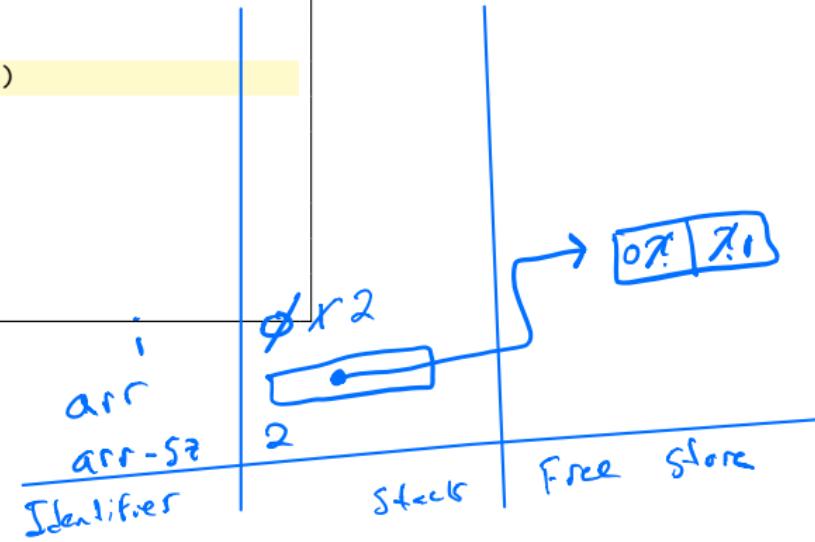
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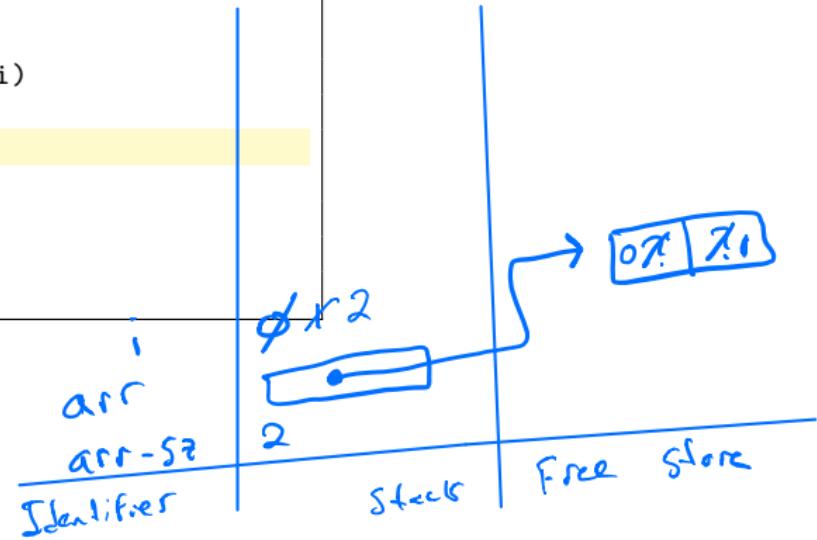
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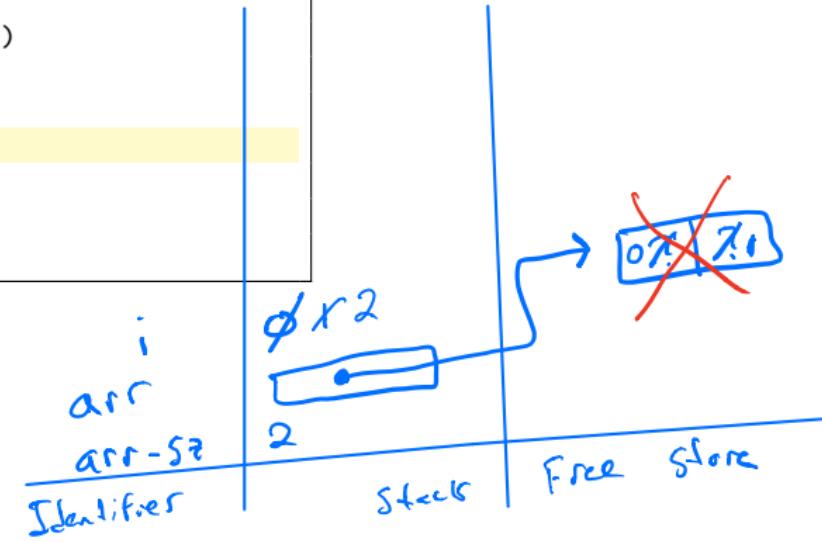
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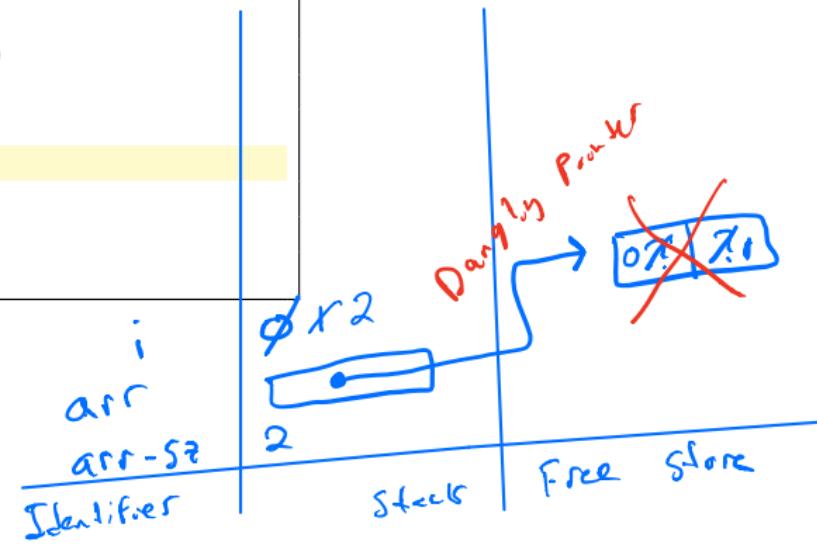
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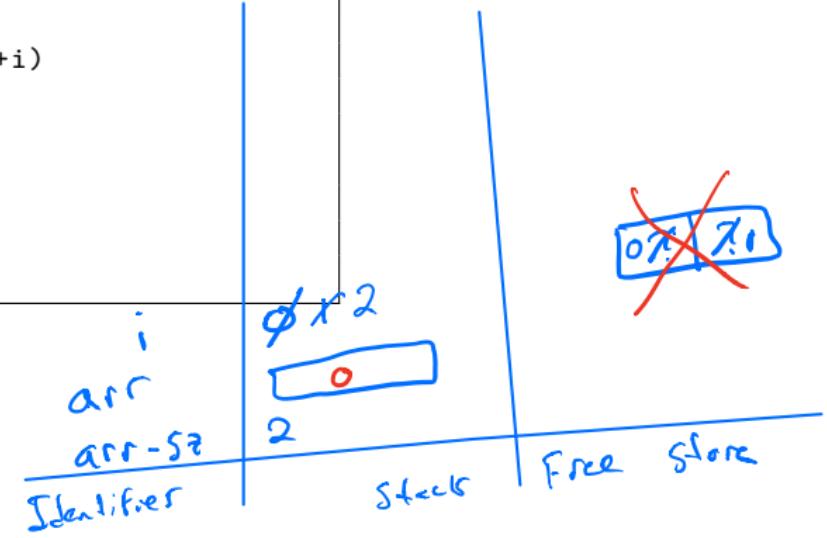
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Creating a one-dimensional array on the free store

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5     for (unsigned int i = 0; i < arr_sz; ++i)
6         arr[i] = i;
7     /* does something interesting */
8     delete [] arr;
9     arr = nullptr;
10    return 0;
11 }
```



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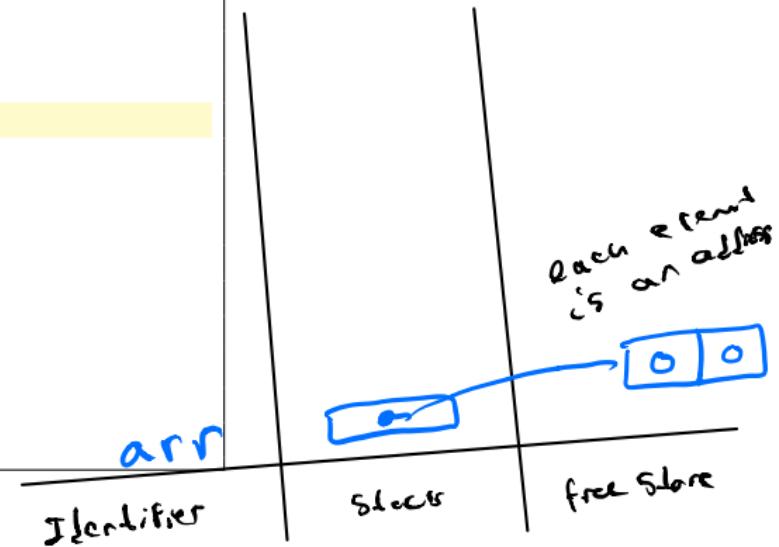
```
1 const unsigned int NOROWS = 2;
2 const unsigned int NOCOLS = 3;
3
4 int main()          arr is a pointer to a pointer to
5 {                  an integer
6
7     int **arr = new int*[NOROWS];
8     for (unsigned int i = 0; i < NOROWS; ++i)
9         arr[i] = new int[NOCOLS];
10
11    for (unsigned int i = 0; i < NOROWS; ++i)
12        delete [] arr[i];
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15    return 0;
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Creating a two-dimensional array on the free store

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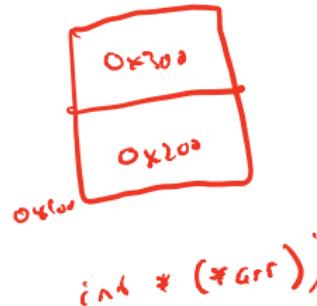
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7     int **arr = new int*[NOROWS];
8     for (unsigned int i = 0; i < NOROWS; ++i)
9         arr[i] = new int[NOCLRS];
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13    delete [] arr;
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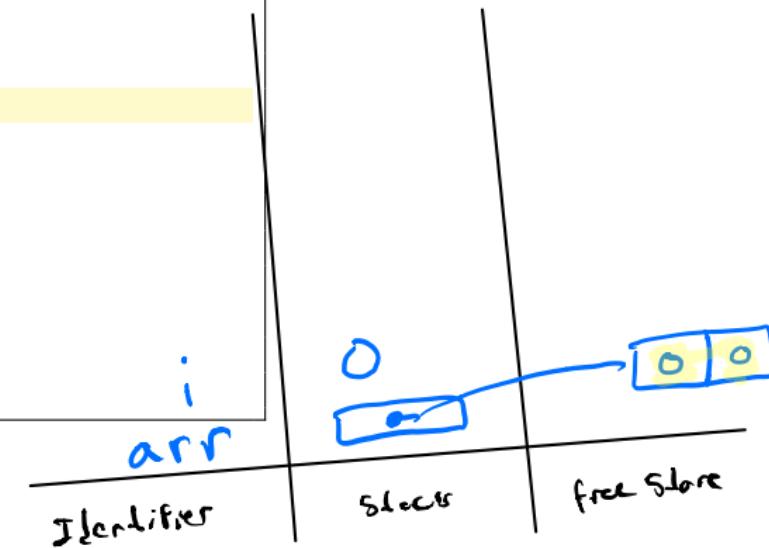
Creating a two-dimensional array on the free store

new int[2];

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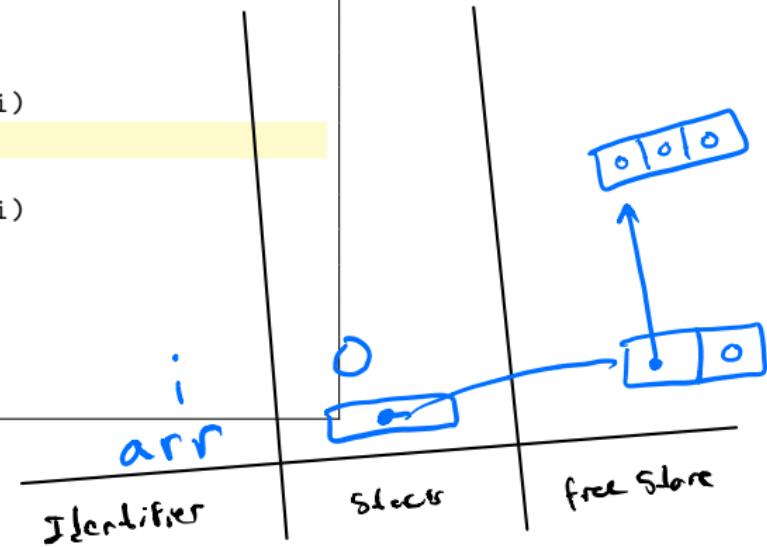


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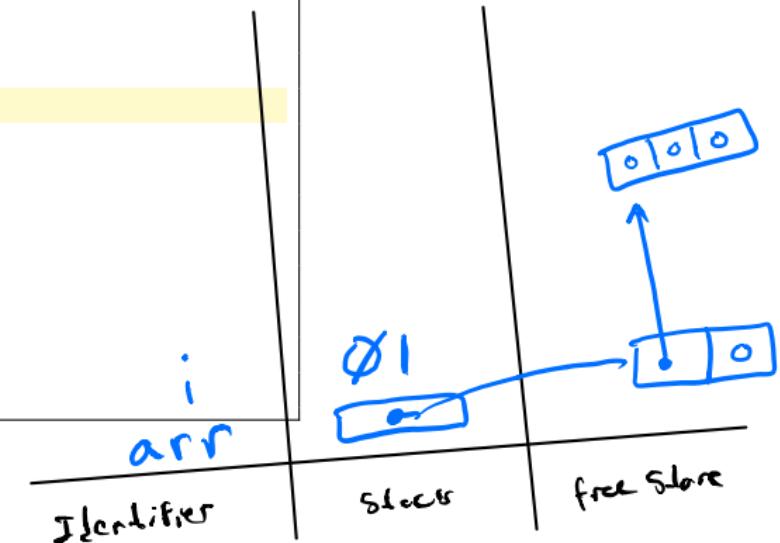
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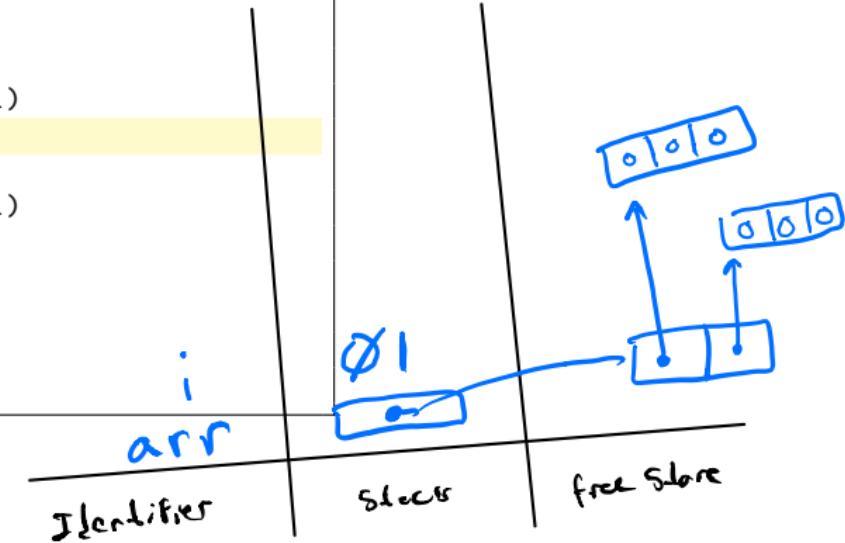
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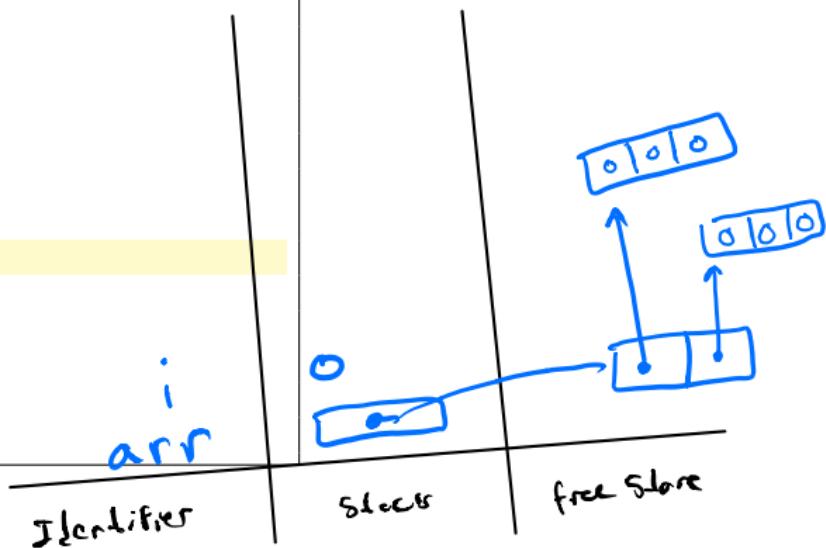
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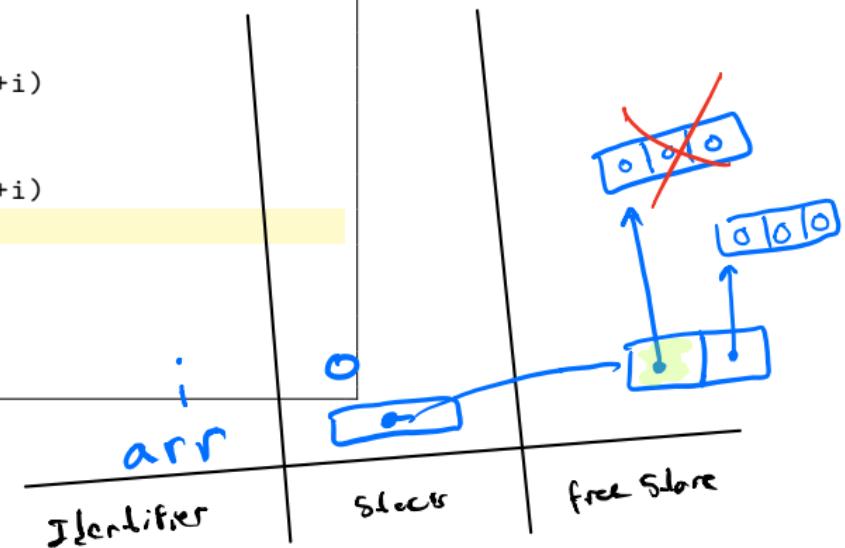
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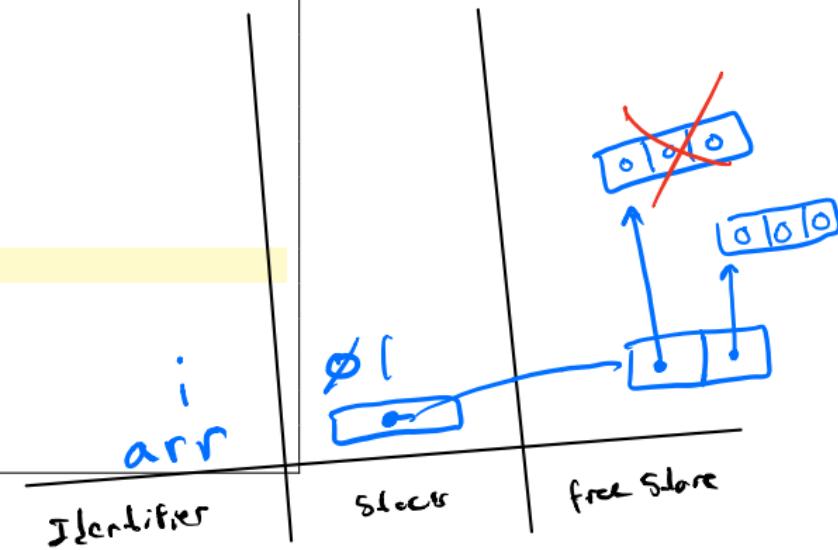
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8     for (unsigned int i = 0; i < NOROWS; ++i)
9         arr[i] = new int[NOCOLS];
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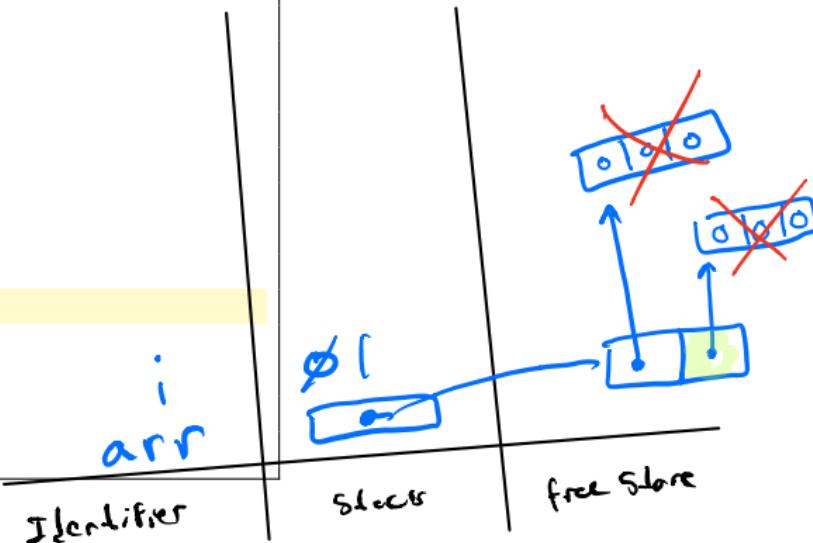
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16 }
```



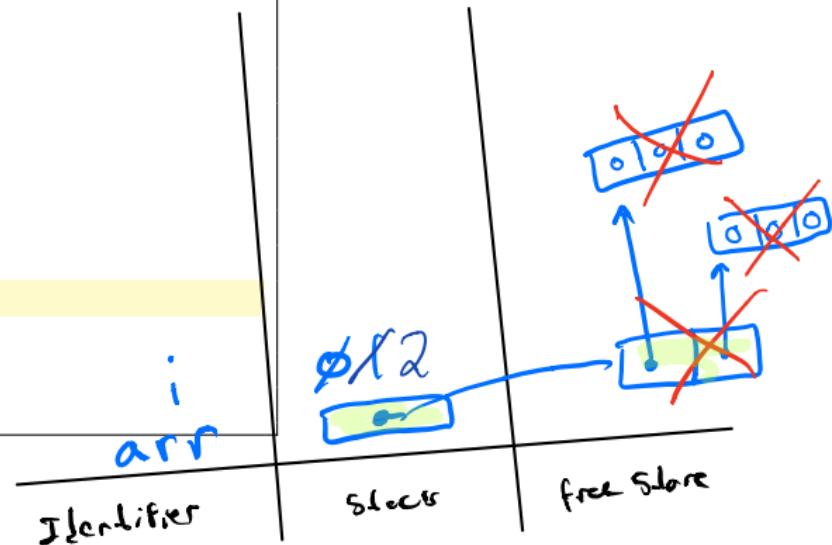
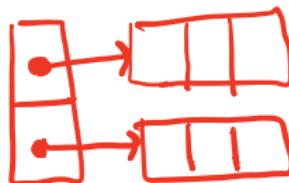
Creating a two-dimensional array on the free store

```
1 const unsigned int NOROWS = 2;
2 const unsigned int NOCOLS = 3;
3
4 int main()
5 {
6
7     int **arr = new int*[NOROWS];
8     for (unsigned int i = 0; i < NOROWS; ++i)
9         arr[i] = new int[NOCOLS];
10
11    for (unsigned int i = 0; i < NOROWS; ++i)
12        delete [] arr[i];
13    delete [] arr;
14
15    return 0;
16 }
```



Creating a two-dimensional array on the free store

```
1 const unsigned int NOROWS = 2;
2 const unsigned int NOCOLS = 3;
3
4 int main()
5 {
6
7     int **arr = new int*[NOROWS];
8     for (unsigned int i = 0; i < NOROWS; ++i)
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Overview

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Creating a one-dimensional array on the free store

Creating a two-dimensional array on the free store

Creating arrays in functions

What's problematic about this?

How's this any different

"Resizing" an array

Shallow vs deep copy

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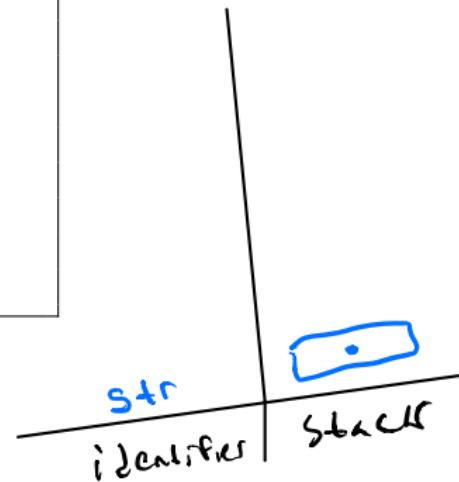
What's problematic about it?

```
1 char * problematic();
2
3 int main()
4 {
5     char *str = problematic();
6     /* tries to do something interesting with str */
7     return 0;
8 }
9
10 char * problematic()
11 {
12     char localStr[] = "Hello!";
13     return localStr;
14 }
```

Names of
arrays evaluate
to addresses

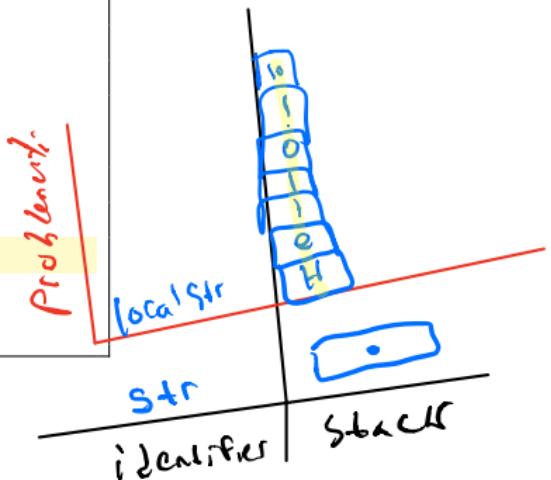
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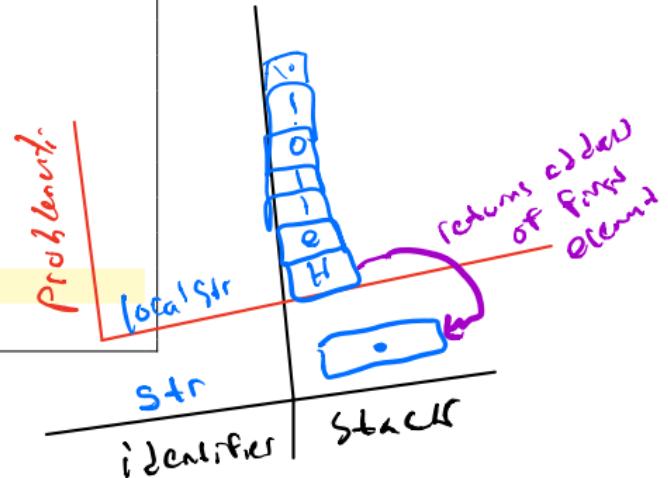
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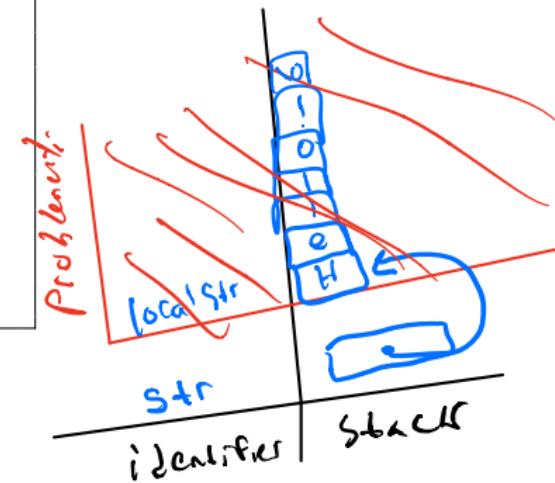
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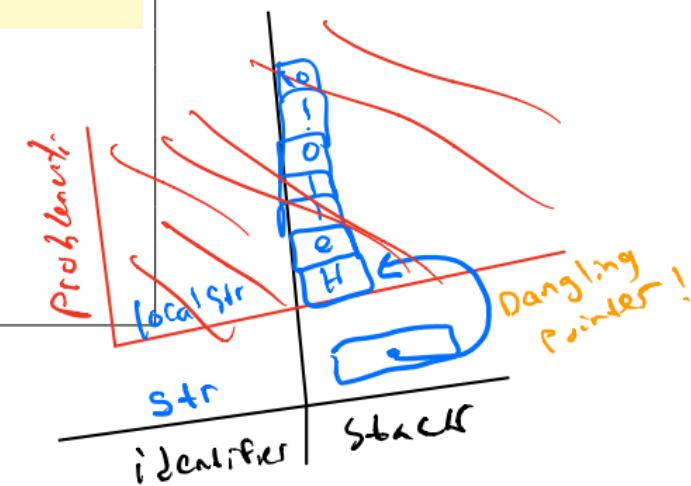
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How's this any different?

```
1 char * notProblematic();
2
3 int main()
4 {
5     char *str = notProblematic();
6     /* does something interesting with str */
7     return 0;
8 }
9 Return type          empty parameter list    No arguments
10 char * notProblematic()
11 {
12     char *localStr = new char[7] {'H', 'e', 'l', 'l', 'o', '!', '\0'};
13     return localStr;
14 }
```

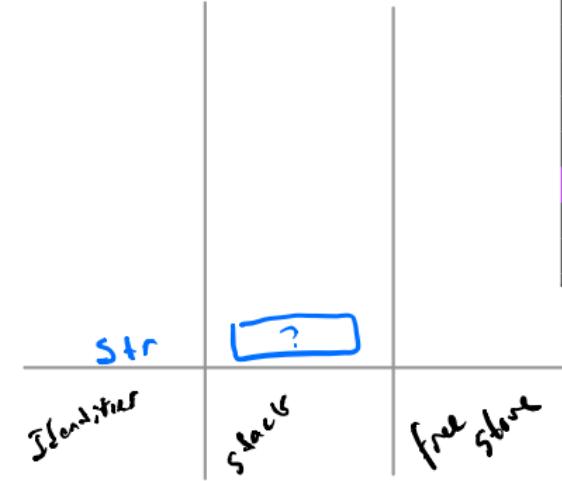
Islands

Stacks

free store

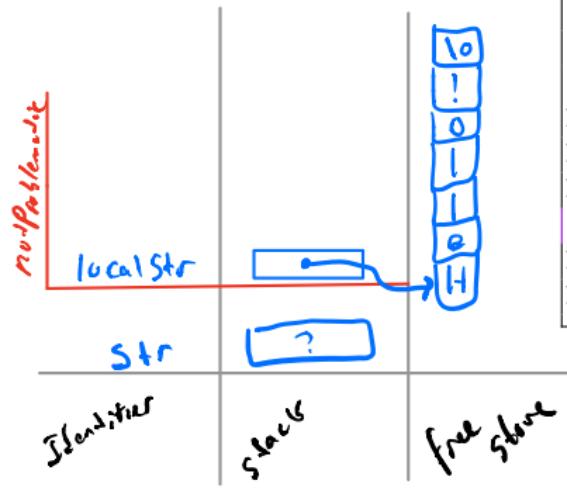
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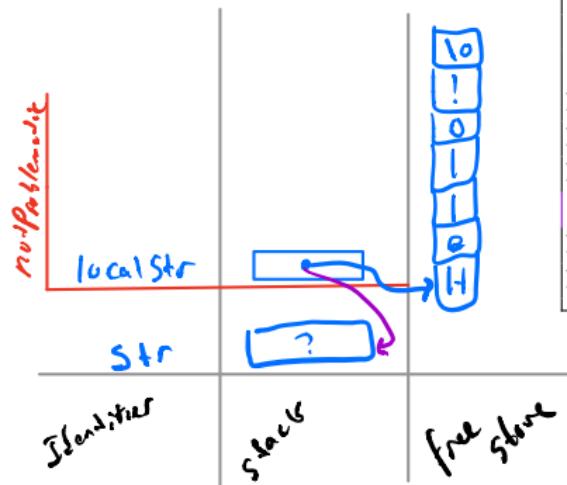
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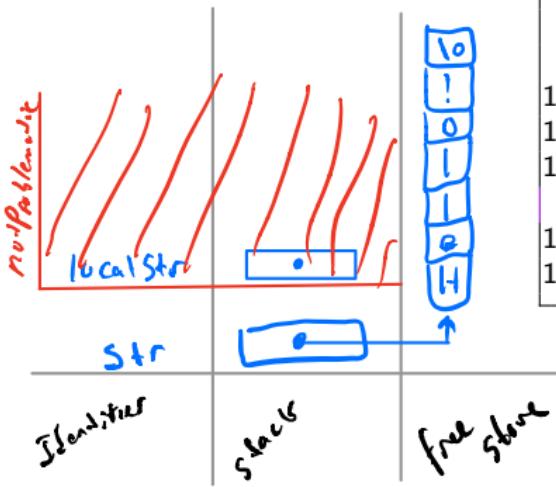


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13     return localStr;
14 }
```



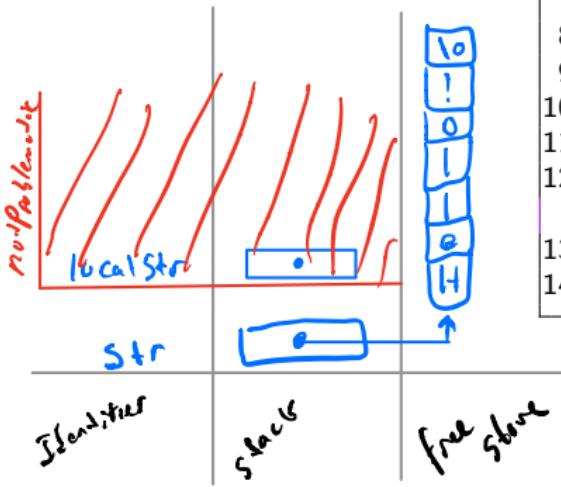
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"Resizing" an array

```
1 void resize(int *&, unsigned int &);  
2  
3 int main()  
4 {  
5     unsigned int cap = 1;  
6     unsigned int sz = 0;  
7     int *arr = new int[cap];  
8     for (unsigned int i = 0; i < 2; ++i) {  
9         if (cap == sz)  
10             resize(arr, cap);  
11         arr[sz] = ↑; sz += 1;  
12     }           (i+1)  
13     return 0;  
14 }  
15  
16 void resize(int *&array, unsigned int &capacity)  
17 {  
18     unsigned int newCapacity = capacity * 2;  
19     int *temp = new int[newCapacity];  
20     for (unsigned int i = 0; i < capacity; ++i)  
21         temp[i] = array[i];  
22     delete [] array;  
23     capacity = newCapacity;  
24     array = temp;  
25 }
```

identifiers

stack

free store

"Resizing" an array

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25 }
```

cap		
identifies	space	free space

"Resizing" an array

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```

identifiers

sz
cap

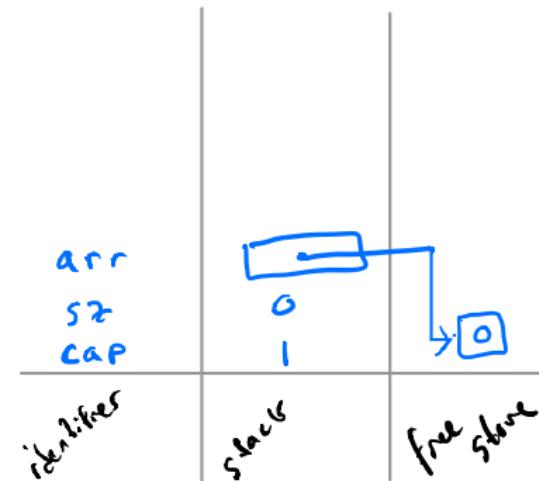
0
1

stack

free store

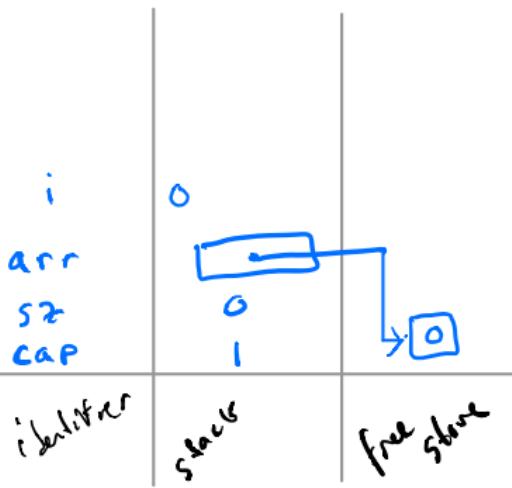
"Resizing" an array

```
1 void resize(int *&, unsigned int &);
2
3 int main()
4 {
5     unsigned int cap = 1;
6     unsigned int sz = 0;
7     int *arr = new int[cap]; // Line 7
8     for (unsigned int i = 0; i < 2; ++i) {
9         if (cap == sz)
10             resize(arr, cap);
11         arr[sz] = ↑; sz += 1;
12     } (i+1)
13     return 0;
14 }
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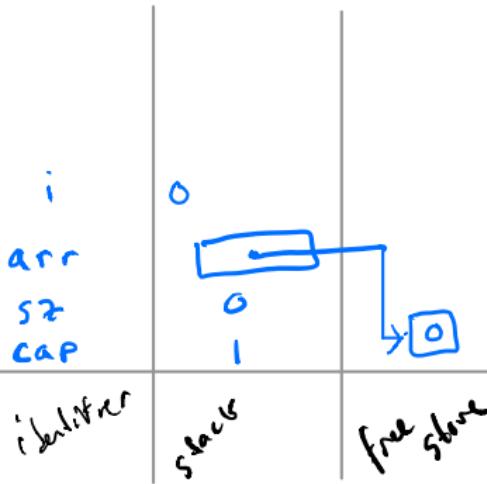
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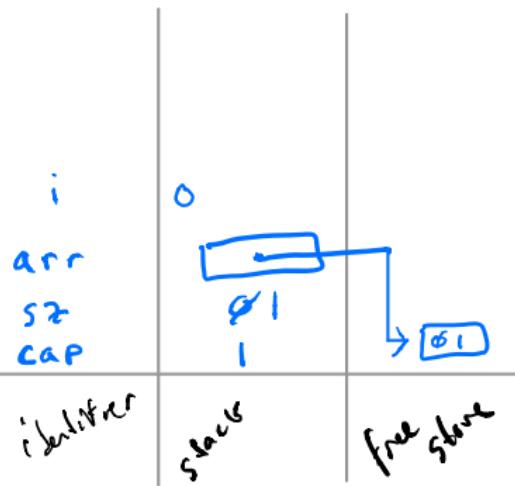
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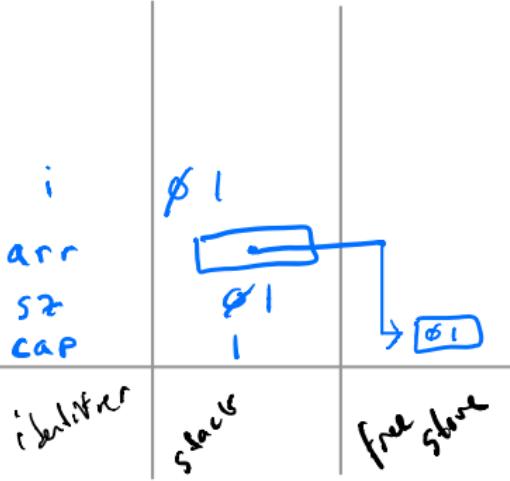
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"Resizing" an array

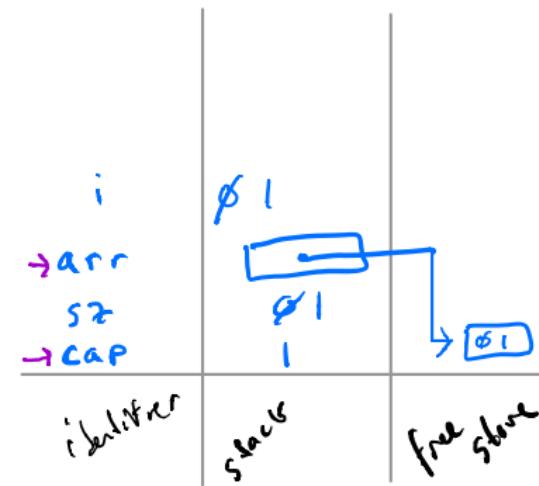
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```



"Resizing" an array

int i = 7;
int arr[7];

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3 int main()  
4 {  
5     unsigned int cap = 1;  
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7     int *arr = new int[cap];  
8     for (unsigned int i = 0; i < 2; ++i) {  
9         if (cap == sz)  
10             resize(arr, cap);  
11         arr[sz] = i; sz += 1;  
12     }  
13     return 0;  
14 }  
15 // Array is a reference  
16 // to a pointer to an integer  
17 void resize(int *&array, unsigned int &capacity)  
18 {  
19     unsigned int newCapacity = capacity * 2;  
20     int *temp = new int[newCapacity];  
21     for (unsigned int i = 0; i < capacity; ++i)  
22         temp[i] = array[i];  
23     delete [] array;  
24     capacity = newCapacity;  
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```



int *arr = arr
(i+1) int *arr = arr
int &capacity = cap
int &capacity = cap

"Resizing" an array

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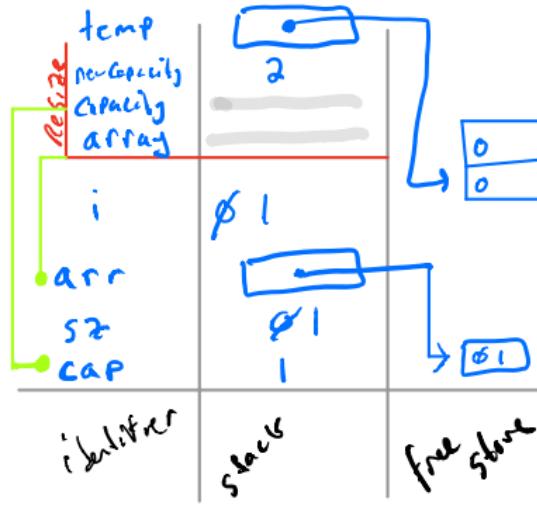
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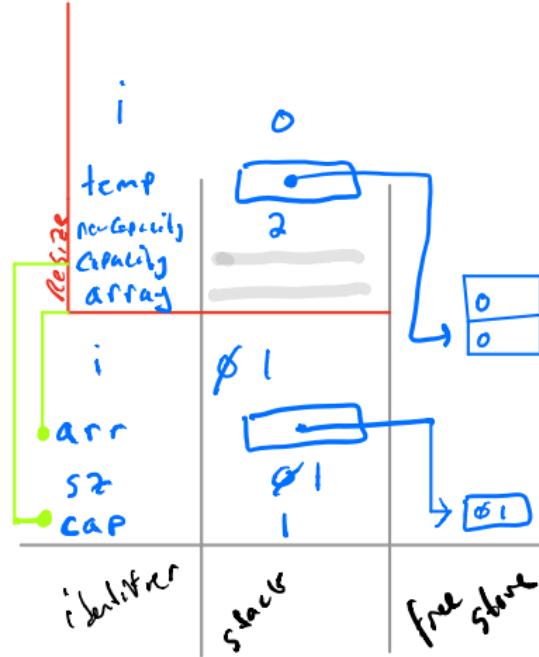
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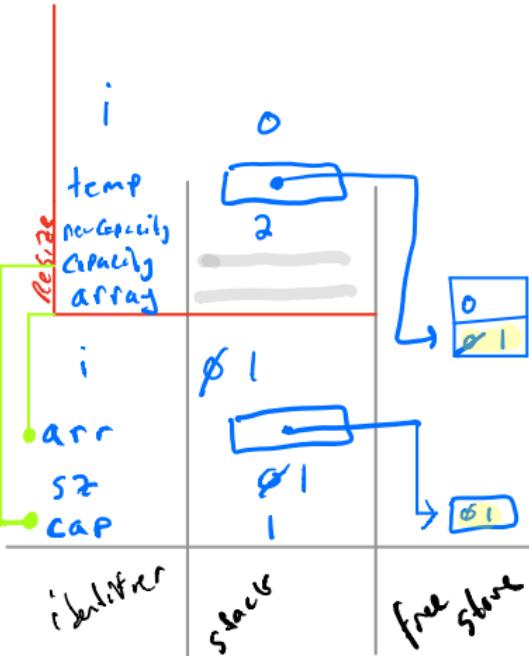
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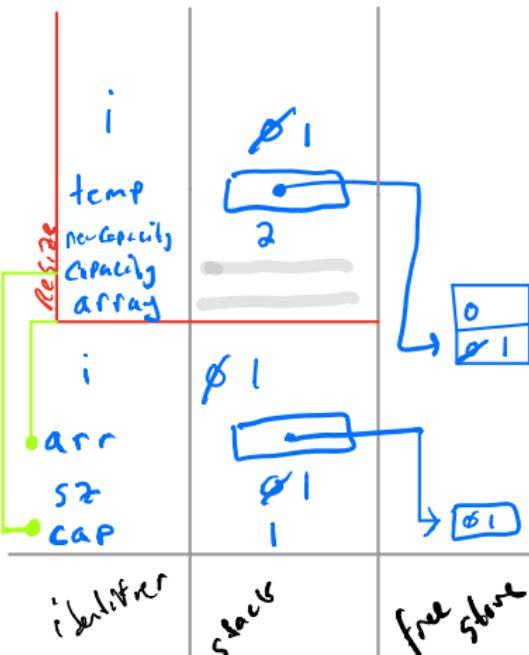
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19     int *temp = new int[capacity * 2];
20     for (unsigned int i = 0; i < capacity; ++i)
21         temp[i] = array[i];
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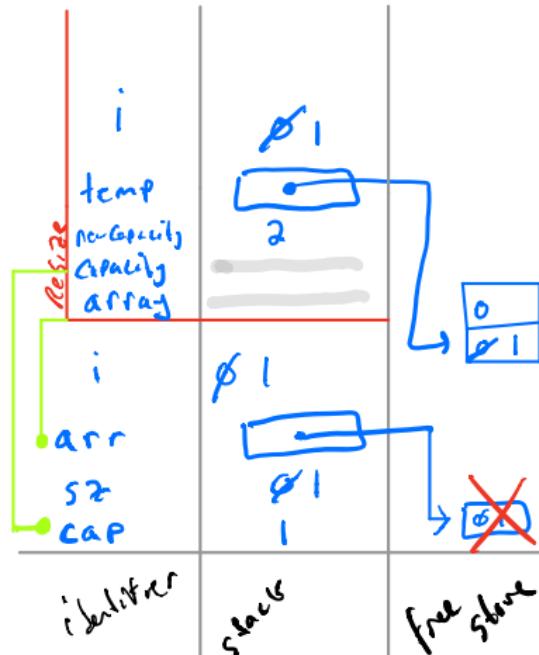
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23     capacity = newCapacity;
24     array = temp;
25 }
```



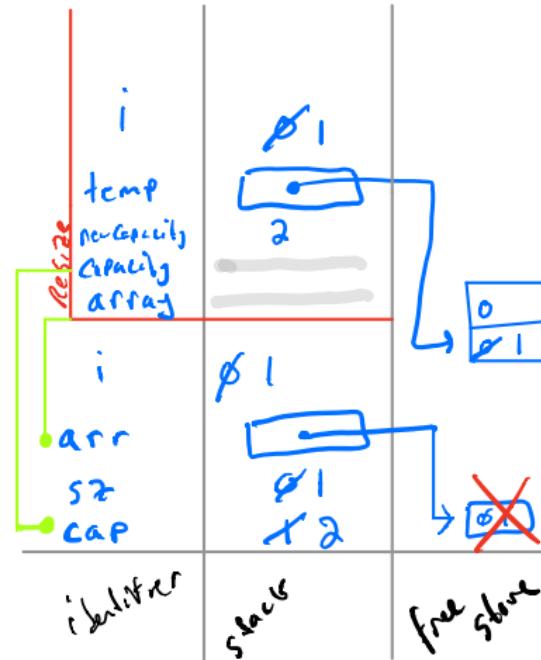
"Resizing" an array

```
1 void resize(int *&, unsigned int &);
2
3 int main()
4 {
5     unsigned int cap = 1;
6     unsigned int sz = 0;
7     int *arr = new int[cap];
8     for (unsigned int i = 0; i < 2; ++i) {
9         if (cap == sz)
10             resize(arr, cap);
11         arr[sz] = i; sz += 1;
12     } (i+1)
13     return 0;
14 }
15
16 void resize(int *&array, unsigned int &capacity)
17 {
18     unsigned int newCapacity = capacity * 2;
19     int *temp = new int[newCapacity];
20     for (unsigned int i = 0; i < capacity; ++i)
21         temp[i] = array[i];
22     delete [] array;
23     capacity = newCapacity;
24     array = temp;
25 }
```



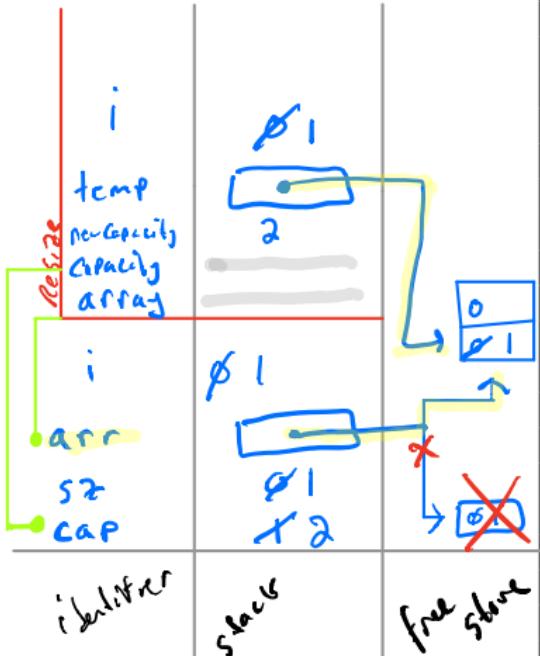
"Resizing" an array

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1 void resize(int *&, unsigned int &);
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3 int main()
4 {
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6     unsigned int sz = 0;
7     int *arr = new int[cap];
8     for (unsigned int i = 0; i < 2; ++i) {
9         if (cap == sz)
10             resize(arr, cap);
11         arr[sz] = i; sz += 1;
12     } (i+1)
13     return 0;
14 }
15
16 void resize(int *&array, unsigned int &capacity)
17 {
18     unsigned int newCapacity = capacity * 2;
19     int *temp = new int[capacity * 2];
20     for (unsigned int i = 0; i < capacity; ++i)
21         temp[i] = array[i];
22     delete [] array;
23     capacity = newCapacity;
24     array = temp;
25 }
```

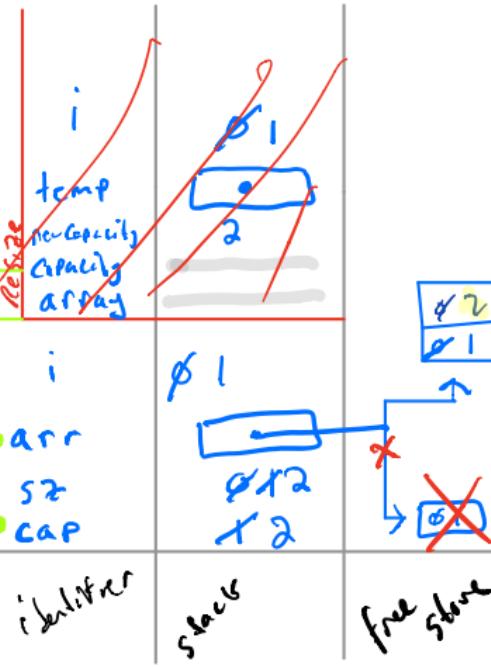


"Resizing" an array

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1 void resize(int *&, unsigned int &);
2
3 int main()
4 {
5     unsigned int cap = 1;
6     unsigned int sz = 0;
7     int *arr = new int[cap];
8     for (unsigned int i = 0; i < 2; ++i) {
9         if (cap == sz)
10             resize(arr, cap);
11         arr[sz] = i; sz += 1;
12     } (i+1)
13     return 0;
14 }
15
16 void resize(int *&array, unsigned int &capacity)
17 {
18     unsigned int newCapacity = capacity * 2;
19     int *temp = new int[newCapacity];
20     for (unsigned int i = 0; i < capacity; ++i)
21         temp[i] = array[i];
22     delete [] array;
23     capacity = newCapacity;
24     array = temp;
25 }
```



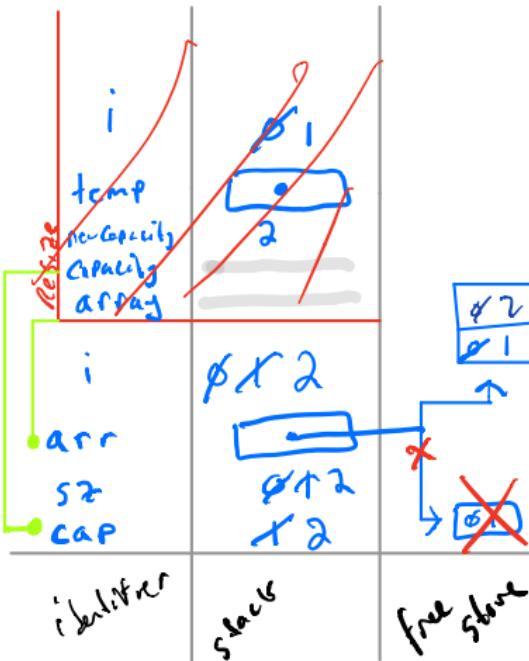
"Resizing" an array



```
1 void resize(int *&, unsigned int &);
2
3 int main()
4 {
5     unsigned int cap = 1;
6     unsigned int sz = 0;
7     int *arr = new int[cap];
8     for (unsigned int i = 0; i < 2; ++i) {
9         if (cap == sz)
10             resize(arr, cap);
11         arr[sz] = p1; sz += 1;
12     } (i+1)
13     return 0;
14 }
15
16 void resize(int *&array, unsigned int &capacity)
17 {
18     unsigned int newCapacity = capacity * 2;
19     int *temp = new int[newCapacity];
20     for (unsigned int i = 0; i < capacity; ++i)
21         temp[i] = array[i];
22     delete [] array;
23     capacity = newCapacity;
24     array = temp;
25 }
```

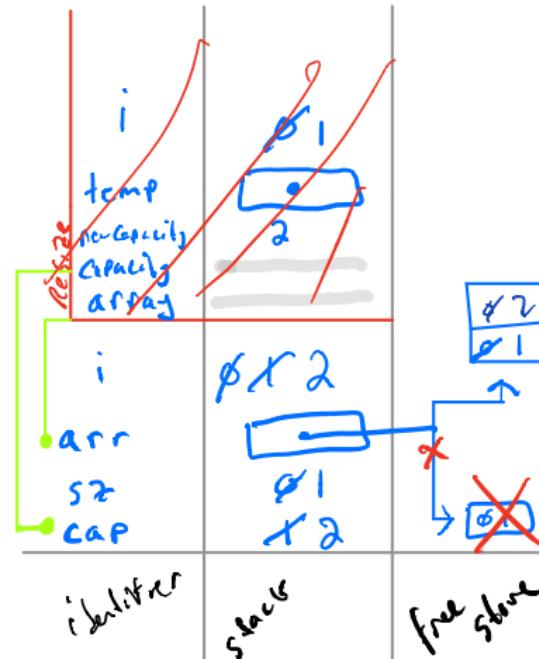
"Resizing" an array

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1 void resize(int *&, unsigned int &);
2
3 int main()
4 {
5     unsigned int cap = 1;
6     unsigned int sz = 0;
7     int *arr = new int[cap];
8     for (unsigned int i = 0; i < 2; ++i) {
9         if (cap == sz)
10             resize(arr, cap);
11         arr[sz] = i; sz += 1;
12     }           ↑ (i+1)
13     return 0;
14 }
15
16 void resize(int *&array, unsigned int &capacity)
17 {
18     unsigned int newCapacity = capacity * 2;
19     int *temp = new int[newCapacity];
20     for (unsigned int i = 0; i < capacity; ++i)
21         temp[i] = array[i];
22     delete [] array;
23     capacity = newCapacity;
24     array = temp;
25 }
```



"Resizing" an array

```
1 void resize(int *&, unsigned int &);
2
3 int main()
4 {
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7     int *arr = new int[cap];
8     for (unsigned int i = 0; i < 2; ++i) {
9         if (cap == sz)
10             resize(arr, cap);
11         arr[sz] = ↑; sz += 1;
12     }                                (i+1)
13     return 0;
14 }
15
16 void resize(int *&array, unsigned int &capacity)
17 {
18     unsigned int newCapacity = capacity * 2;
19     int *temp = new int[capacity * 2];
20     for (unsigned int i = 0; i < capacity; ++i)
21         temp[i] = array[i];
22     delete [] array;
23     capacity = newCapacity;
24     array = temp;
25 }
```



Overview

Passing arrays to functions

Creating a one-dimensional array on the free store

Creating a two-dimensional array on the free store

Creating arrays in functions

What's problematic about this?

How's this any different

"Resizing" an array

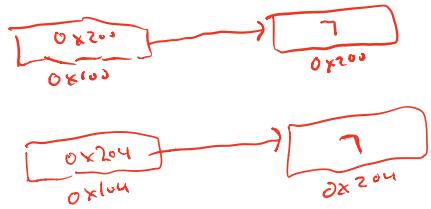
Shallow vs deep copy

Shallow vs deep copy

- ▶ Shallow copy: The value stored in the pointer will be copied, but the memory it points to will not be duplicated
 - ▶ Result: two pointers pointing to the same object
- ▶ Deep copy: Makes copy of the dynamically allocated object pointed to and stores address in a pointer
 - ▶ Result: two pointers pointing to the different objects with the same values



```
int *p1 = new int{7};  
int *p2 = new int{*p1};
```

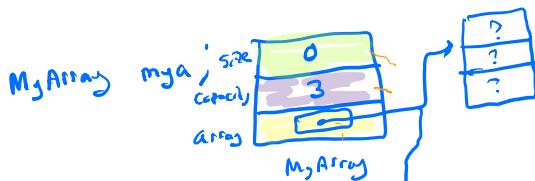


```
struct MyArray {  
    int *array;  
    int capacity = 0;  
    int size = 0;
```

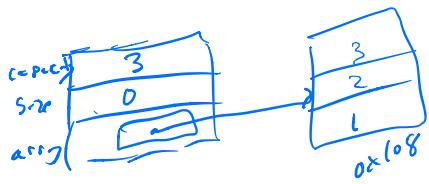
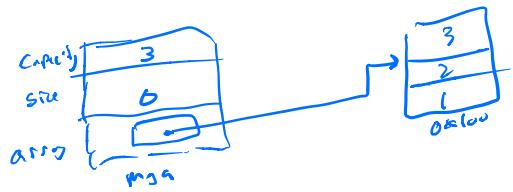
3:

```
MyArray mya;  
maya.array = new int[3];  
maya.capacity = 3;  
maya.size = 0;
```

MyArray mya2 = mya;
// by default member wise copy



but we performed a deep copy
(which is not default behavior)



```

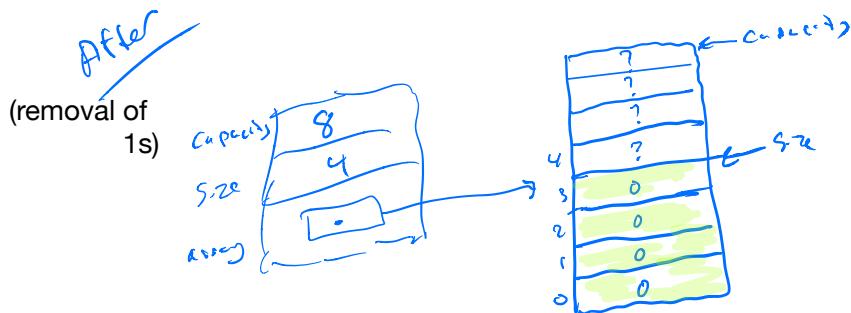
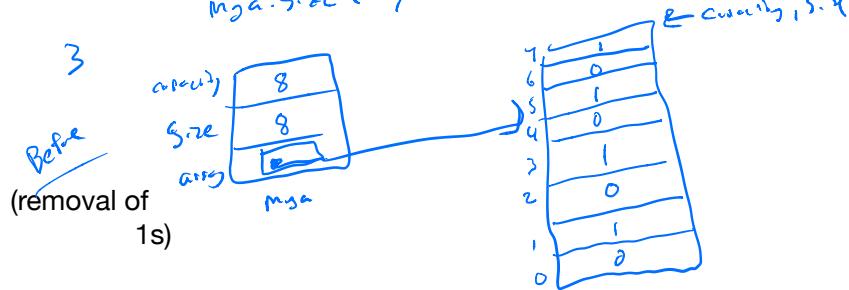
MyArry mya;
maya.array = new array[8];
maya.capacity = 8;
maya.size = 0;

```

```

for (int i=0; i < mya.capacity; ++i) {
    mya.array[i] = i%2;
    mya.size += 1;
}

```



```
int NoRemove = 0;  
int val2remove = 1;  
for (int i = 0, j = 0; i < mya.size(); ++i)  
{  
    if (mya.array[i] != val2remove)  
    {  
        mya.array[j] = mya.array[i];  
        j += 1;  
    }  
    else  
    {  
        noRemove++;  
    }  
}  
mya.size() = NoRemove;
```