Heaps and Garbage Collection

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Programming Language Concepts
Lecture 8, 02 February 2023

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  - Access to non-local variables by following a chain of **access links**
  - **Control links** to go back to caller at the end of the function call

Dynamic allocation

```
class A {
    int x, y, z;
    A(x,y,z) {
        this.x = x;  ...
    }
    public int f(int n) {
        int arr[n];  ...
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main {
    A aObj(2,5,7);
    aObj.f(100);  ...
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- `aObj` itself has pointers to the class definition
- The AR for `f` has a pointer to an array stored on heap

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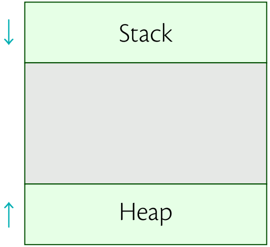

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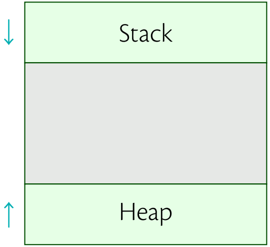
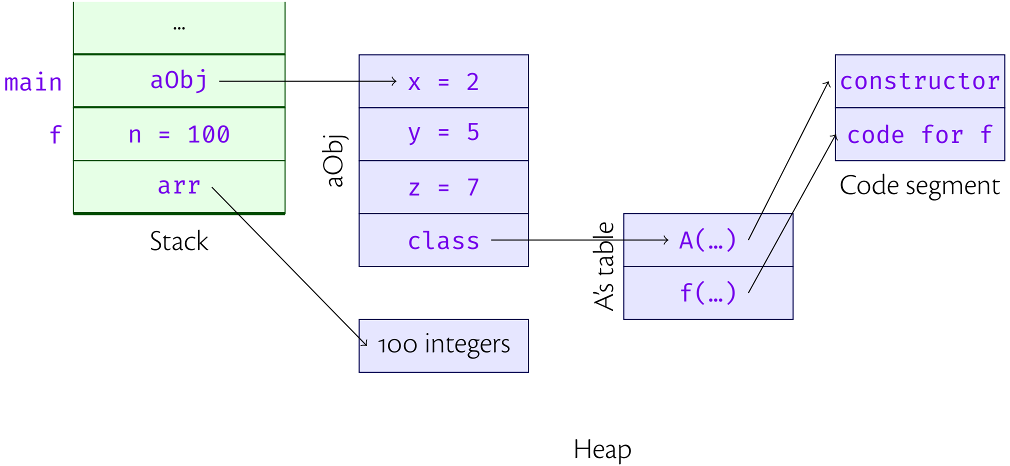


- Consist of chunks of **allocated** and **unallocated** memory

Stack and Heap



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- Calling `perimeter` on each element of the array runs the code pointed to by the appropriate subclass table

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- This is called **garbage** – waste of memory

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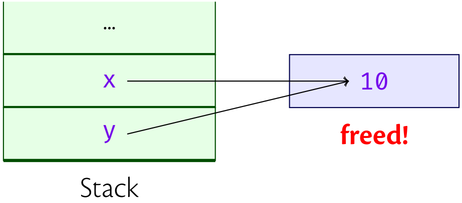
- **malloc / free** in C
- **new / delete** in C++
- **free / delete** tells the system to take back ownership of memory locations from the program – **deallocation**
- Can cause the problem of **dangling pointers** – pointers to deallocated variables

```
int *x = malloc(
    sizeof(int));
*x = 10;
y = x;
free(x);
```



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- **Huge security risk!**
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- Can happen even with explicit deallocation

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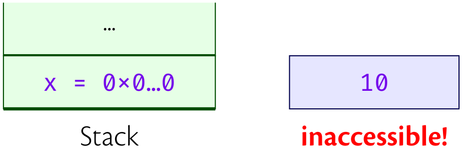

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- Garbage collection – identify garbage and add to the free list
- Two broad methods – **mark-and-sweep** and **reference counting**

Mark-and-sweep

Mark phase

```
//  all nodes are white
shade roots;
while (there are gray nodes) {
    choose a gray node n;
    shade n->left and n->right;
    n.color = black;
}
//  no gray nodes
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shade(n): if n.color == white
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- **Garbage collection is run while pausing other programs!**

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- Each GC run will return a higher fraction of the visited nodes to the free list

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- Infrequently, **a decrement to the reference count might trigger a chain of deallocations**

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- **Cyclic garbage is not reclaimed!**
- Can be handled by running mark-and-sweep at less frequent intervals

Swift and weak references

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- An example usage …

```
class Person {
    let name: String
    init(name: String) {
        self.name = name
    }
    var apartment: Apartment?
}
```

```
class Apartment {
    let unit: String
    init(unit: String) {
        self.unit = unit
    }
    weak var tenant: Person?
}
```

Swift's ARC (automatic reference counting)

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- Swift's **ARC** automatically changes weak references to deallocated nodes to **`nil`**
- Because programmers cannot use optional values without checking if they are non-nil, there is no safety issues due to dangling pointers