CS 35L- Software Construction Laboratory

Fall 2018

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Course Information

- Assignment 10 Presentation
  - Please **upload your slides** to CCLE week10 Lab3
  - Speakers

10/29	Jake Wallin		AI OpenScale-pros, cons, future

C Programming and Debugging

Part II

Outline

- GDB – Debugging (Review)
- **Issues on C Programming**
- **Hints for Assignment 4**

Running

`# gdb <program> [core dump]`
Start GDB (with optional core dump).

`# gdb --args <program> <args…>`
Start GDB and pass arguments

`# gdb --pid <pid>`
Start GDB and attach to process.

`set args <args...>`
Set arguments to pass to program to be debugged.

`run`
Run the program to be debugged.

`kill`
Kill the running program.

Breakpoints

`break <where>`
Set a new breakpoint.

`delete <breakpoint#>`
Remove a breakpoint.

`clear`
Delete all breakpoints.

`enable <breakpoint#>`
Enable a disabled breakpoint.

`disable <breakpoint#>`
Disable a breakpoint.

Watchpoints

`watch <where>`
Set a new watchpoint.

`delete/enable/disable <watchpoint#>`
Like breakpoints.

<where>

`function_name`
Break/watch the named function.

`line_number`
Break/watch the line number in the current source file.

`file:line_number`
Break/watch the line number in the named source file.

Conditions

`break/watch <where> if <condition>`
Break/watch at the given location if the condition is met.
Conditions may be almost any C expression that evaluate to true or false.

`condition <breakpoint#> <condition>`
Set/change the condition of an existing break- or watchpoint.

Examining the stack

`backtrace`
`where`
Show call stack.

`backtrace full`
`where full`
Show call stack, also print the local variables in each frame.

`frame <frame#>`
Select the stack frame to operate on.

Stepping

`step`
Go to next instruction (source line), diving into function.

`next`
Go to next instruction (source line) but don‘t dive into functions.

`finish`
Continue until the current function returns.

`continue`
Continue normal execution.

Variables and memory

`print/format <what>`
Print content of variable/memory location/register.

`display/format <what>`
Like „print“, but print the information after each stepping instruction.

`undisplay <display#>`
Remove the „display“ with the given number.

`enable display <display#>`
`disable display <display#>`
En- or disable the „display“ with the given number.

`x/nfu <address>`
Print memory.
n: How many units to print (default 1).
f*:* Format character (like „print“).
u: Unit.

Unit is one of:

b: Byte,
h: Half-word (two bytes)
w: Word (four bytes)
g: Giant word (eight bytes)).

Displaying Source Code

- list *filename*: *line_number*
  - *Displays source code centered around the line with the specified line number*
- list *line_number*
  - Display lines in the current source file if not specified the file name
- list *from*,[*to*] (line number/function names)
  - Display the specified range of the source code
- list *function_name*
  - source code centered around the line in which the specified function begins
- list, l
  - Display more lines of source code following those presented by the last list command

Review: Program Process Layout

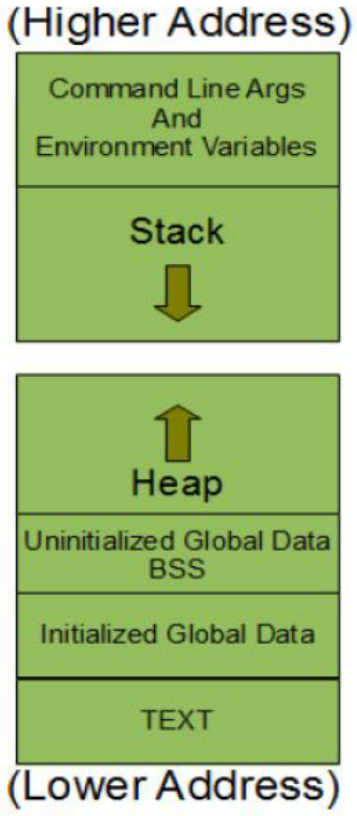


Image source : thegeekstuff.com

- TEXT segment
  - Contains machine instructions to be executed
- Global variables
  - Initialized\uninitialized
- Heap segment
  - Dynamic memory allocation
  - Malloc, free
- Stack segment
  - Push frame: function invoked
  - Pop frame: function returned
  - Stores: local variables; return address, registers
- Command line arguments and environmental variables

C Language

- C: a subset of C++, very similar
- Differences
  - No object oriented features: class, overloading, virtual function etc.
  - Memory Allocation
  - For C language: **main function doesn’t return 0 automatically**

Type

- Built-in types
  - Integers, Floating-point, character strings
  - No bool (before C99)

- Compiling ‘C’ only
  - gcc **-std=c99** hello.c

Struct

- No classes in C
- Function: package related data (variables of different types) together
- Single name is convenient (rename: *typedef*)

```
struct Student {
        char name[64];
        char UID[10];
        int age;
        int year;
};
struct Student s;
```

```
typedef struct {
char name[64];
char UID[10];
 int age;
int year;
 } Student;
Student s;
```

C Struct vs. C++ Class

- C structs cannot have member functions
- There's no such thing as access specifiers in C
- C structs don't have constructors defined for them

- C++ classes can have member functions
- C++ class members have access specifiers and are private by default
- C++ classes must have at least a default constructor

Pointers Review

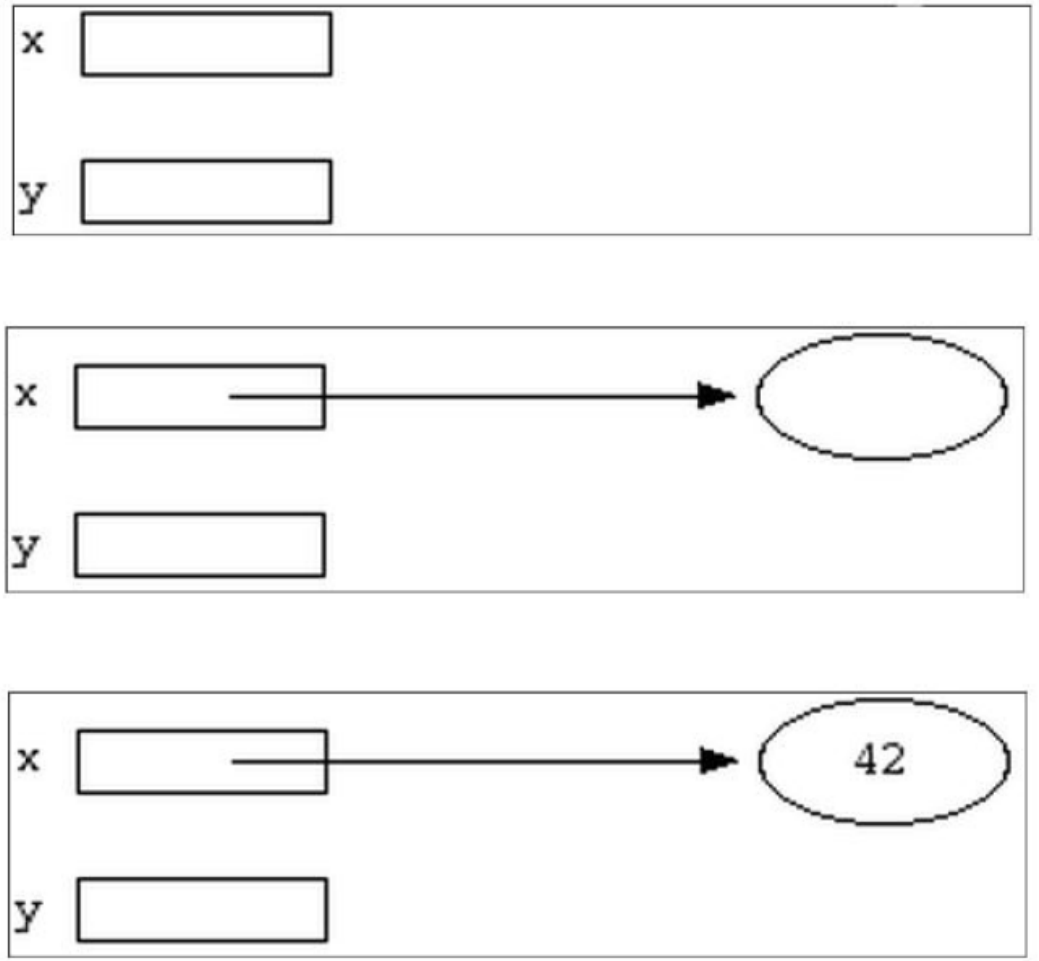
- Variables that store **memory addresses**
- Declaration
  - <variable_type> *<name>;
  - int *ptr; //declare ptr as a pointer to int
  - int var = 77; // define an int variable
  - ptr = &var; // let ptr point to the variable var

Dereferencing Pointers

- Accessing the value that the pointer points to
- Example:
  - double x, *ptr;
  - ptr = **&**x; // let ptr point to x
  - ***ptr** = 7.8; // assign the value 7.8 to x

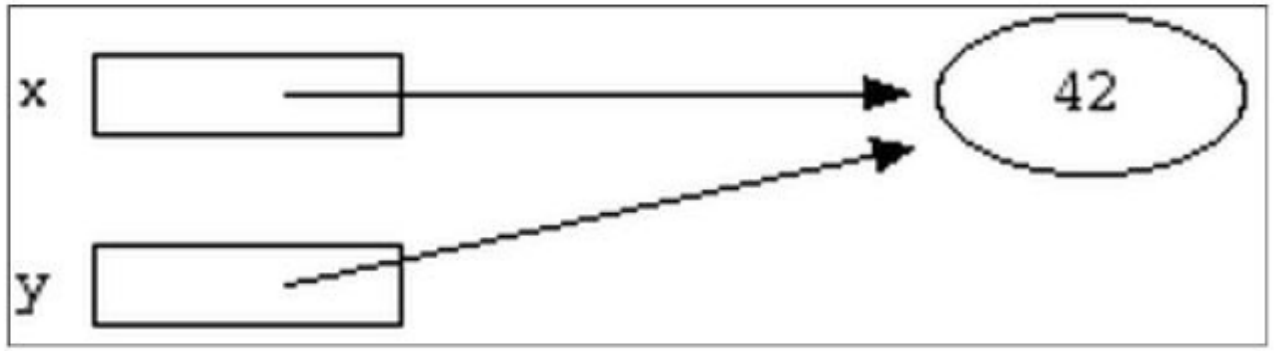
Pointer Example

```
int *x;

int *y;

int var;   x = &var;

*x = 42;
```



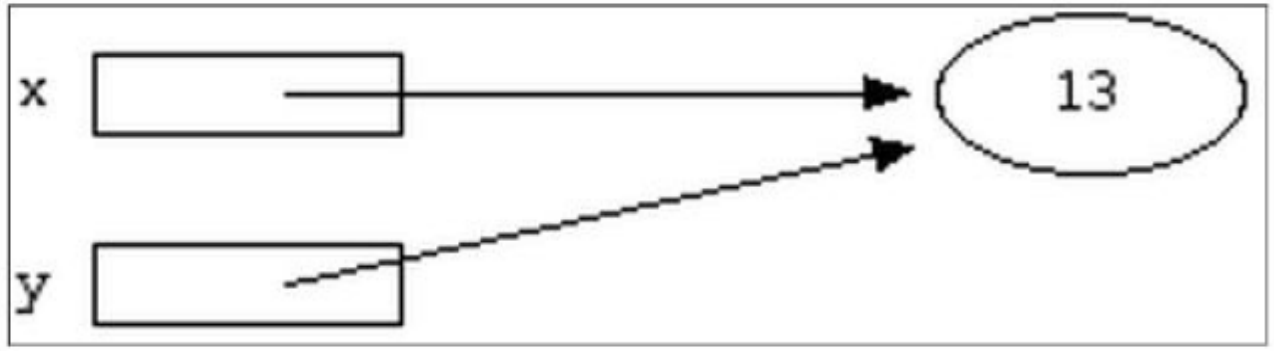
Pointer Example

y = x;



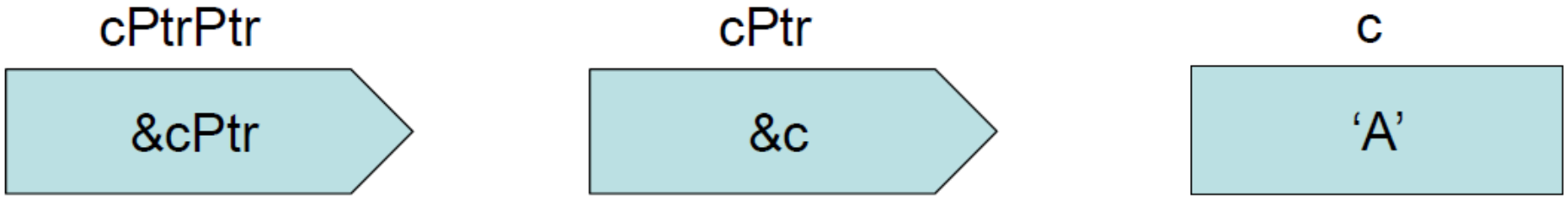
*x = 13; or

*y = 13;



Pointers to Pointers

char c = ‘A’ char *cPtr = &c char **cPtrPtr = &cPtr



Pointers to Functions

- Also known as: **function pointers** or **functors**
- Task of homework 4: write a sorting function
  - Has to work for ascending and descending sorting + other
- How?
  - Write multiple functions
  - Provide a flag as an argument to the function
  - Polymorphism and virtual functions
  - Use function pointers!!

qsort Example

```
#include <stdio.h>
#include <stdlib.h>
int compare (const void * a, const void * b)
{
  return ( *(int*)a - *(int*)b );
}
int main ()
{
  int values[] = { 40, 10, 100, 90, 20, 25 };
  qsort (values, 6, sizeof(int), compare);
  int n;
  for (n = 0; n < 6; n++)
     printf ("%d ",values[n]);
return 0;
}
```

Pointers to Functions

- User can pass in a function to the sort function
- Declaration
  - double (*func_ptr) (double, double);
  - func_ptr = &pow; // func_ptr points to pow()
- Usage
  - // Call the function referenced by func_ptr

    double result = (*func_ptr)(1.5, 2.0);
  - // The same function call

    result = func_ptr(1.5, 2.0);

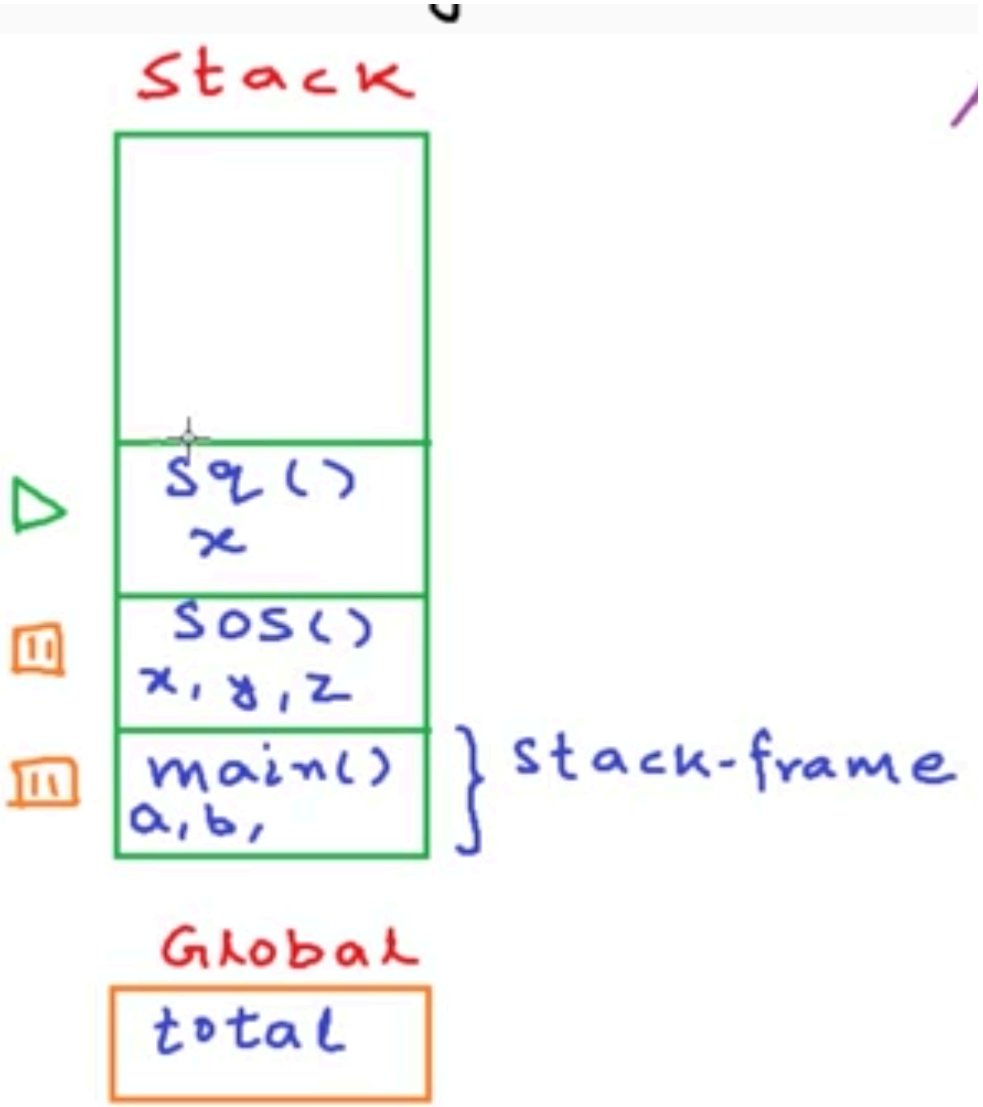
Dynamic Memory Allocation

- malloc(size_t size): allocates a block of memory whose size is at least size
- free(void *ptr): frees the block of memory pointed to by ptr
- realloc(void *ptr, size_t newSize) : Resizes allocated memory
- Allocate memory **on heap**

```
Rectangle_t *ptr = (Rectangle_t*) malloc(sizeof
(Rectangle_t));
if(ptr == NULL)
{
  printf("Something went wrong in malloc");
  exit(-1);
}
else
{
//Perform tasks with the memory
//
//
free(ptr);
ptr = NULL;
}


ptr = (Rectangle_t*) realloc(ptr, 3*sizeof
(Rectangle_t))
```

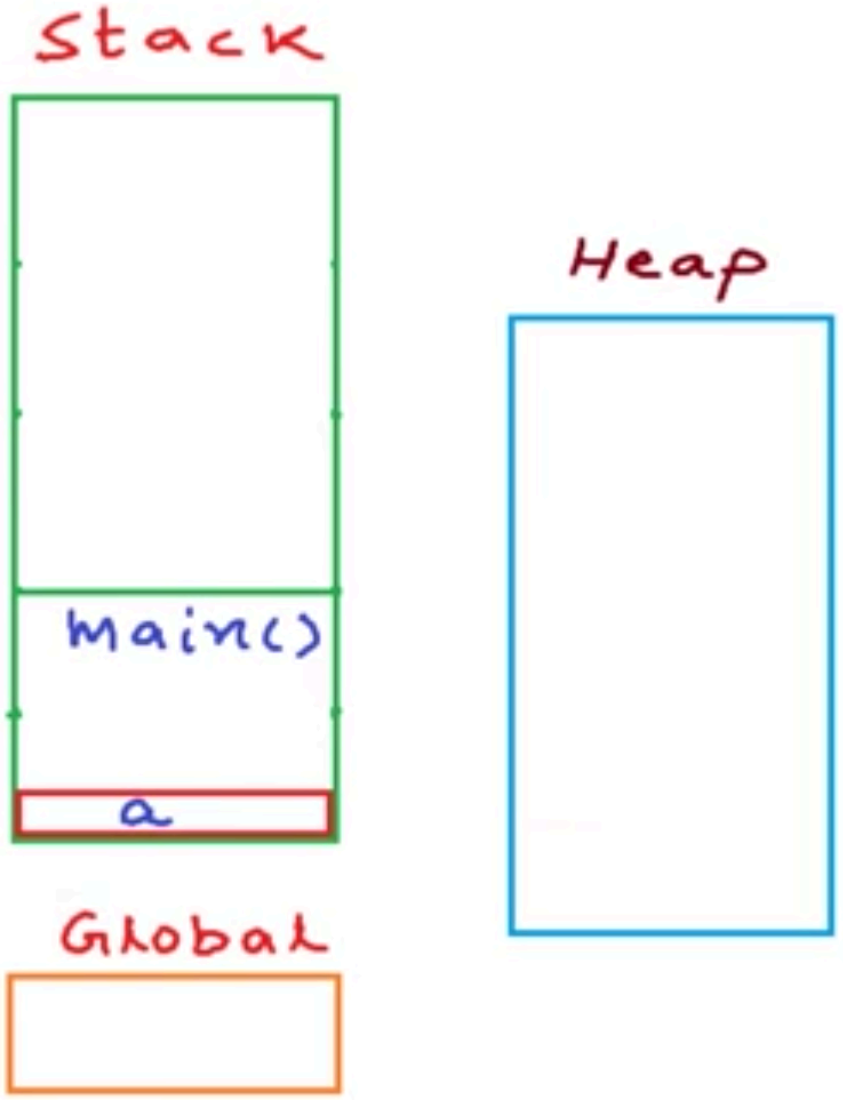
Demo: Stack vs Heap

```c
#include<stdio.h>
int total;
int Square(int x)
{
    return x*x;  // x^2
}
int SquareOfSum(int x,int y)
{
    int z = Square(x+y);
    return z;  // (x+y)^2
}
int main()
{
    int a = 4, b = 8;
    total = SquareOfSum(a,b);
    printf("output = %d",total);
}
```



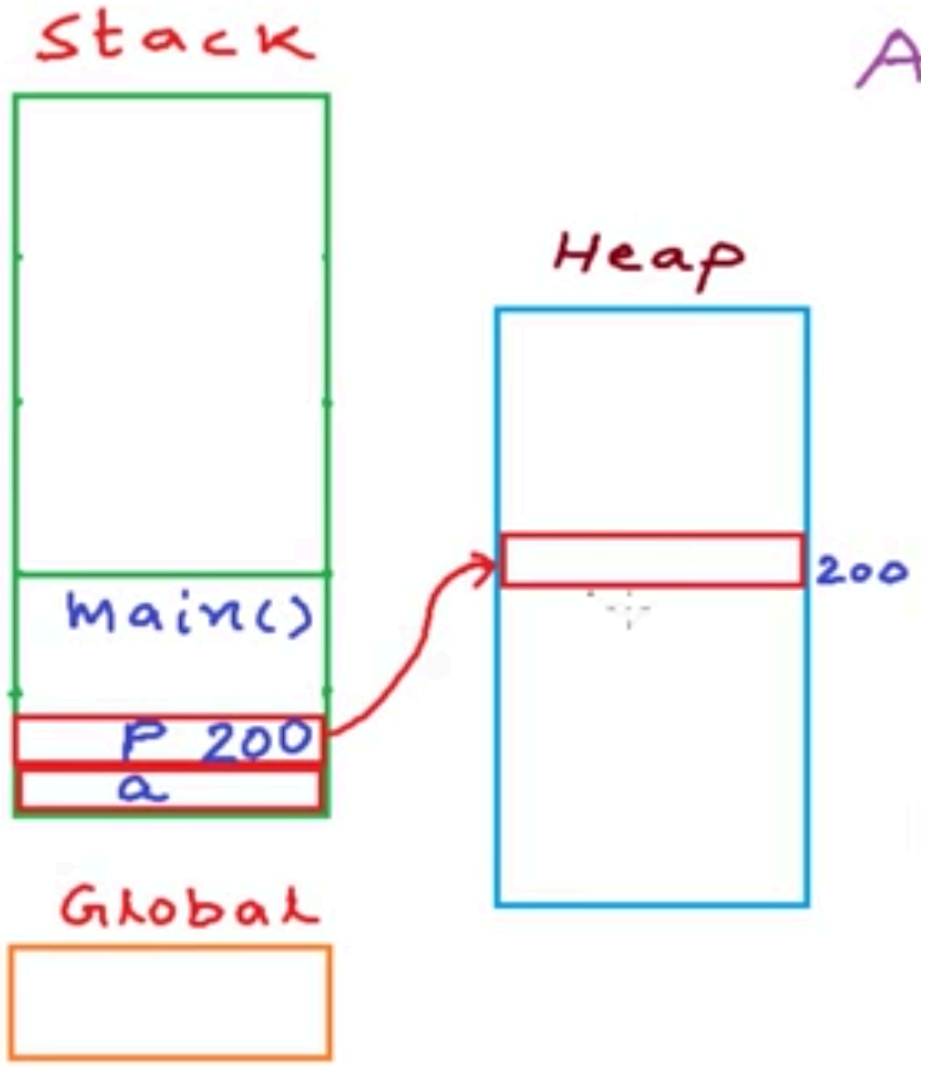
Demo: Stack vs Heap

```c
#include<stdio.h>
#include<stdlib.h>
int main()
{
   int a; // goes on stack
```



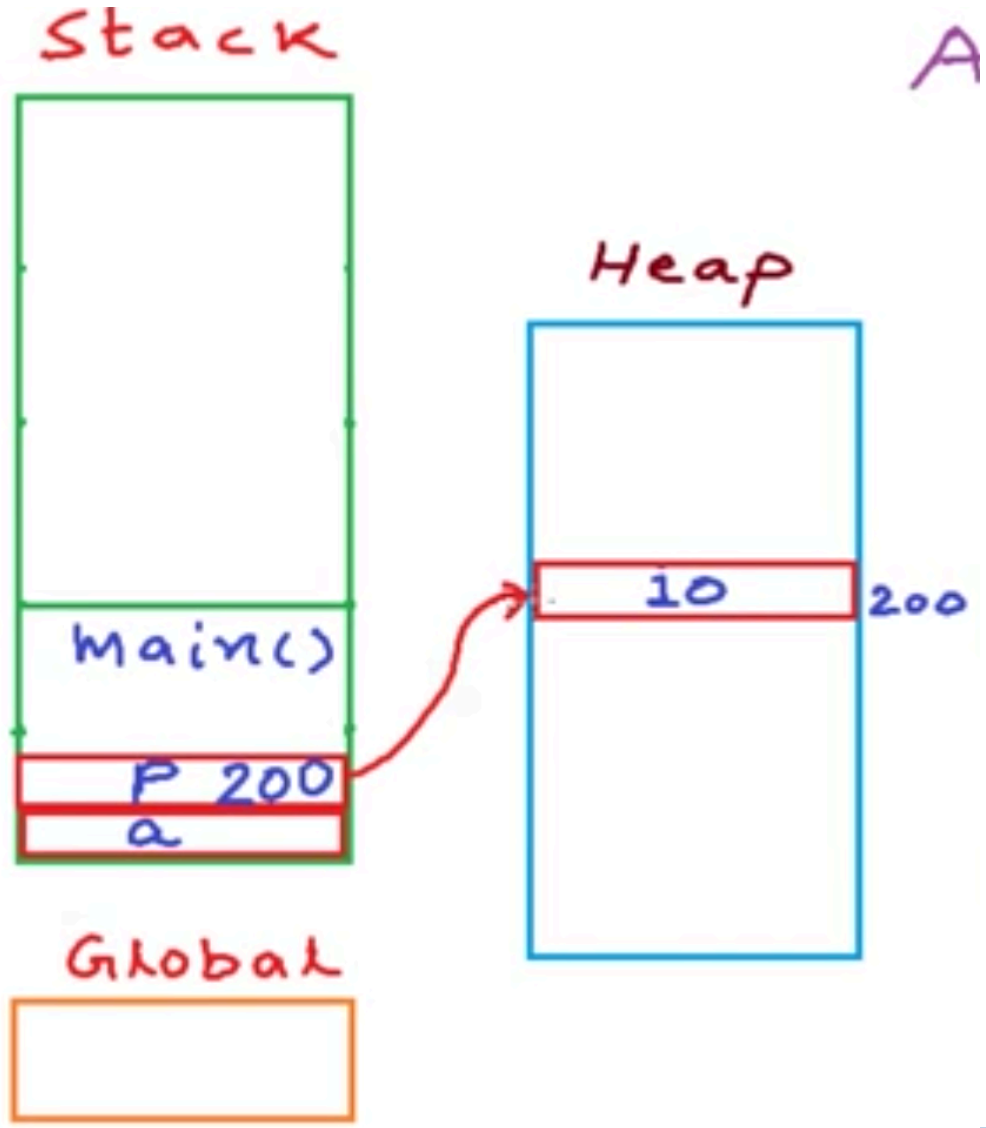
Demo: Stack vs Heap

```c
#include<stdio.h>
#include<stdlib.h>
int main()
{
   int a; // goes on stack
   int *p;
   p = (int*)malloc(sizeof(int));
```



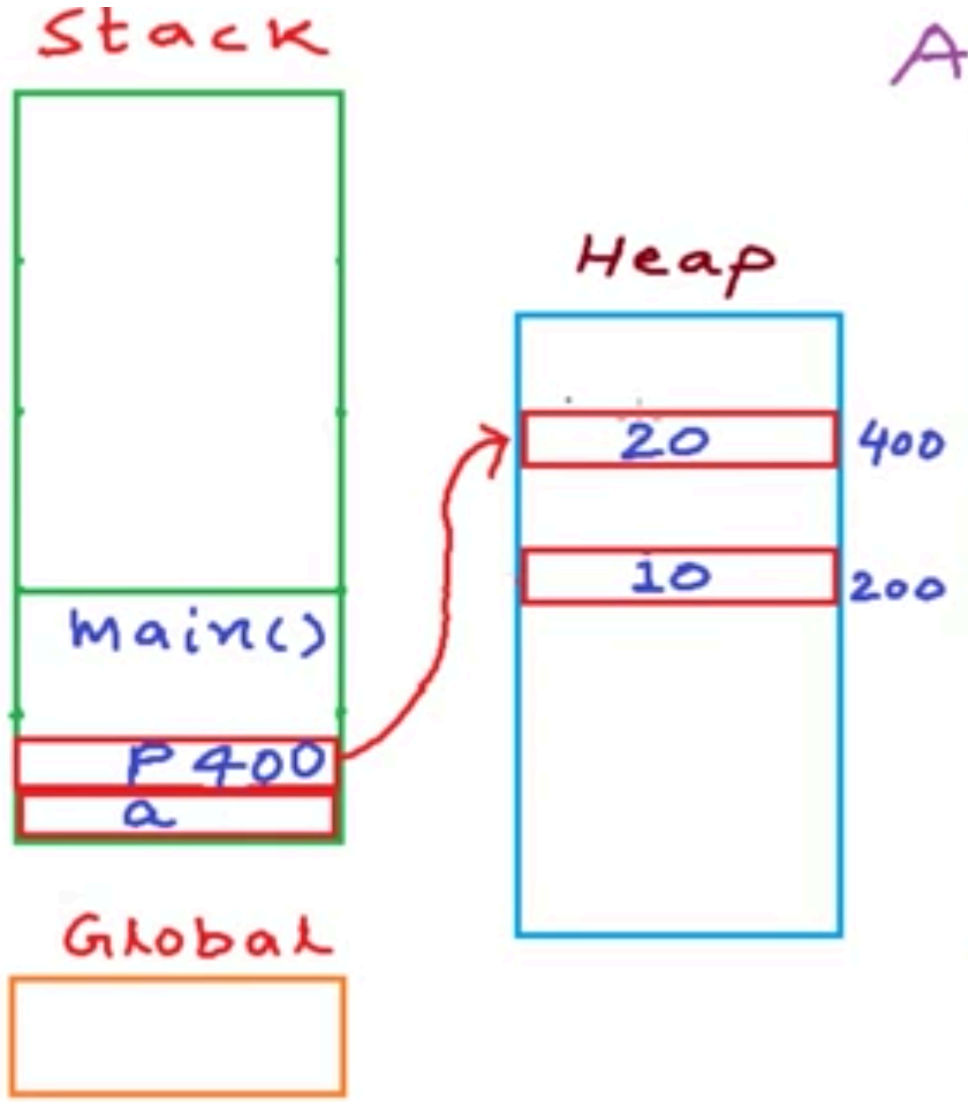
Dynamic memory allocation

```c
#include<stdio.h>
#include<stdlib.h>
int main()
{
   int a; // goes on stack
   int *p;
   p = (int*)malloc(sizeof(int));
   *p = 10;
```



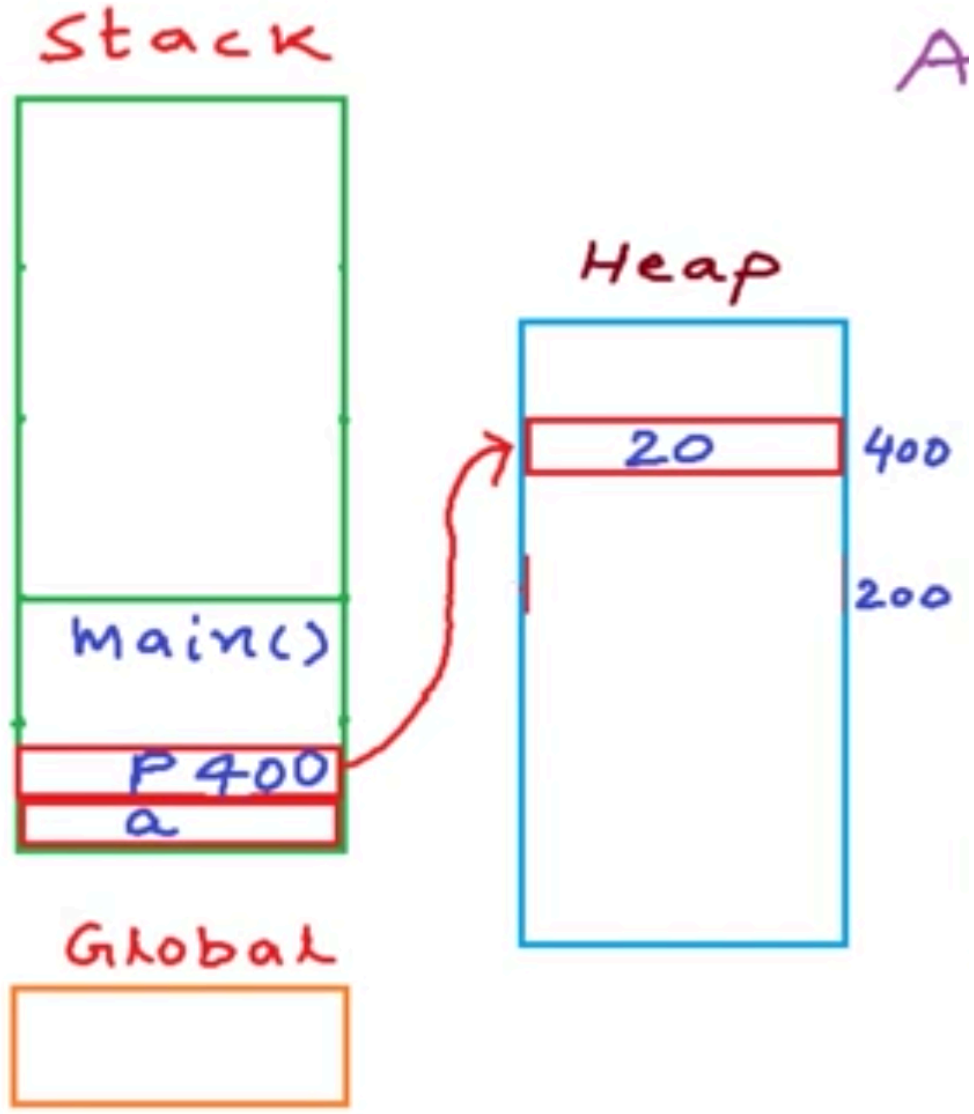
Dynamic memory allocation

```c
#include<stdio.h>
#include<stdlib.h>
int main()
{
   int a; // goes on stack
   int *p;
   p = (int*)malloc(sizeof(int));
   *p = 10;
   p = (int*)malloc(sizeof(int));
   *p = 20;
```



Dynamic memory allocation

```c
#include<stdio.h>
#include<stdlib.h>
int main()
{
   int a; // goes on stack
   int *p;
   p = (int*)malloc(sizeof(int));
   *p = 10;
   free(p);
   p = (int*)malloc(sizeof(int));
   *p = 20;
}
```



Reading text information

- Common streams and their file pointers
  - Standard input – stdin
  - Standard output – stdout
  - Standard error - stderr
- Reading/Writing characters
  - getc(FILE *_fp_);
  - putc(int c, FILE *pf);
- Reading/Writing Lines
  - char *fgets(char *_buf_, int _n_, FILE *_fp_);
  - int fputs(const char *_s_, FILE *_fp_);

Formatted Input/Output

- Open and close files
  - FILE * fopen(const char * restrict *filename*, const char * restrict *mode*);
  - int fclose(FILE *fp);
  - FILE *fp can be either a file pointer or stdin, stdout, or stderr

- Output: int fprintf(FILE * fp, const char * format, …);

- Input: int fscanf(FILE * fp, const char * format, …);
  - The format string:
    - int score = 120; char player[] = “Mary”;
    - printf(**“%s has %d points.\n”, player, score**);

    - Note: **restrict** says that the pointer is the only thing that accesses the underlying object. It eliminates the potential for pointer aliasing, enabling better optimization by the compiler.

Ternary Operator ?:

- Short form for a conditional assignment

  result = a > b ? x : y; is equivalent to:

```
if(a>b)
{
   result = x;
}
else
{
   result = y;
 }
```

Lab 4: get started

- Recall what you did in Lab 3
- Download the bugged version of coreutils
- Follow instructions in INSTALL (Similar steps in Assignment 3)
- Patching
  - There is an error when running make command
  - Download and edit the patch
  - Apply the patch using the patch command

Lab 4: Debugging and patching

- Test the files and reproduce the bug
- Use gdb to figure out what's wrong (running from the directory where the compiled ls lives)
- Construct a patch and fix the bug
  - Construct a patch containing your fix in a patch file called lab4.patch
  - It should contain a ChangeLog entry followed by the output of diff -u
- **Method to construct a patch file**
  - Modify the buggy file manually
  - Generate the patch: *diff –u* + redirection
  - Copy from /doc/ChangeLog and paste to your .diff file

Lab 4: Hints

- Try to reproduce the problem in your home directory, instead of the $tmp directory
  - SEASnet NFS file system has 32-bit time stamps
  - Local File System on Linux server has 64-bit time stamps
  - If you touch the files on the NFS file system it will return timestamp around the year 2054
- files have to be touched on local file system (**df –l**)