Outline

- **Review: Memory Layout and Function Call Convention**

- Buffer Overflow Vulnerability

Memory Layout of a Program (x86)

Code

- The program code: fixed size and read only

Static data

- Statically allocated data, e.g., variables, constants

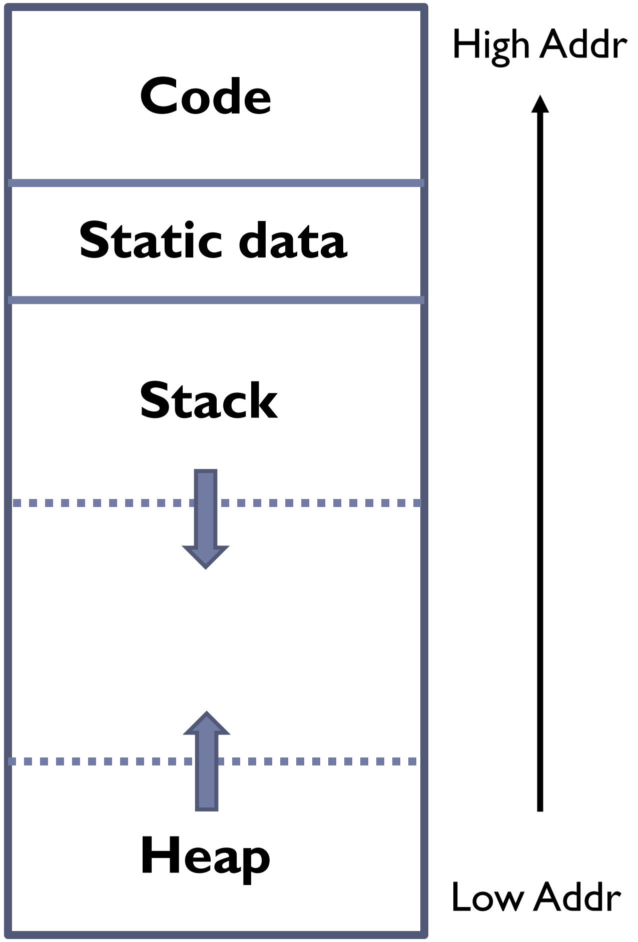
Stack

- Parameters and local variables of methods as they are invoked.
- Each invocation of a method creates one frame which is pushed onto the stack
- Grows to lower addresses

Heap

- Dynamically allocated data, e.g., class instances, data array
- Grows towards higher addresses

Memory layout



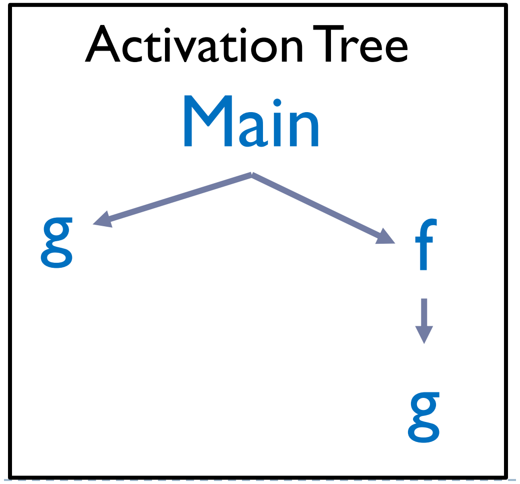
Stack

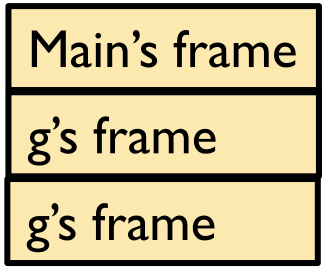
Store local variables (including method parameters) and intermediate computation results

A stack is subdivided into multiple **frames**:

- A method is invoked: a new frame is pushed onto the stack to store local variables and intermediate results for this method;
- A method exits: its frame is popped off, exposing the frame of its caller beneath it

```
Main( ) {
  g( );
  f( );
}
f( ) {
  return g( );
}
g( ) {
  return 1;
}
```





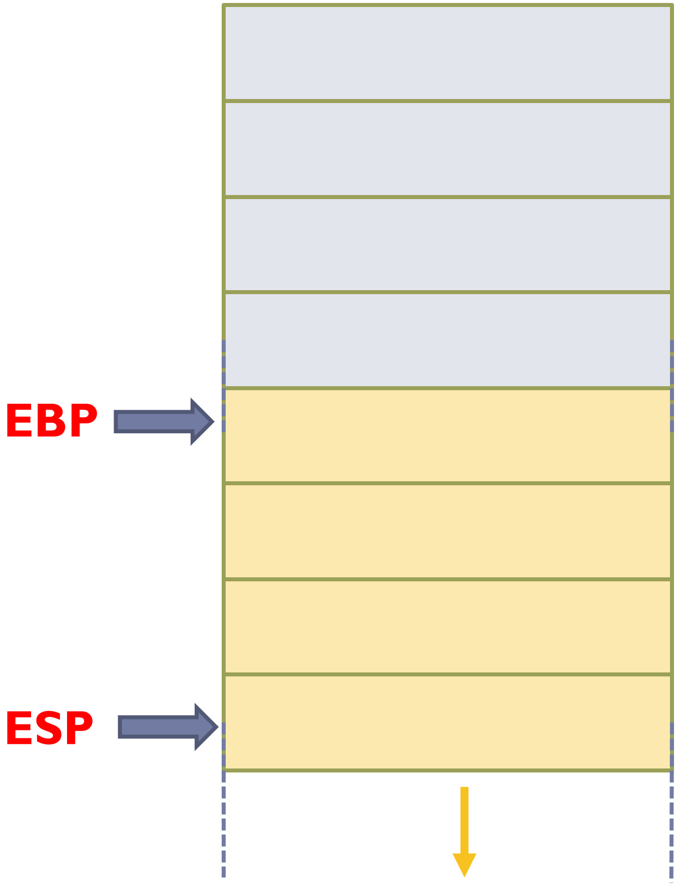
Inside a Frame for One Function

Two pointers:

- **EBP**: base pointer. Fixed at the frame base
- **ESP**: stack pointer. Current pointer in frame (current lowest value on the stack)

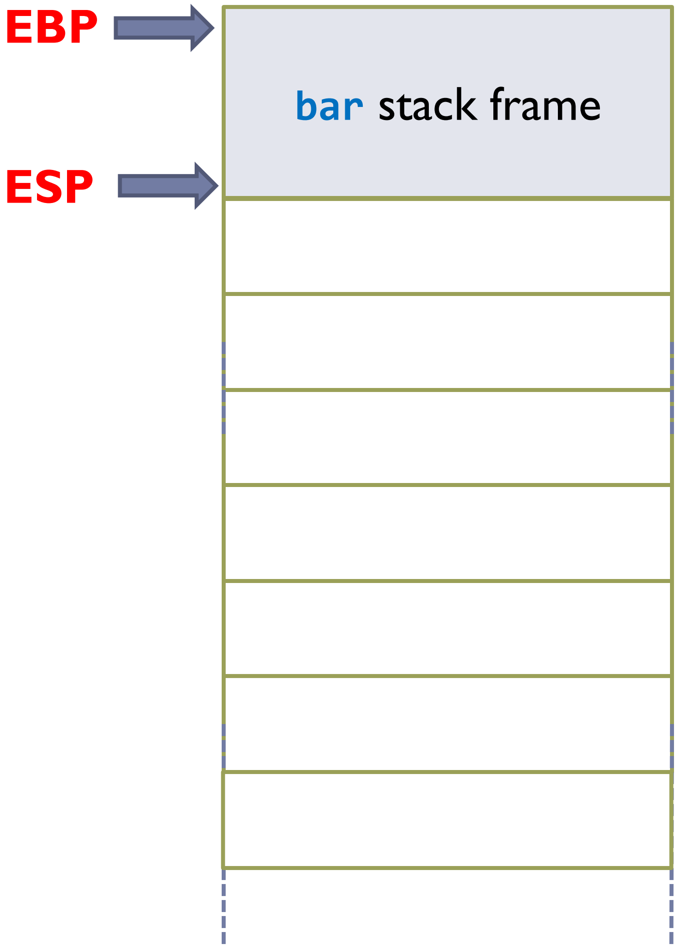
A frame consists of the following parts:

- Function parameters
- Return address of the caller function
  - When the function is finished, execution continues at this return address
- Base pointer of the caller function
- Local variables
- Intermediate operands



Function Call Convention

Initially: EBP and ESP point to the top and bottom of the bar stack frame.



```
void bar( ) {
  foo(1, 2);
}
int foo(int x, int y){
  int z = x + y;
  return z;
}
```