Basic Assembly

Local state

Assembly language programming
By xorpd

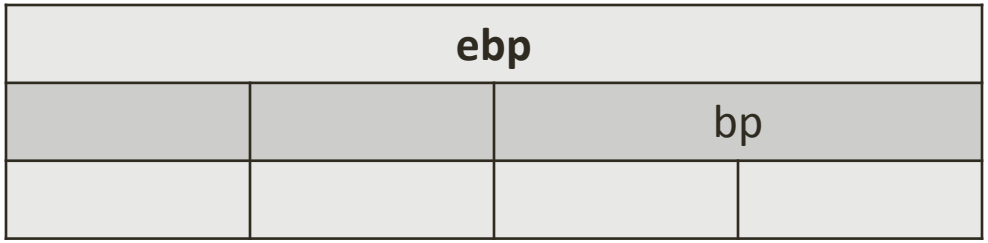
xorpd.net

Objectives

- We will study the EBP register, and its use as the stack base pointer.
- We will learn about function's local variables, and where to store them.
- We will understand the general structure of the stack during the invocation of functions in our program.

EBP

- EBP – Extended base pointer.
  - A register of size 32 bits.



- Historically, ESP could not be used to access memory directly.
  - “dword [esp + 4]” was not possible.
  - The EBP register was used instead.

- These days ESP can access memory directly.
  - EBP is usually used to “hold” the stack frame.

Example

- Extracting the arguments from the stack:

```
sum_nums:

    mov    esi,dword [esp + 4]
    mov    ecx,dword [esp + 8]
    xor    edx,edx
    jecxz  .no_nums
.next_dw:
    lodsd
    add    edx,eax
    loop   .next_dw
.no_nums:
    mov    eax,edx

    ret
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    ret
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```
sum_nums:
    push    ecx
    mov     esi,dword [esp + 8]
    mov     ecx,dword [esp + 0ch]
    xor     edx,edx
    jecxz   .no_nums
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    lodsd
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.no_nums:
    mov     eax,edx
    pop     ecx
    ret
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    ret
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- ESP might change many times during the function.
- We have to follow the current offset of ESP to be able to access arguments.
  - Not fun :(

Holding the stack frame

- We could use EBP to remember what ESP was initially.
  - Then we don't care about changes to esp.

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sum_nums:
    mov     ebp,esp
    push    ecx
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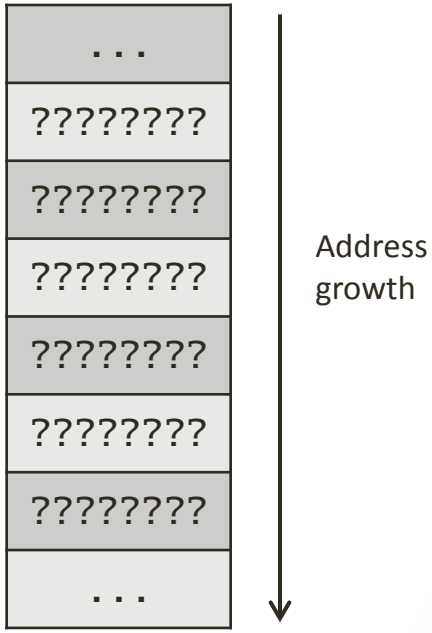

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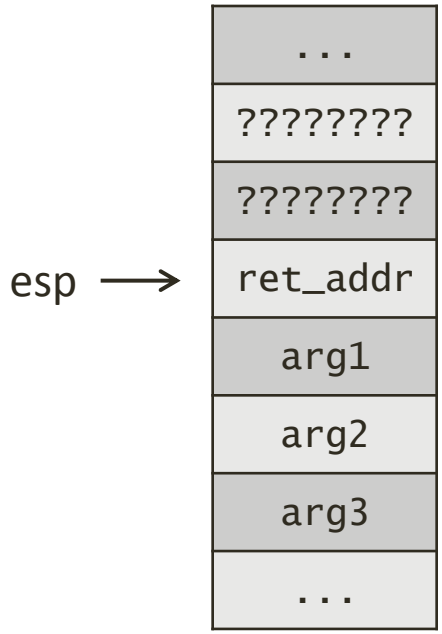

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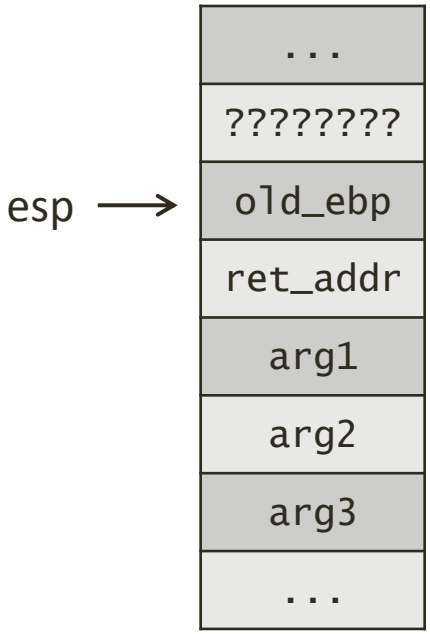

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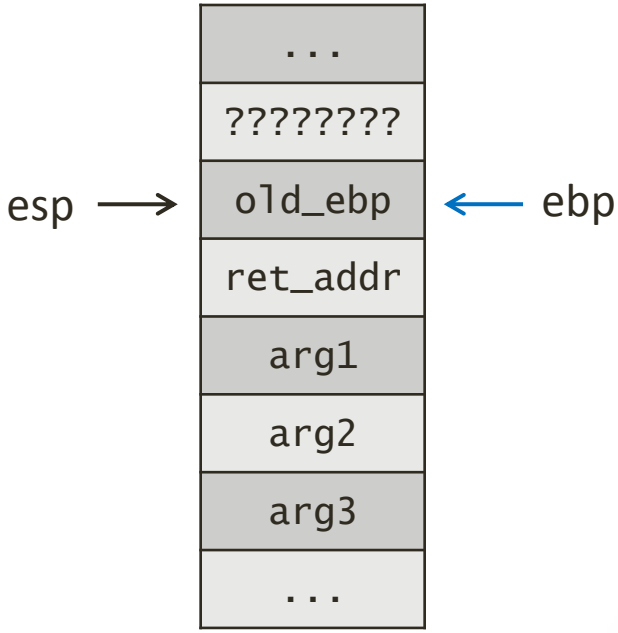

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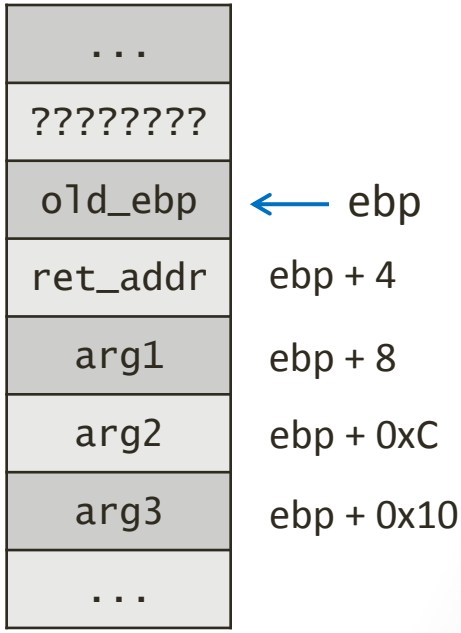

Inside the function:

- old_ebp: $[ebp]$
- ret_addr: $[ebp + 4]$
- arg 1: $[ebp + 8]$
- arg k: $[ebp + 4 + 4 \cdot k]$

Local Variables

- We might need some memory during function execution.
- Using the global memory is usually not a good option.
  - Not very modular. (We want the function to be self contained).
  - Other cons. (Not reentrant)
- We could use the stack!

Local Variables (Cont.)

- Decrease esp to allocate space on stack:

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func:
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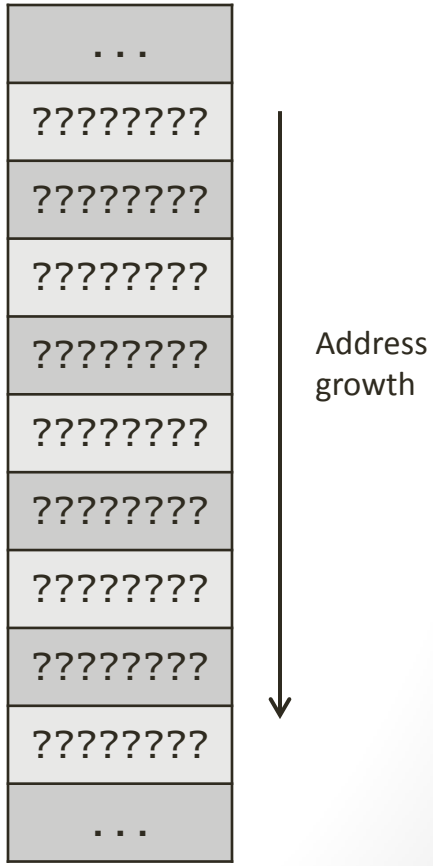

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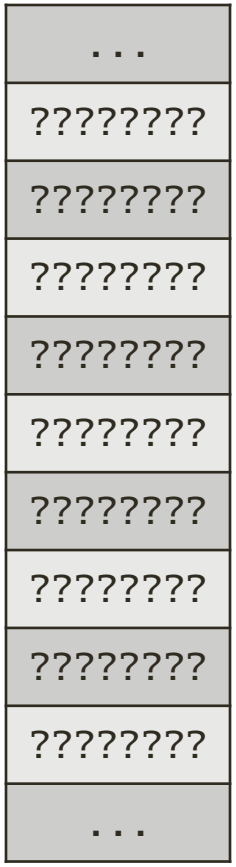

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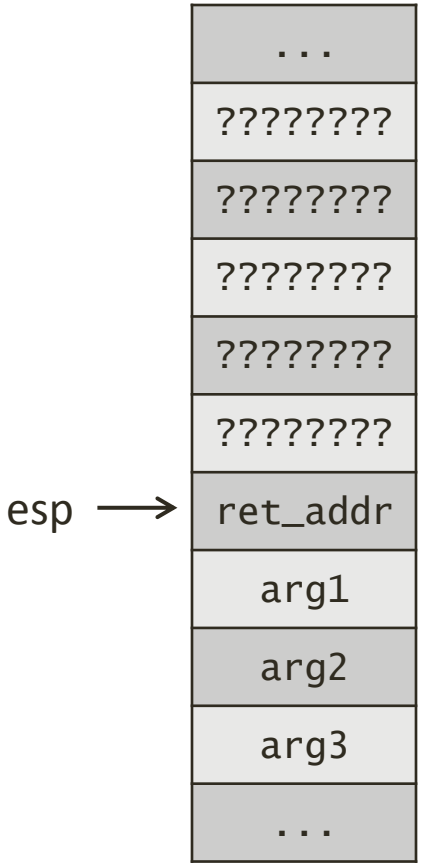

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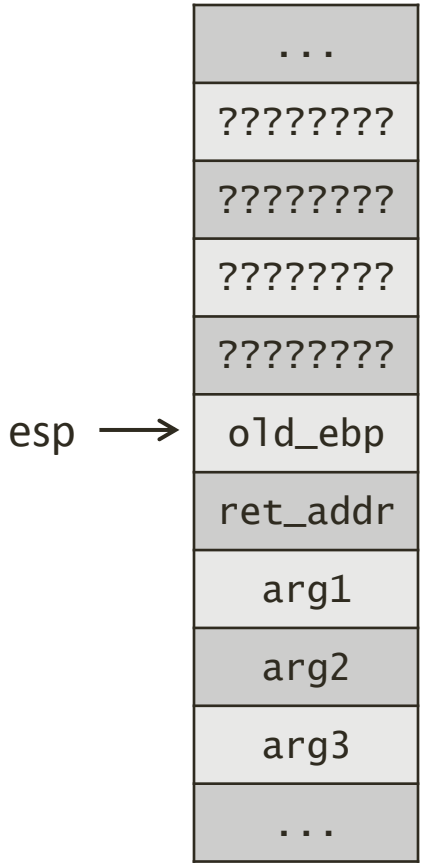

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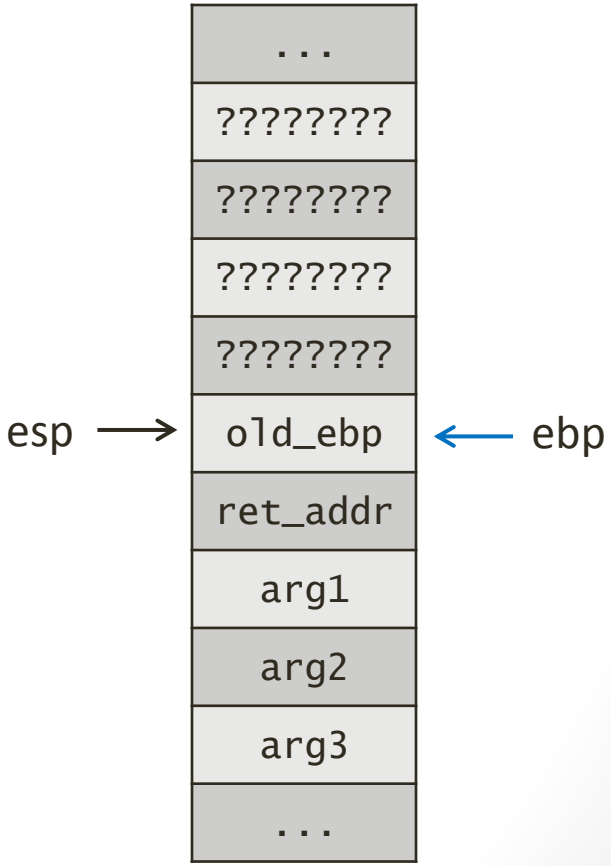

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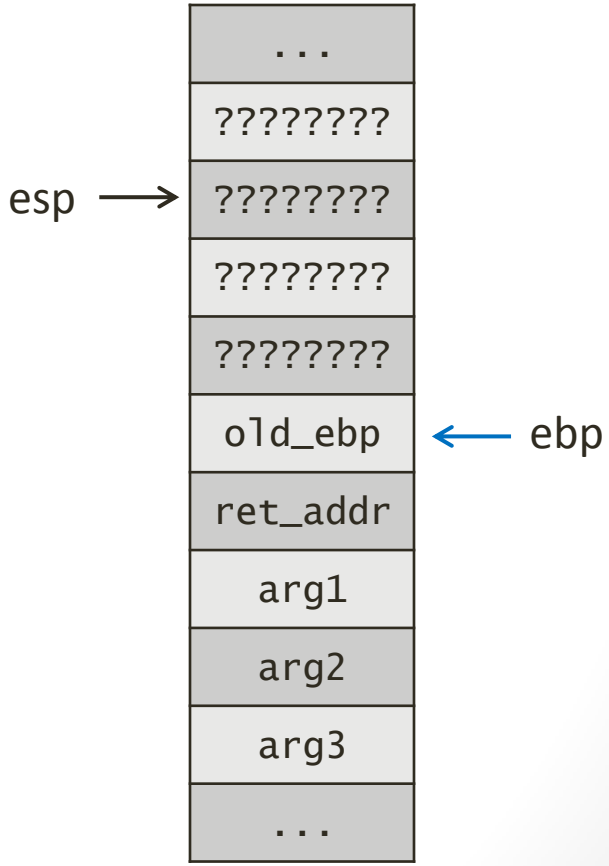

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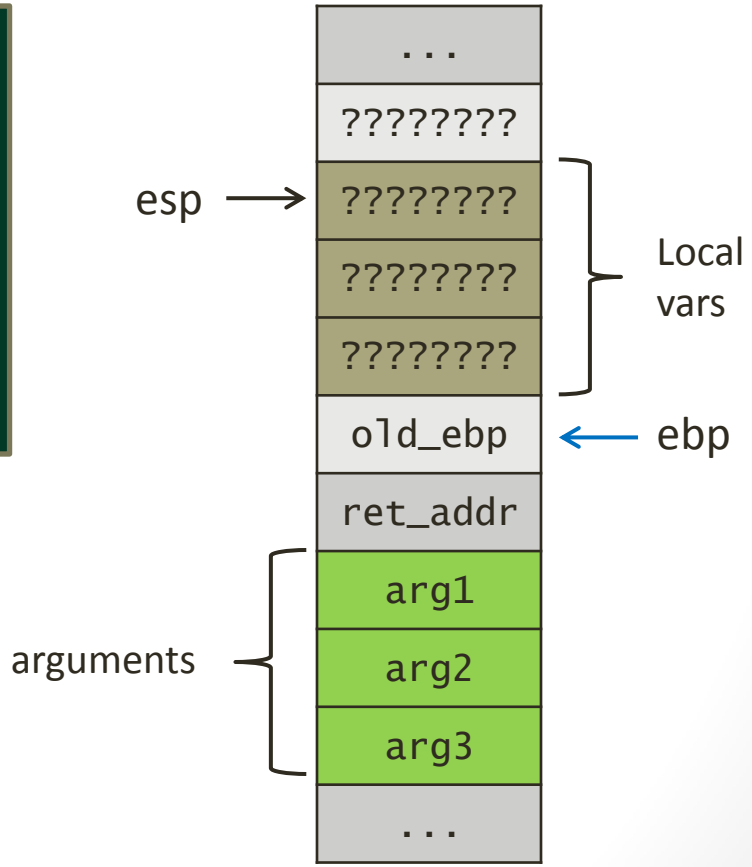

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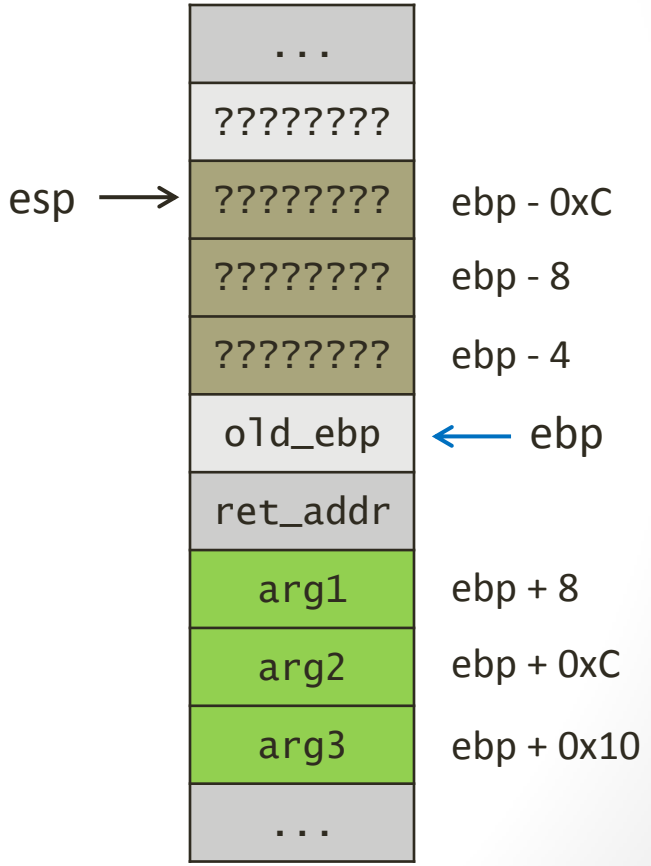

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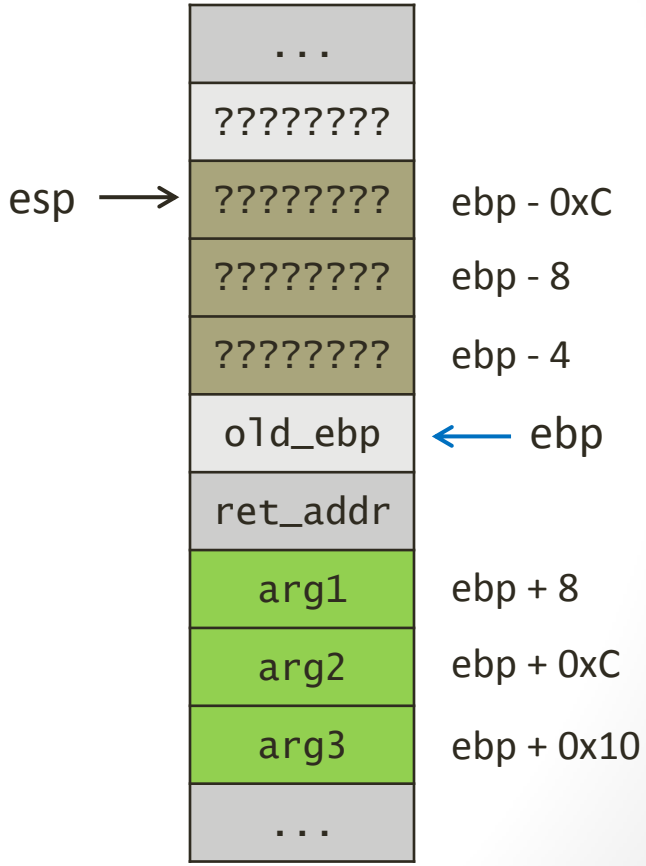

- Variables: $[ebp - 4 \cdot k]$
- Arguments: $[ebp + 4 + 4 \cdot r]$

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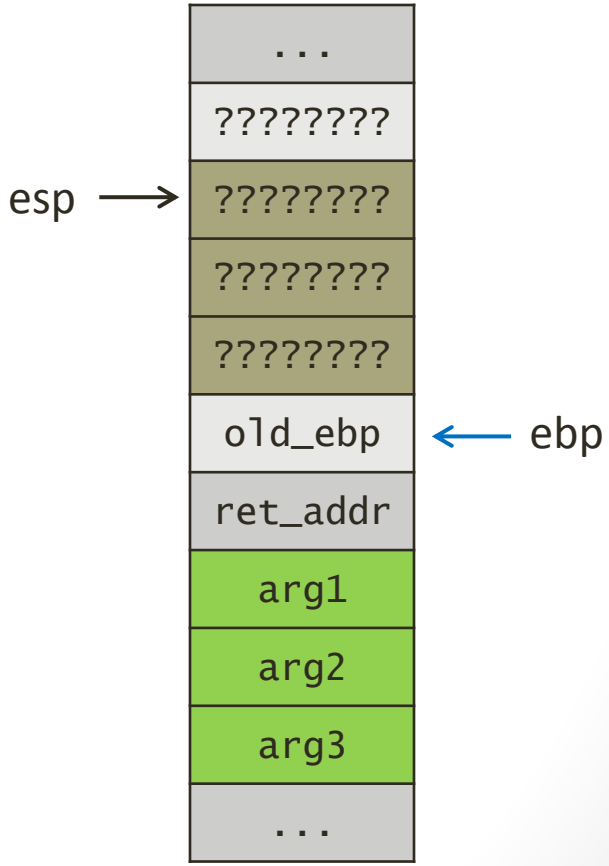

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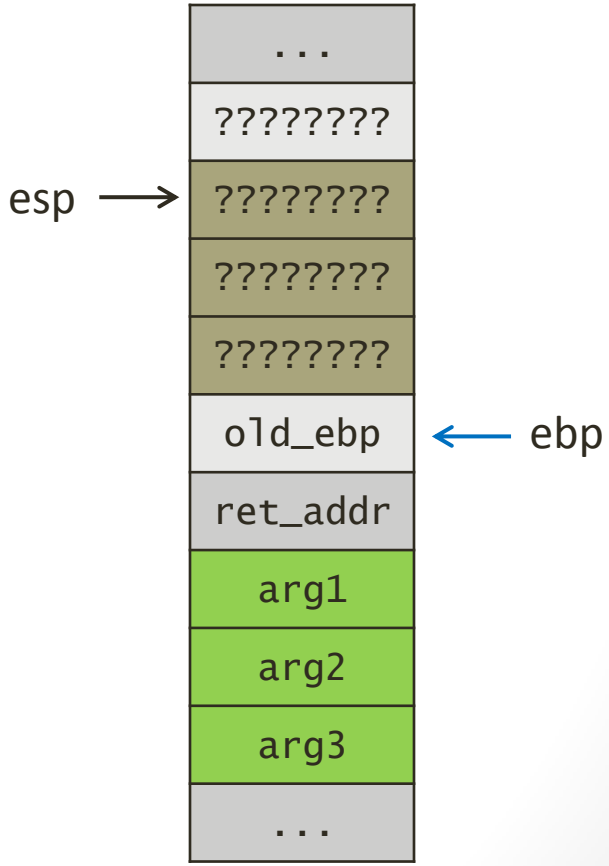

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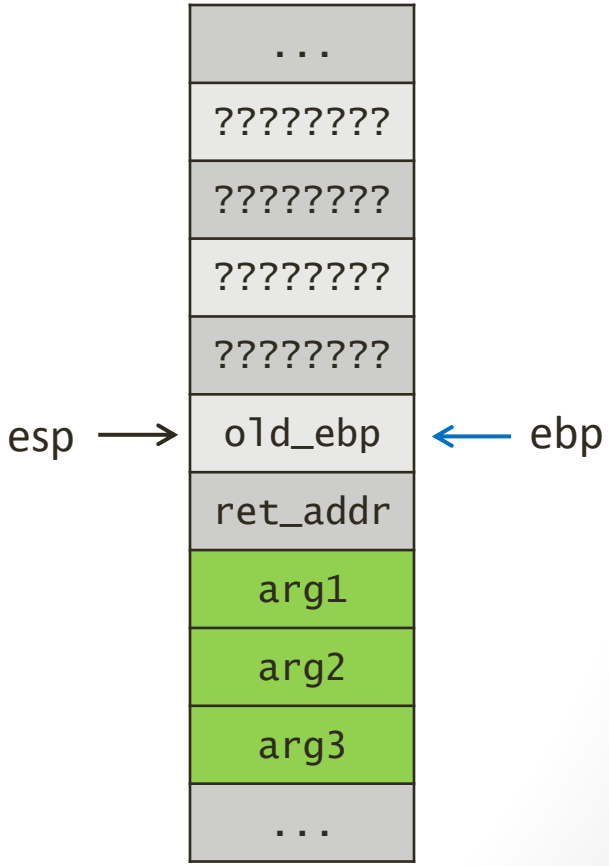

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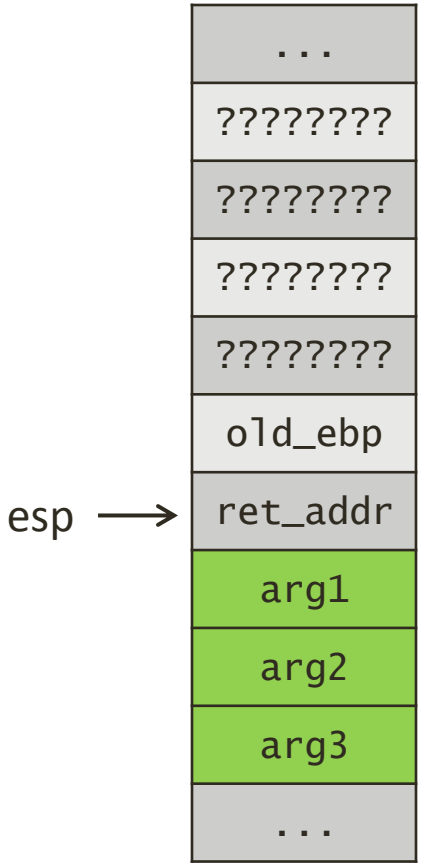

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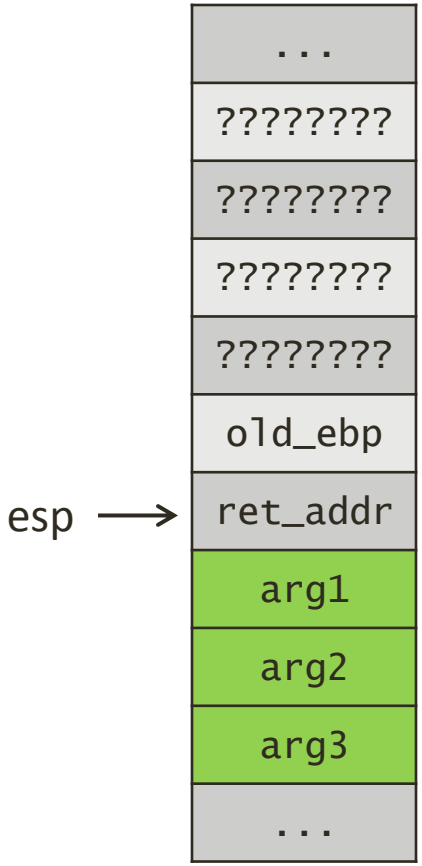


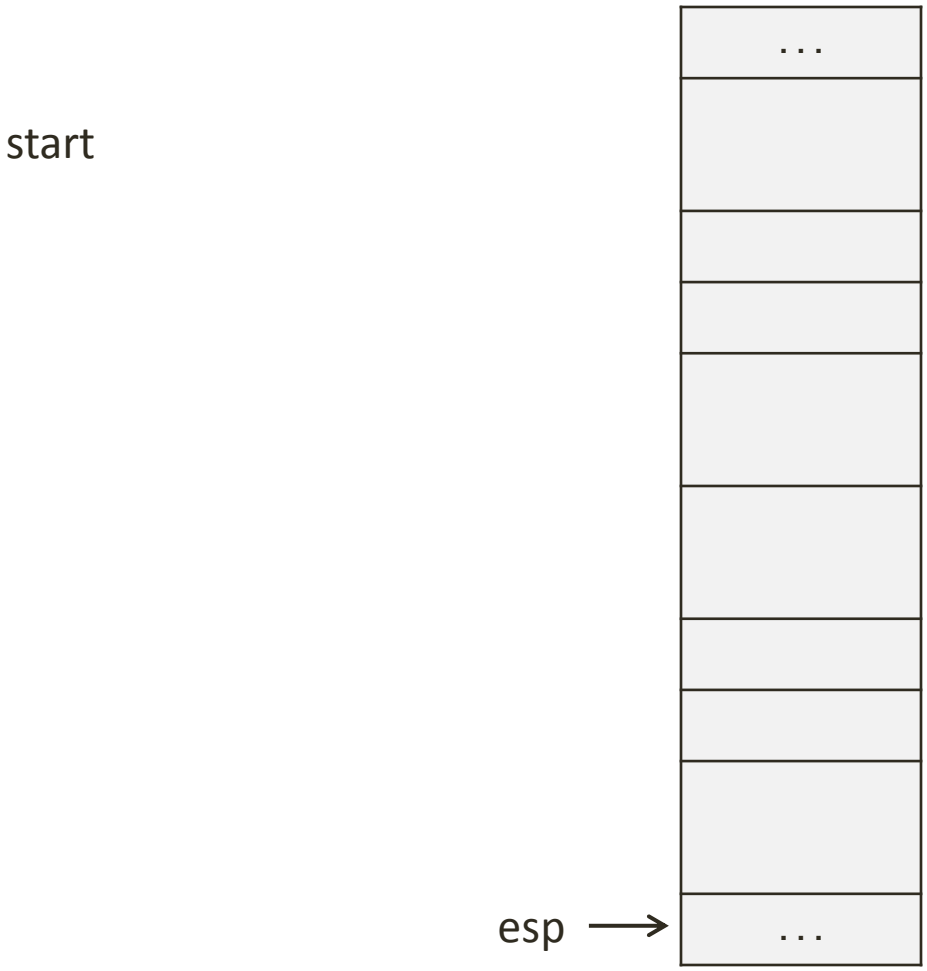
- The local state is freed when the function returns.
  - Local data lives a short life.

The call stack

- Every function being called has a “frame” inside the stack.
  - Arguments
  - Return address
  - Old EBP (Previous frame)
  - Local variables

- The stack tells the story of all functions currently “open”, all the way to the current function.

The call stack (Cont.)



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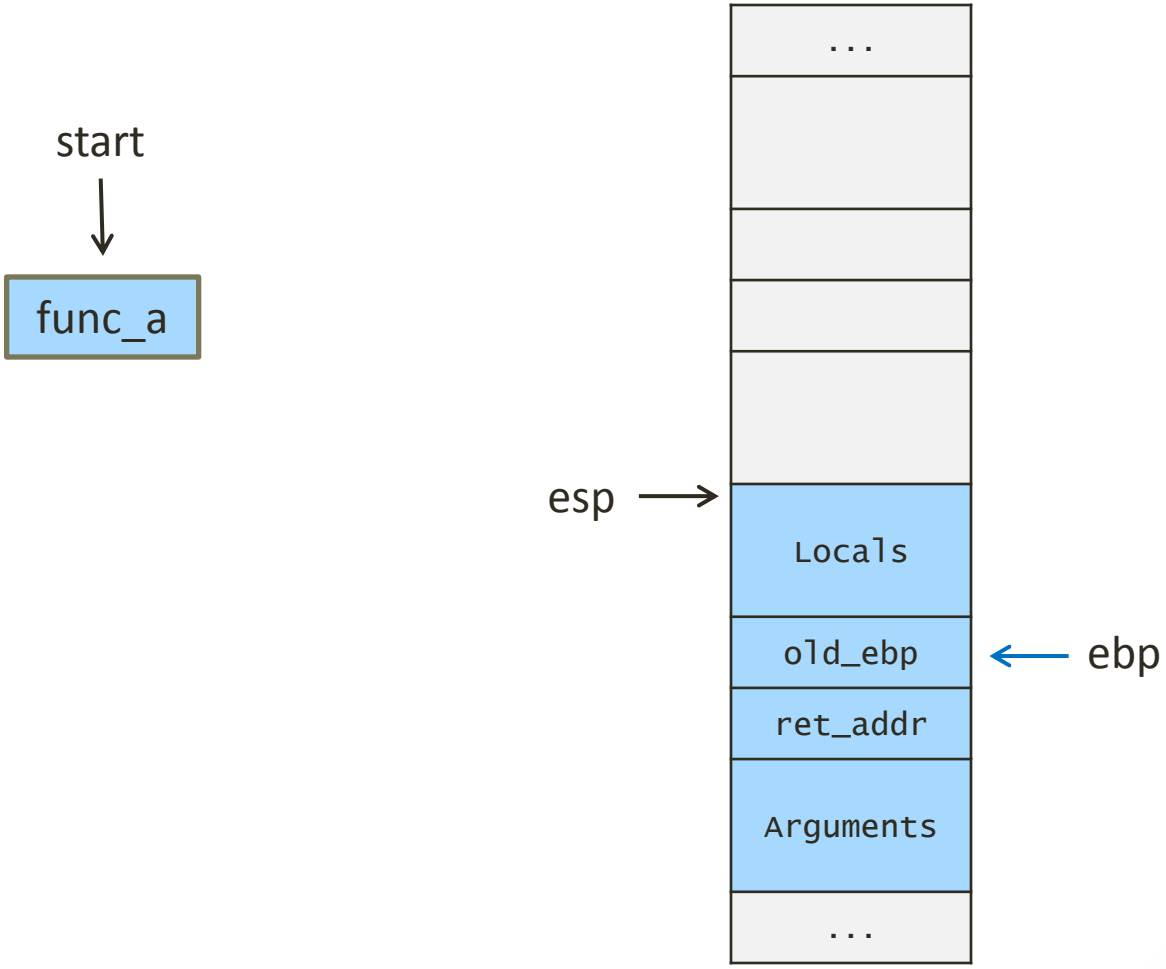

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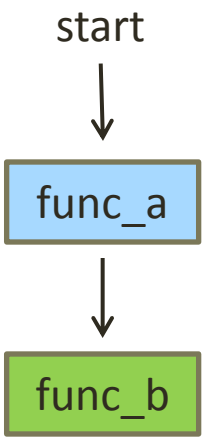

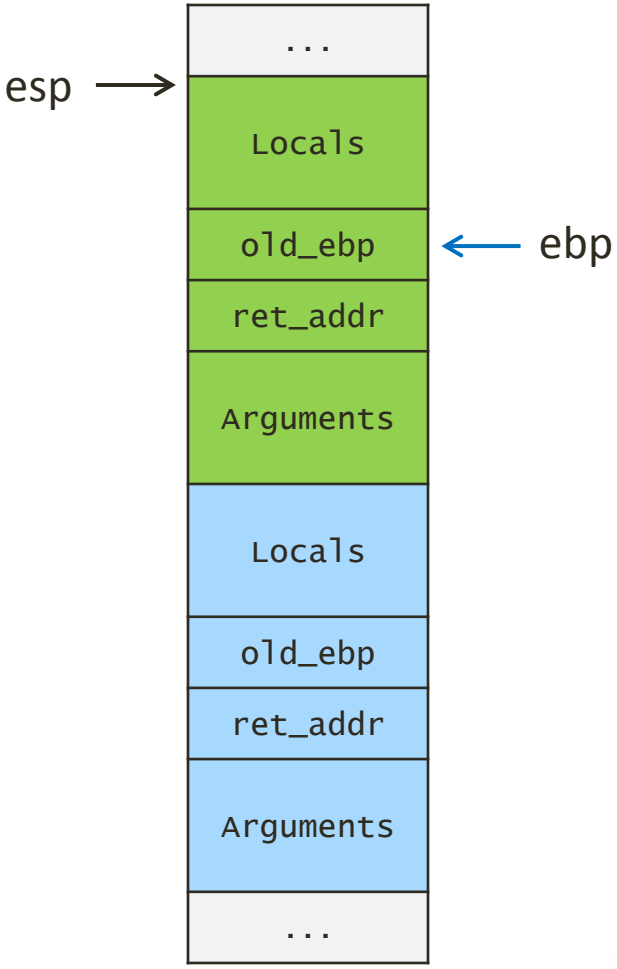

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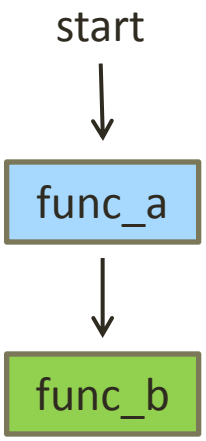

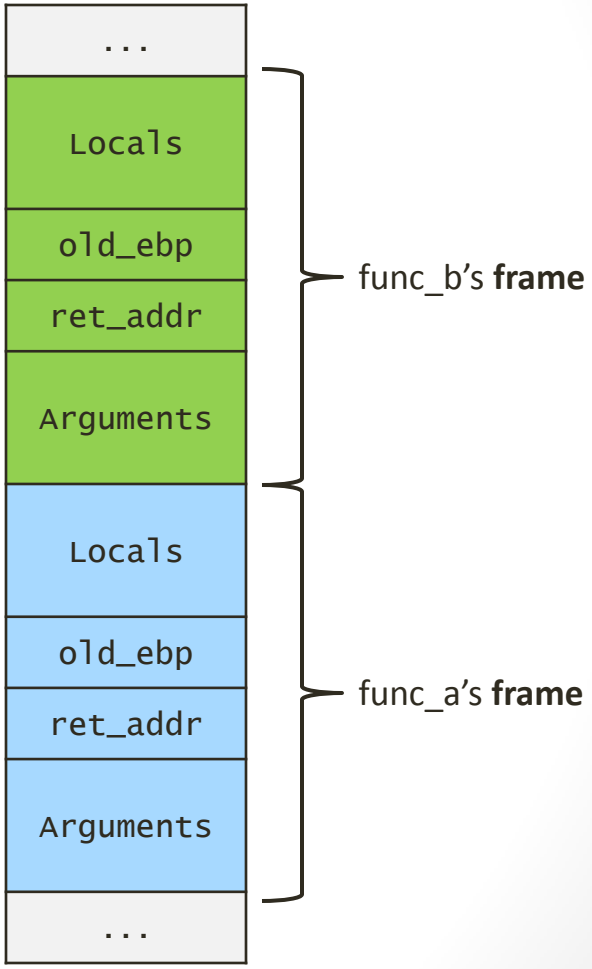

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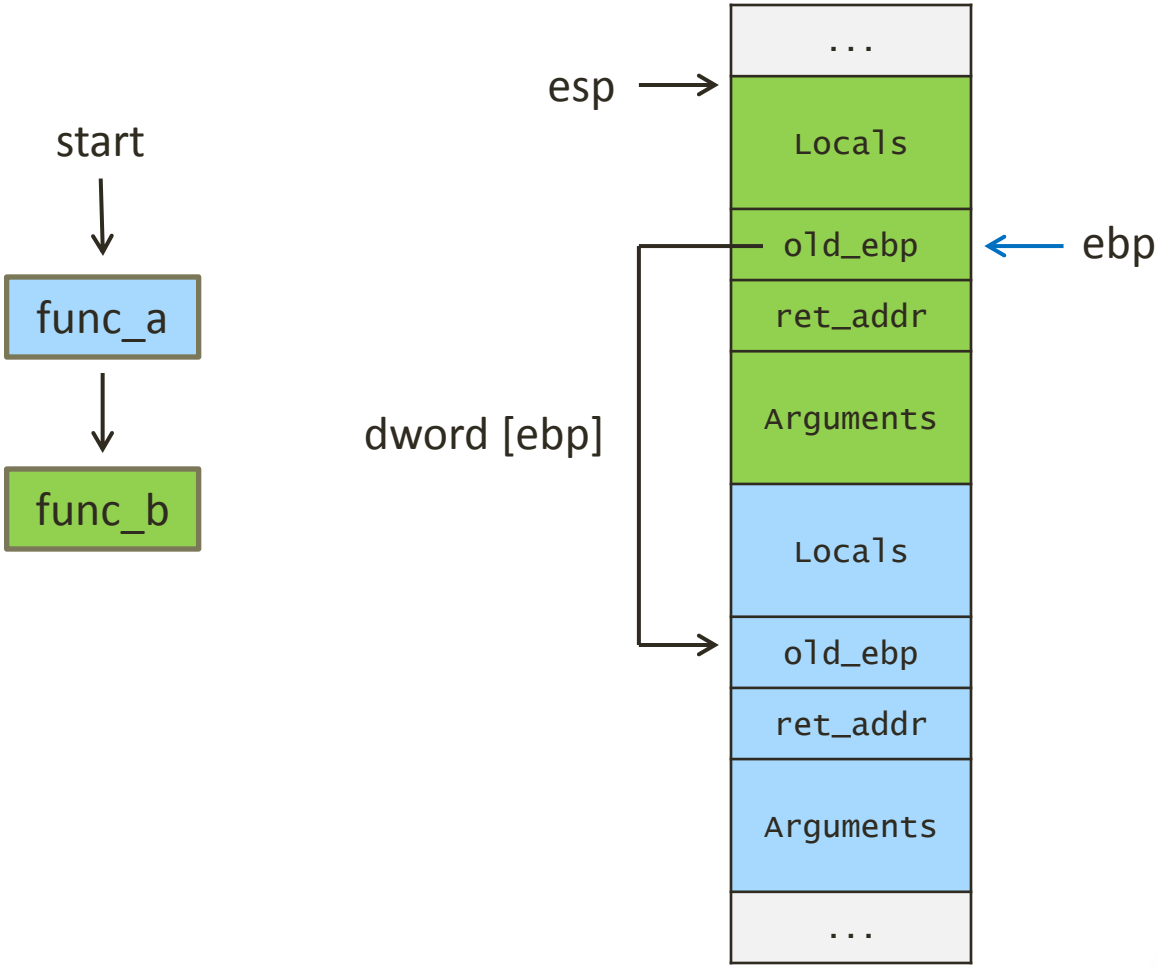
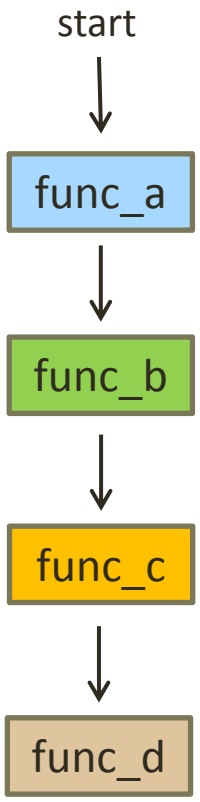


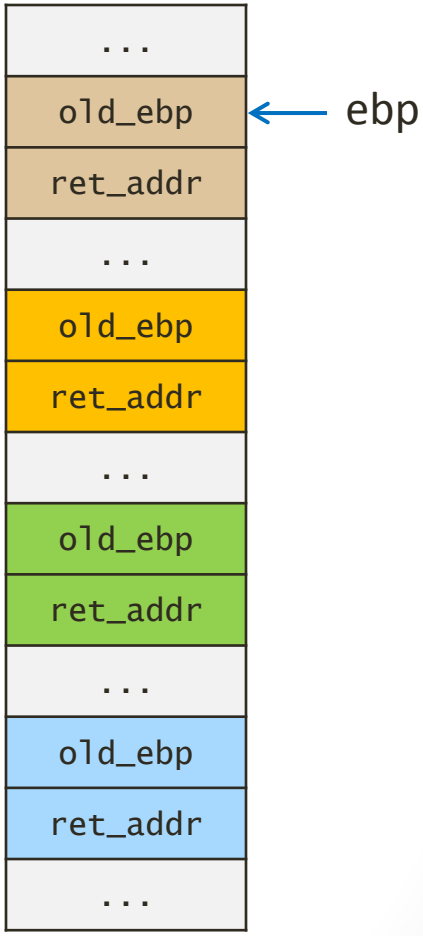
The call stack (Cont.)

- Traversing the call stack:
  - EBP entries form a “linked list”!

The call stack (Cont.)

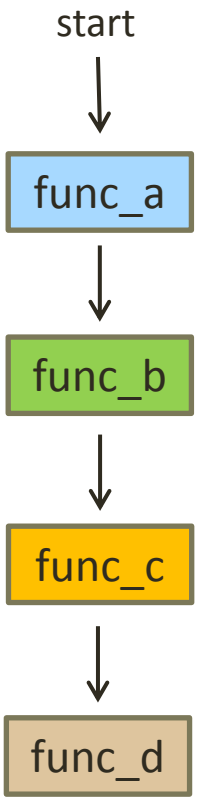
- Traversing the call stack:
  - EBP entries form a “linked list”!

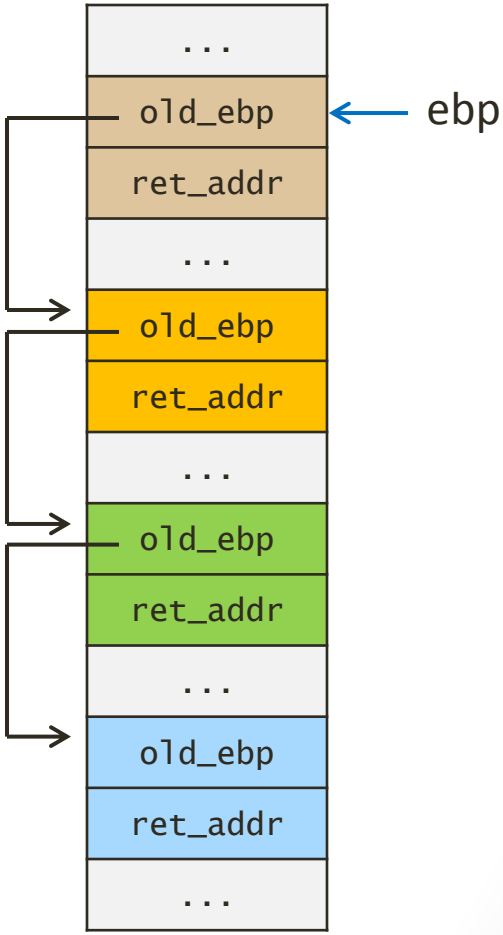




The call stack (Cont.)

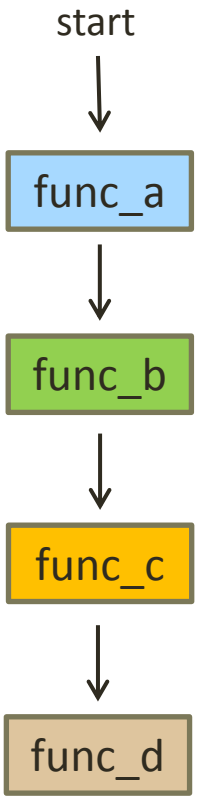
- Traversing the call stack:
  - EBP entries form a “linked list”!

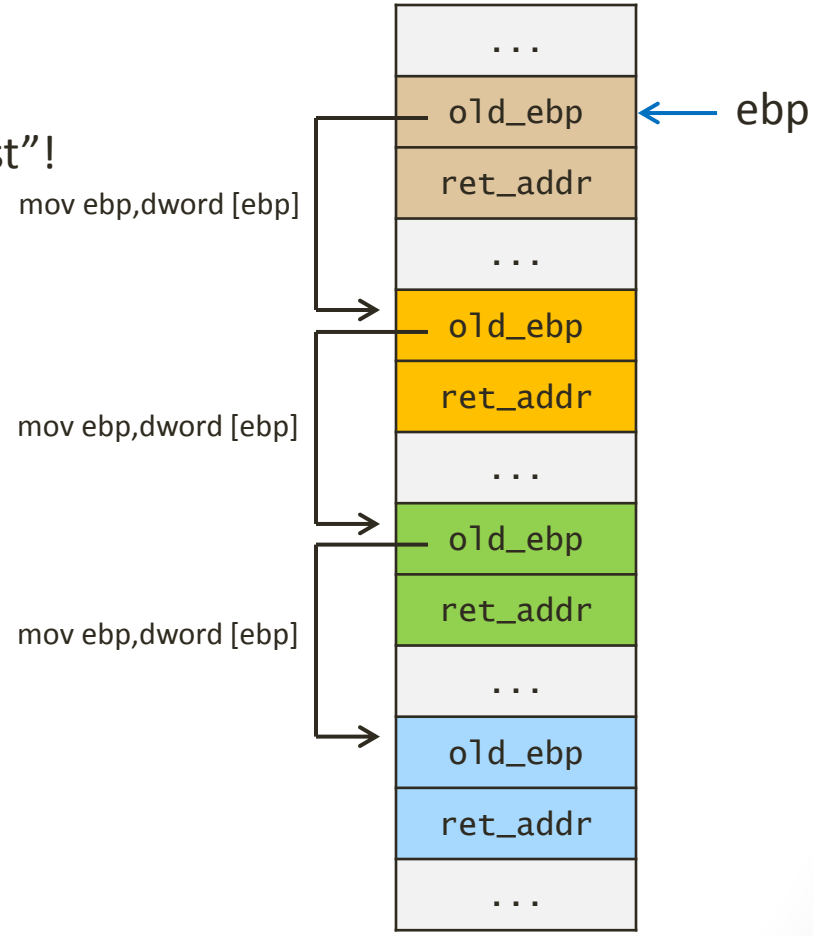




The call stack (Cont.)

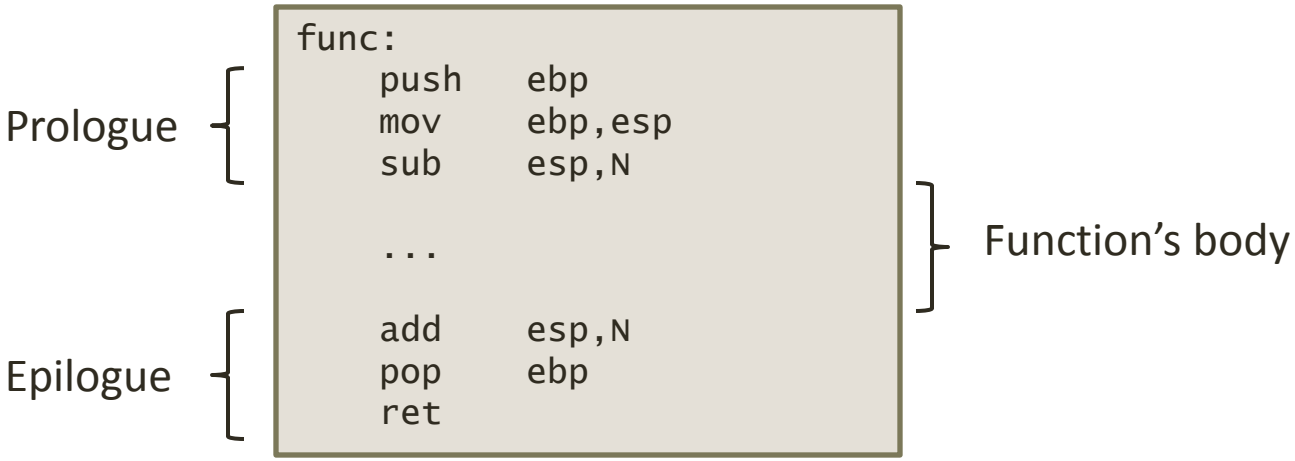
- Traversing the call stack:
  - EBP entries form a “linked list”!





ENTER and LEAVE

- Almost all functions begin and end in the same standard way.
- Those standard beginning and ending are also called **Prologue** and **Epilogue**.



- This construct is so common, that new instructions were introduced to do this job.

ENTER and LEAVE (Cont.)

- Building a stack frame using ENTER and LEAVE:

```
func:
    push   ebp
    mov    ebp,esp
    sub    esp,N

    ...

    add    esp,N
    pop    ebp
    ret
```

ENTER and LEAVE (Cont.)

- Building a stack frame using ENTER and LEAVE:

```
func:
    push    ebp
    mov     ebp,esp
    sub     esp,N

    ...

    add     esp,N
    pop     ebp
    ret
```

```
func:
    enter   N,0

    ...

    add     esp,N
    pop     ebp
    ret
```

ENTER and LEAVE (Cont.)

- Building a stack frame using ENTER and LEAVE:

```
func:
    push    ebp
    mov     ebp,esp
    sub     esp,N

    ...

    mov     esp,ebp
    pop     ebp
    ret
```

```
func:
    enter   N,0

    ...

    mov     esp,ebp
    pop     ebp
    ret
```

ENTER and LEAVE (Cont.)

- Building a stack frame using ENTER and LEAVE:

```
func:
    push    ebp
    mov     ebp,esp
    sub     esp,N

    ...

    mov     esp,ebp
    pop     ebp
    ret
```

```
func:
    enter   N,0

    ...

    leave
    ret
```

ENTER and LEAVE (Cont.)

- Building a stack frame using ENTER and LEAVE:

```
func:
    push    ebp
    mov     ebp,esp
    sub     esp,N

    ...

    mov     esp,ebp
    pop     ebp
    ret
```

```
func:
    enter   N,0

    ...

    leave
    ret
```

- Much cleaner :)

ENTER and LEAVE (Cont.)

- ENTER Size,NestingLevel
  - Make stack frame for procedure parameters.
  - Operation (For NestingLevel = 0):
    - ```
      push    ebp
      mov     ebp,esp
      sub     esp,N
      ```

      ENTER N,0

- LEAVE
  - High level procedure exit.
  - Operation:
    - ```
      mov     esp,ebp
      pop     ebp
      ```

      LEAVE

FAQ

- Do I have to use EBP for stack based argument passing?
  - Answer: No, but it is a good practice to do so.
- Which way should I choose to write my function prologue and epilogue – ENTER and LEAVE or `push ebp` … ?
  - Answer: It's your code, you decide.
  - ENTER is shorter. Some say it is slower though.

Summary

- We use EBP to “hold” the stack frame.
  - EBP has the initial value of ESP.
- We make space for local variables on the stack by decreasing ESP.
  - We free that space by increasing ESP.
- The stack is divided into frames of different functions.
- EBPs on the stack form a linked list that can be traversed.
- The ENTER and LEAVE instruction build and destroy the stack frame.

Exercises

- Read code.
- Write code.
- Enjoy :)