EECE.3170: Microprocessor Systems Design I

Summer 2016

Lecture 8: Solution to Key Questions
June 6, 2016

This document provides a solution to the key questions for Monday's lecture—the design of functions in assembly, given a general description and C-style function prototype.

a. `int fact(int n)`

Given a single integer argument, `n`, return n! = n × (n – 1) × (n – 2) × … × 1

Solution: Here's a C version of the function, followed by the assembly code that implements it:

```
int fact(int n) {
   int i;
   int fact = 1;

   for (i = n; i > 1; i--)
        fact *= i;

   return fact;
}
```

Assembly code for factorial function:

```
fact      PROC                    ; Start of subroutine
  push    ebp                     ; Save ebp
  mov     ebp, esp                ; Copy esp to ebp
  sub     esp, 8                  ; Create space for i, fact

; CODE FOR: int fact = 1;
  mov     DWORD PTR -8[ebp], 1    ; fact = 1

; CODE FOR: i = n;
  mov     eax, DWORD PTR 8[ebp]   ; eax = n
  mov     DWORD PTR -4[ebp], eax  ; i = n

; CODE FOR i > 1
L1:
  cmp     DWORD PTR -4[ebp], 1    ; Compare i to 1
  jle     L2                      ; If i <= 1, exit loop

; CODE FOR: fact *= i;
  mov     eax, DWORD PTR -8[ebp]  ; eax = fact
  imul    eax, DWORD PTR -4[ebp]  ; eax = fact * i
  mov     DWORD PTR -8[ebp], eax  ; fact = eax = fact * i

; CODE FOR: i--;
  mov     eax, DWORD PTR -4[ebp]  ; eax = i
  sub     eax, 1                  ; eax--
  mov     DWORD PTR -4[ebp], eax  ; i = eax = i - 1
  jmp     L1                      ; Return to loop start

; CODE FOR: return fact;
L2:
  mov     eax, DWORD PTR -8[ebp]  ; Copy fact to eax, which
                                  ;  holds return value

; CLEANUP
  mov     esp, ebp                ; Clear space for i, fact
  pop     ebp                     ; Restore ebp
  ret                             ; Return from subroutine
fact      ENDP
```

b. `int max(int v1, int v2)`

Given two integer arguments, return the largest of the two values.

Solution: Here's a C version of the function, followed by the assembly code that implements it:

```
   int max(int v1, int v2) {
      if (v1 > v2)
           return v1;
      else
           return v2;

   }
```

```
max       PROC                    ; Start of subroutine
   push   ebp                     ; Save ebp
   mov    ebp, esp                ; Copy ebp to esp
                                  ; No local variables
; CODE FOR: if (v1 > v2)
   mov    eax, DWORD PTR 8[ebp]   ; eax = v1
   cmp    eax, DWORD PTR 12[ebp]  ; Compare v1 to v2
   jle    L1                      ; Jump to L1 if v1 <= v2
                                  ;  ((v1 > v2) is false)

; CODE FOR: return v1;
   jmp    L2                      ; Jump to L2
                                  ; Return value (v1) is
                                  ;   already in eax
                                  ; L2 is start of
                                  ;   "cleanup" code

; CODE FOR: else
;              return v2;
L1:
   mov    eax, DWORD PTR 12[ebp]  ; Copy v2 into eax
                                  ; eax always holds
                                  ; function return value

; CLEANUP
L2:
   pop    ebp                     ; Restore ebp
   ret                            ; Return from subroutine
max       ENDP
```

c. `void swap(int *a, int *b)`

Given two memory addresses, `a` and `b`, swap the contents of those addresses. You may assume `a` and `b` are offsets into the data segment.

Solution: Here's a C version of the function, followed by the assembly code that implements it:

```
void swap(int *a, int *b) {
   int temp;
   temp = *a;
   *a = *b;
   *b = temp;
}
```

```
swap    PROC                    ; Start of subroutine
  push  ebp                     ; Save ebp
  mov   ebp, esp                ; Copy ebp to esp
  sub   esp, 4                  ; Create space for temp
  push  ecx                     ; Save ecx to stack
  push  edx                     ; Save edx to stack
  push  eax                     ; Save eax to stack (void fn)

; CODE FOR: temp = *a
  mov   eax, DWORD PTR 8[ebp]   ; eax = address that "a"
                                ;   points to
  mov   ecx, DWORD PTR [eax]    ; ecx = value that "a"
                                ;   points to = *a
  mov   DWORD PTR -4[ebp], ecx  ; temp = *a

; CODE FOR: *a = *b
  mov   ecx, DWORD PTR 12[ebp]  ; ecx = address that "b"
                                ;   points to
  mov   edx, DWORD PTR [ecx]    ; edx = value that "b"
                                ;   points to = *b
  mov   DWORD PTR [eax], edx    ; *a = *b
                                ; eax still holds address
                                ;   "a" points to

; CODE FOR: *b = temp;
  mov   eax, DWORD PTR -4[ebp]  ; eax = temp
  mov   DWORD PTR [ecx], eax    ; *b = temp
                                ; ecx still holds address
                                ;   "b" points to

; CLEANUP
  pop   eax                     ; Restore eax
  pop   edx                     ; Restore edx
  pop   ecx                     ; Restore ecx
  mov   esp, ebp                ; Clear space for temp
  pop   ebp                     ; Restore ebp
```

```
   ret                              ; Return from subroutine
swap       ENDP
```