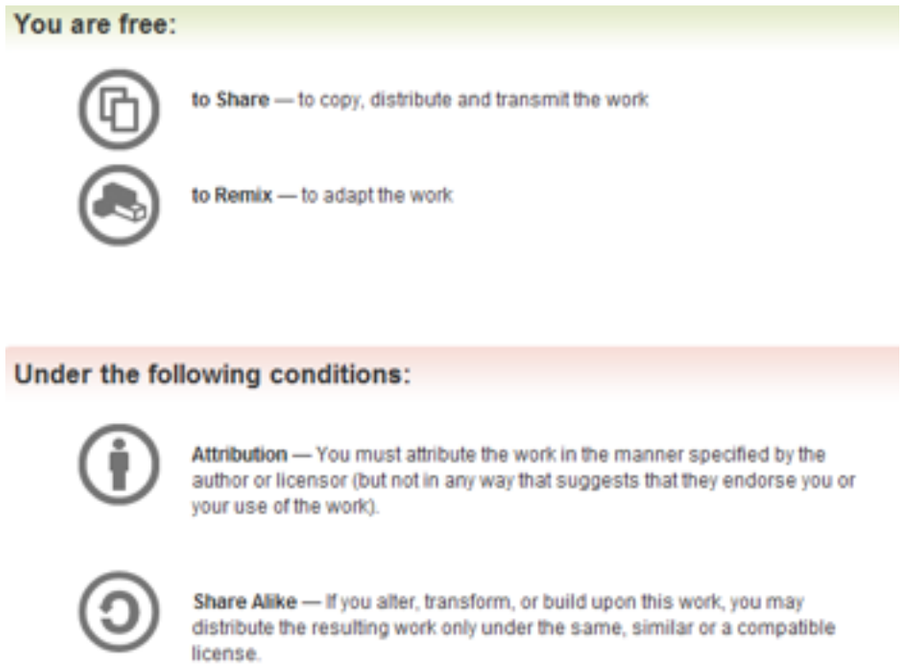
Introduction to Intel x86-64 Assembly, Architecture, Applications, & Alliteration

Xeno Kovah – 2014-2015
xeno@legbacore.com

All materials is licensed under a Creative Commons “Share Alike” license.

- http://creativecommons.org/licenses/by-sa/3.0/



Attribution condition: You must indicate that derivative work
"Is derived from Xeno Kovah's 'Intro x86-64' class, available at http://OpenSecurityTraining.info/IntroX86-64.html"

Attribution condition: You must indicate that derivative work

"Is derived from Xeno Kovah's ‘Intro x86-64’ class, available at http://OpenSecurityTraining.info/IntroX86-64.html"

Example9.c
Journey to the center of memcpy()

```
//Journey to the center of memcpy
#include <stdio.h>

typedef struct mystruct{
     int var1;
    char var2[4];
} mystruct_t;

int main(){
    mystruct_t a, b;
    a.var1 = 0xFF;
    memcpy(&b, &a, sizeof(mystruct_t));
    return 0xAce0Ba5e;
}
```

```
main:
 sub         rsp,38h
 mov         dword ptr [a],0FFh
 mov         r8d,8
 lea         rdx,[a]
 lea         rcx,[b]
 call        memcpy (0140001046h)
 mov         eax,0ACE0BA5Eh
 add         rsp,38h
 ret
```

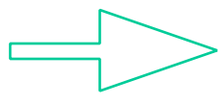
It begins…

```
memcpy:
 mov        r11,rcx  ; rcx == &b
 mov        r10,rdx ; rdx == &a
 cmp        r8,10h ; r8 == sizeof(mystruct_t) == 8
 jbe        mcpy00aa+95h (07FEEB9DA349h)
;It will take the jump because 0x8 is below or equal (JBE) 0x10
MoveBytes16:
 mov        r10,r11  ; doesn't need to keep rdx copy anymore
MoveBytes16a:
 lea        r9,[__mbctype_initialized (07FEEBC10000h)]
 mov        rax,r8
 mov        eax,dword ptr [r9+r8*4+4A363h]
 add        rax,r9  ; the 4 preceding instructions are just
calculating based on the size (r8) and some lookup table,
where to jump next to continue
 jmp        rax
```

```
MoveSmall8: ; oh, well that's a convenient name…
 mov        rax,qword ptr [rdx]
 mov        qword ptr [r10],rax  ; bam, 8 byte copy and done!
 mov        rax,r11
 ret      ;done already? But I just got here!
```

;So that was all fairly un-interesting…And we didn't find any new instructions. So let's go back and change the size of our struct so that we don't take that initial JBE and see what happens on the other path…

```
typedef struct mystruct{
    int var1;
   char var2[4];
} mystruct_t;
```



```
typedef struct mystruct{
    int var1;
   char var2[16];
} mystruct_t;
```

It re-begins…

```
memcpy:
 mov        r11,rcx  ; rcx == &b == destination
 mov        r10,rdx ; rdx == &a == source
 cmp        r8,10h ; r8 == sizeof(mystruct_t) == 0x14
 jbe        mcpy00aa+95h (07FEEB9DA349h)
;This time it will NOT take the jump because 0x14 is not below or
equal (JBE) 0x10. So it falls through to…
 sub        rdx,rcx
 jae        mcpy00aa (07FEEDE0A2B4h)  ; if the copy destination
is above (unsigned) compare or equal to the source, then we can
skip the next check. In our case it happens to not be
 mov        rax,r10  ; copy the start address of the src
 add        rax,r8  ; calculate the last byte of the src to be copied
 cmp        rcx,rax  ; check if the dst's start address is less than
the last byte of the src (meaning they overlap)
 jl         MoveSmall+297h (07FEEDE0A5FAh)
mcpy00aa:
```

```
mcpy00aa:
 bt         dword ptr [__favor (07FEEDF93408h)],1  ; check some bit
that we have no idea what it is (but probably a configuration bit)
 jae        mcpy00aa+1Dh (07FEEDE0A2D1h) ; if it's set, jmp
; in our case it seems not to be set, so we fall through
 push       rdi ; save rdi (because it's going to be used)
 push       rsi ; save rsi
 mov        rdi,rcx ; move dst into rdi
 mov        rsi,r10 ; move src into rsi
 mov        rcx,r8  ; move size into dcx
 rep movs    byte ptr [rdi],byte ptr [rsi] ; that which we seek!
 pop        rsi  ; restore
 pop        rdi  ; restore
 mov        rax,r11 ; set return value to the copy of dst
 ret
```

http://blog.kevineikenberry.com/wp-content/uploads/2013/10/seinfeld_jerry.jpg

REP MOVS
Repeat Move Data String to String

- MOVS is one of number of instructions that can have the “rep” prefix added to it, which repeat a single instruction multiple times.
- All rep operations use *cx register as a “counter” to determine how many times to loop through the instruction. Each time it executes, it decrements *cx. Once *cx == 0, it continues to the next instruction.
- Either stores 1, 2, 4, or 8 bytes at a time
- Either fill 1 byte at [di] with [si] or fill 2/4/8 bytes at [*di] with [*si].
- Moves the *di register forward 1/2/4/8 bytes at a time, so that the repeated store operation is storing into consecutive locations.
- So there are 3 pieces which must happen before the actual rep stos occurs: set *di to the starting destination, *si to the starting source, and *cx to the number of times to store
- Note: Unlike MOV, MOVS can move memory to memory…but only between [*si] and [*di]
- A lot of people don’t pay attention to the fact that it’s REP ***MOVS***, not REP *MOV* (even though you may say it like “rep move”)

Book page 101-102

High level pseudo-code approximation

(how interesting…it's like I went in *reverse* of the normal software *engineering* process…)

```
memcpy(void * dst, void * src, unsigned int len){
  if(len <= 0x10){
    //sequence of individual mov instructions
    //as appropriate for the size to be copied
  }
  else{
  if(src < dst){ //check for potential overlap…
    if(dst < src+len) //uh oh, they definitely overlap
    //Path we didn't take @ 07FEEDE0A5FAh
  }
  if(07FEEDF93408h & 2){
    //Don't know what's up with this. Some configuration bit most likely
  }
  else{
    //Use byte-wise REP MOVS as generic memcpy
  }
…
}
```

Instructions we now know (30)

- NOP
- PUSH/POP
- CALL/RET
- MOV
- ADD/SUB
- IMUL
- MOVZX/MOVSX
- LEA
- JMP/Jcc (family)
- CMP/TEST
- AND/OR/XOR/NOT
- INC/DEC
- SHR/SHL/SAR/SAL
- DIV/IDIV
- REP STOS
- REP MOVS