x86 64bit assembly code to C interface

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Outline

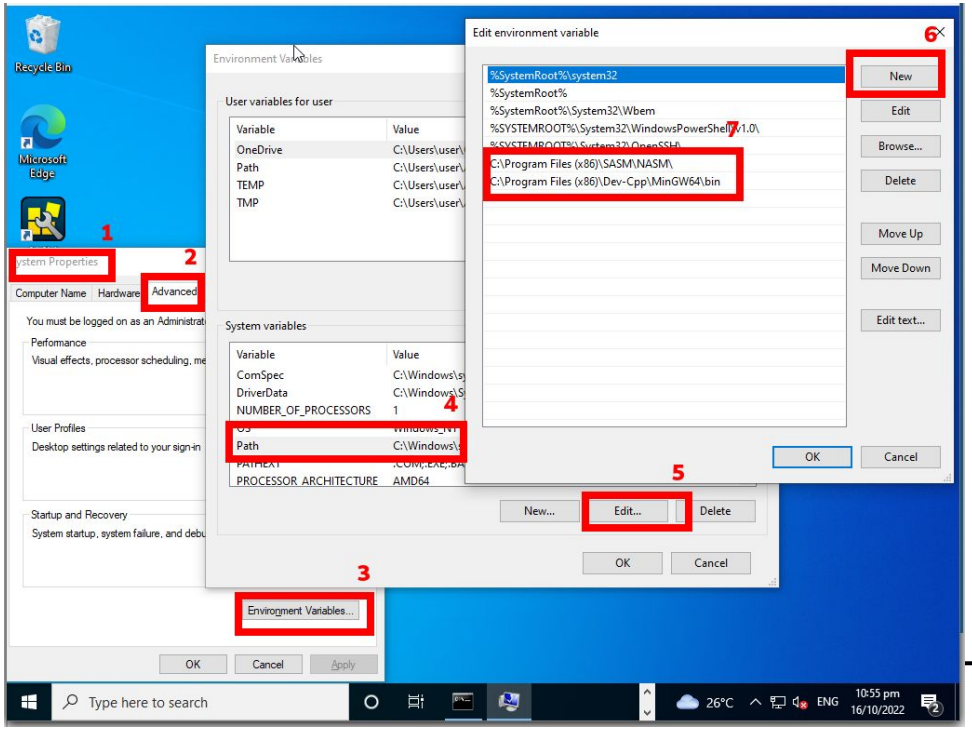
- Environment Configuration
- Call Conventions
- x86 call C
- C call x86
- Combination

Environment Configuration

Environment Configuration

- SASM
- NASM
  - Included in sasm
- Dev-Cpp TDM-GCC
  - Download the installer
- GCC
  - Included in dev-cpp tdm-gcc

Add NASM and GCC(MinGW64) To the system variable Path



- Locate nasm inside installed sasm folder
- Locate mingw bin inside installed dev-cpp

Call Conventions

- Caller and callee
- Register Volatility
- Parameter Passing
- Return Value

Caller and Callee

- Caller - call to function
- Callee - the function

Asm-call-C

- Caller: x86 asm
- Callee: C (printf/scanf)

C-call-Asm

- Caller: C
- Callee: x86 asm

Register Volatility

Volatile

- Registers whose values are allowed to be overwritten by a call.
- To preserve:
  - push values to stack before call
  - Pop values from stack after call

Non-volatile

- Registers whose values are not allowed to be overwritten by a call.
- One is required to preserve:
  - Push values to stack within call
  - Pop values to stack before return

Register type	
Volatile	RAX, RCX, RDX, R8-R11, XMM0-XMM5, YMM0-YMM5
Non-volatile	RBX, RSI, RDI, RBP, RSP, R12-R15, XMM6-XMM15, YMM6-YMM15

Parameter Passing

- Conventions for parameter passing is operating system dependent.
- For windows based parameter passing see table.

parameter	long long int	Int	Short	Char	Float
1st	RCX	ECX	CX	CL	xmm0
2nd	RDX	EDX	DX	DL	xmm1
3rd	R8	R8D	R8W	R8B	xmm2
4th	R9	R9D	R9W	R9B	xmm3
return	RAX	EAX	AX	AL	xmm0

Parameter Passing

- Windows based integer passing
- First four parameters into: RCX, RDX, R8, R9
- Other parameters into stack
- Return value: RAX

Stack Parameter Passing

Address (by 8)	Data
	Shadow space 4
	Shadow space 3
	Shadow space 2
rsp→	Shadow space 1

Adjustment

- RCX, RDX, R8, and R9 as 1st 2nd 3rd, and 4th parameter
- RAX as return value

The 1st four parameters are stored in a 32 bytes in the stack memory called “shadow space.”

- Remaining parameters should be pushed after the shadow space
- Stack should be 16 bytes aligned

Operating System Parameter Passing

Windows

- First four parameters:
  RCX, RDX, R8, R9
- Beyond four parameters:
  Stack
- Stack Alignment:
  16 Bytes
- Return value
  RAX

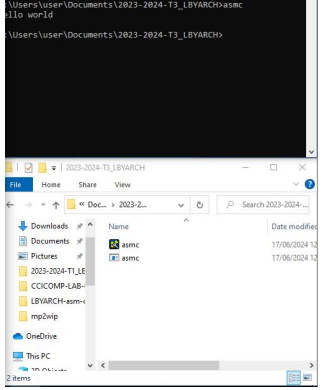
- **This lecture is windows based**

Unix (Linux/BSD/x86Mac)

- First six parameters:
  RDI, RSI, RCX, RDX, R8, R9
- Beyond four parameters:
  Stack
- Stack Alignment:
  16 Bytes
- Return value
  RAX

Asm-call-C

- Asm use printf
- Asm use scanf
- Call with few parameters
- Call with many parameters
- Assemble compile and run



X86 call C: printf

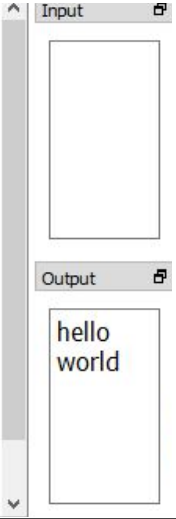
- X86 assembly code that calls the printf function
- The string address is stored into rcx
- String address can be loaded either: (same effect)
  - lea rcx, [msg] or
  - mov rcx, msg
- Stack space
  - allocated (subtracted to rsp) and
  - freed (add to rsp)
  - 8*S where S should be enough for shadow spaces and parameter passing

```
section .data
msg db "hello world",10,0

section .text
bits 64
default rel
global main
extern printf

main:
    sub rsp, 8*5
    lea rcx, [msg]
    call printf
    add rsp, 8*5

    xor rax, rax
    ret
```




```
section .text                ; indicates a 64 bit asm code
bits 64
default rel
global main


extern printf                ; printf function
                             ; params passed via rcx, rdx, r8,
r9, stack
                             ; Rcx - first parameter - string

main:
        sub rsp, 8*5         ; allocates 8 byte aligned
spaces for stack
        …
        add rsp, 8*5
```

Assemble and run

Method 1: in sasm

File > save as .exe

Method 2: 3 commands in cmd

> nasm -f win64 asmfile.asm

> gcc -m64 asmfile.obj -o asmfile.exe

> asmfile.exe

x86 to C: Printf Many Parameter Pass

```
section .data
msg1 db "double %lf %lf %lf %lf %lf %lf",10,0
var1 dq 1.5
var2 dq 2.5
var3 dq 3.5
var4 dq 4.5
var5 dq 5.5
var6 dq 6.5
```

```
section .text
bits 64
default rel
global main
extern printf

main:
    sub rsp, 8*7
    mov rax, [var6]
    mov [rsp+48], rax

    mov rax, [var5]
    mov [rsp+40], rax

    mov rax, [var4]
    mov [rsp+32], rax

    mov r9, [var3]
    mov r8, [var2]
    mov rdx, [var1]
    mov rcx, msg1
    call printf
    add rsp, 8*7

    xor rax, rax
    ret
```

- First 4 parameters
  - Rcx = msg1
  - Rdx = var1
  - R8 = var2
  - R9 = var4
- Parameter 5 onwards
  - Stack
  - Start at [rsp+32], account for shadow space

```
\Users\user\Documents\2023-2024-T3_LBYARCH>asmc2
uble 1.500000 2.500000 3.500000 4.500000 5.500000 6.500000

\Users\user\Documents\2023-2024-T3_LBYARCH>
```

```
section .data
prompt1 db "enter double: ",0
scanformat db "%lf",0
inputdouble dq 0
prompt2 db "value entered: %lf",10,0
```

```
section .text
bits 64
default rel
global main
extern printf, scanf

main:
    ; print prompt1
    sub rsp, 8*5
    lea rcx, [prompt1]
    call printf
    add rsp, 8*5

    ; scanf
    sub rsp, 8*5
    lea rdx, [inputdouble]
    lea rcx, [scanformat]
    call scanf
    add rsp, 8*5

    ; print prompt2
    sub rsp, 8*5
    mov rdx, [inputdouble]
    lea rcx, [prompt2]
    call printf
    add rsp, 8*5

    xor rax, rax
    ret
```

X86 call C: scanf

Scanf
- data from command line interpreted using string formatter (scanformat) %d, %s, %f, %lf

Printf
- prints string format with additional parameters
- printf(“value entered %lf”,inputdouble); translated as (see third code block)

C-call-Asm

- No parameters
- Integer Parameters
- Double precision Parameters
- Many parameters
- Pointer parameter
- Return Value

C code

```c
#include <stdio.h>
extern void asmhello();

int main()
{
    asmhello();
    return 0;
}
```

Asm code

```
section .data
msg db `hello world \n`,0

section .text
bits 64
default rel
global asmhello
extern printf

asmhello:
    sub rsp, 8*5
    mov rcx, msg
    call printf
    add rsp, 8*5

    ret
```

```
s>cfile
hello world
```

C to x86: No Parameters

- C - caller
- X86 assembly - function

- Assembly function in c as
  extern void

- Assembly function
- Label paired with ret instruction (asmhello:)

Compile Assemble and Run

```
> nasm -f win64 asmfile.asm

> gcc -c cfile.c -o cfile.obj -m64

> gcc cfile.obj asmfile.obj -o cfile.exe -m64

> cfile.exe
```

C code

```c
#include <stdio.h>
#include <stdlib.h>

extern int asmsum(int a, int b);

int main()
{
    int a = 1;
    int b = 2;
    int c = asmsum(a, b);
    printf("sum: %d",c);
    return 0;
}
```

Asm Code

```
section .text
bits 64
default rel
global asmsum

asmsum:
    ; a@rcx, b@rdx
    mov rax, rcx
    add rax, rdx
    ; return value rax
    ret
```

```
cfile.exe
sum: 3
```

C to x86: Integer Values

- Parameter passing via registers (and stack)
- In C code
  - Asm function asmsum as extern int
  - Initialize a and b, call asmsum to add in c, then print the result
- In Asm code
  - First parameter in rcx
  - Second parameter in rdx
  - Return value in rax

parameter	long long int	Int	Short	Char	Float
1st	RCX	ECX	CX	CL	xmm0
2nd	RDX	EDX	DX	DL	xmm1
3rd	R8	R8D	R8W	R8B	xmm2
4th	R9	R9D	R9W	R9B	xmm3
return	RAX	EAX	AX	AL	xmm0

C to x86: Float Values

C code

```c
#include <stdio.h>
#include <stdlib.h>

extern double asmsum(double a, double b);

int main()
{
    double a = 1;
    double b = 2;
    double c = asmsum(a, b);
    printf("sum: %lf",c);
    return 0;
}
```

- In C code
  - Asm function asm sum as extern double
  - Initialize a and b, call asmsum to add in c, then print the result

- In Asm code
  - First parameter in xmm0
  - Second parameter in xmm1
  - Return value in mm0

sm Code

```
section .text
bits 64
default rel
global asmsum

asmsum:
    ; a@xmm0, b@xmm1
    addsd xmm0, xmm1
    ; return value xmm0
    ret
```

```
file.exe
sum: 3.000000
```

parameter	long long int	Int	Short	Char	Float
1st	RCX	ECX	CX	CL	xmm0
2nd	RDX	EDX	DX	DL	xmm1
3rd	R8	R8D	R8W	R8B	xmm2
4th	R9	R9D	R9W	R9B	xmm3
return	RAX	EAX	AX	AL	xmm0

```c
#include <stdio.h>
#include <stdlib.h>

extern int asmsum(int a, int b, int c, int d, int e, int f);

int main()
{
    int a=1, b=2, c=3, d=4, e=5, f=6;
    int g = asmsum(a,b,c,d,e,f);
    printf("sum: %d",g);
    return 0;
}
```

```
section .text
bits 64
default rel
global asmsum

asmsum:
    push rsi
    push rbp
    mov rbp, rsp
    add rbp, 16

    ; a@rcx, b@rdx, c@r8, d@r9, e,f@stack
    mov rax, rcx
    add rax, rdx
    add rax, r8
    add rax, r9
    add rax, [rbp+40]
    add rax, [rbp+48]
    ; return value rax

    pop rbp
    pop rsi
    ret
```

C to c86: Many Parameters

- Many, 5 and more
  - First 4 parameters in registers
  - Succeeding parameters in stack starting at [rsp+40]
- In example: receiving parameters
  - Parameters sent by c code are int a, b, c, d, e, f, g
  - a, b, c, d were in rcx, rdx, r8, r9
  - e, f are in stack
  - Stack starts at rsp(or rbp)+40, then increments of 8
  - 40 = 4*8 shadow addresses bytes + 8 bytes for return address
- Good Practice
  - Preserve rsp, operate on rbp
  - Preserve original rbp by pushing to the stack, then pop afterwards

C code

```c
#include <stdio.h>
#include <stdlib.h>

extern void vecadd(int n, int* arr1, int* arr2, int*arr3);

int main()
{
    int vec1[] = {10, 20, 30, 40};
    int vec2[] = {1, 2, 3, 4};
    int* vec3 = (int*)malloc(4*sizeof(int));
    int n = 4;
    vecadd(n, vec1, vec2, vec3);

    int i;
    for(i = 0; i < n; i++)
        printf("%d ",vec3[i]);
    return 0;
}
```

C to X86: Vector Addition

- Parameters:
  - N number of elements
  - vec1 and vec2 initialized array
  - vec3 allocated result space
- 1st parameter N received at rcx
- 2nd, 3rd, and 4th parameters are pointers
  - addresses of vec1, vec2, and vec3
- Each element are increments of 4
  - because int is 4 bytes
- Addition result
  - placed on memory space of vec3

Asm Code

```
section .text
bits 64
default rel
global vecadd

vecadd:
    ; n@rcx, vec1@rdx, vec2@r8, vec3@r9
    L1:
        mov rax, [rdx]
        mov rbx, [r8]
        add rax, rbx
        mov [r9], rax
        add rdx, 4
        add r8, 4
        add r9, 4
        loop L1
    ret
```

```
cfile.exe
11 22 33 44
```

Combination

- C call asm that call C
- C call asm with simultaneous stack use

C code

```c
int main()
{
    int a=1, b=2, c=3;
    asmfunc(a,b,c);
    return 0;
}
```

C to x86: x86 to C

- C calls asm
- Asm calls printf

Asm code

```asm
section .data
msg db "params a=%d b=%d c=%d",0

section .text
bits 64
default rel
global asmfunc
extern printf

asmfunc:
    ; parameter received a@rcx, b@rdx, c@r8

    ; printf parameter printf msg, a, b, c
    sub rsp, 8*5
    mov r9, r8
    mov r8, rdx
    mov rdx, rcx
    lea rcx, [msg]
    call printf
    add rsp, 8*5

    ret
```

```
C:\Users\user\Documents\2023-2024-T3_LBYARCH\CToAsm-2-FewParams>compileassemblerun.bat

C:\Users\user\Documents\2023-2024-T3_LBYARCH\CToAsm-2-FewParams>nasm -f win64 asmfile.asm

C:\Users\user\Documents\2023-2024-T3_LBYARCH\CToAsm-2-FewParams>gcc -c cfile.c -o cfile.obj -m64

C:\Users\user\Documents\2023-2024-T3_LBYARCH\CToAsm-2-FewParams>gcc cfile.obj asmfile.obj -o cfile.exe -m64

C:\Users\user\Documents\2023-2024-T3_LBYARCH\CToAsm-2-FewParams>cfile.exe
params a=1 b=2 c=3
C:\Users\user\Documents\2023-2024-T3_LBYARCH\CToAsm-2-FewParams>
```

C to x86: Many Parameters, simultaneous stack use

cfile.c

```c
#include <stdio.h>
extern void asmfunc();

int main()
{
    int a=1, b=2, c=3, d=4, e=5, f=6, g=7, h=8, i=9;
    asmfunc(a,b,c,d,e,f,g,h,i);
    return 0;
}
```

asmfile.asm

```
extern printf

asmfunc:
    ; parameter received a@rcx, b@rdx, c@r8, d@r9, e,f,g,h@stack

    ; printf parameter printf msg, a, b, c, d, e, f, h, i
    sub rsp, 8*10


    mov rax, [rsp+150]  ; received as 5th param: rsp + (8*9) + (8*10)
    mov [rsp+70], rax   ; printf param10 i

    mov rax, [rsp+142]  ; received as 5th param: rsp + (8*8) + (8*10)
    mov [rsp+62], rax   ; printf param9 h

    mov rax, [rsp+136]  ; received as 5th param: rsp + (8*7) + (8*10)
    mov [rsp+56], rax   ; printf param8 g

    mov rax, [rsp+128]  ; received as 5th param: rsp + (8*6) + (8*10)
    mov [rsp+48], rax   ; printf param7 f

    mov rax, [rsp+120]  ; received as 5th param: rsp + (8*5) + (8*10)
    mov [rsp+40], rax   ; printf param6 e

    mov [rsp+32], r9    ; printf param5 d

    mov r9, r8          ; printf param4 c
    mov r8, rdx         ; printf param3 b
    mov rdx, rcx        ; printf param2 a
    lea rcx, [msg]      ; printf param1 msg
    call printf
    add rsp, 8*10

    ret
```

- Simultaneous stack use
  - As receiving parameters
  - As sending parameters to printf
- In example: receiving parameters
  - Parameters sent by c code are int a, b, c, d, e, f, g, h
  - a, b, c, d were in rcx, rdx, r8, r9
  - e, f, g, h, are in stack
  - Stack starts at rsp+120, then increments of 8
    - Calculated with starting rsp
      +80(new parameters stack adjust),
      +40(skip old stack shadow and return address)
- In example: sending parameters to printf
  - 1st printf parameter
    - Rcx = string format msg
  - 2nd-4th printf parameter
    - Rdx, r8, r9 = a, b, c residing on rcx, rdx, r8
  - Succeeding parameters
    - Stack = d residing on r9
    - Stack = e, f, g, h residing on stack
    - Pass using the stack +32 (skipping shadow)

—

x86 and C interface