

# libasm sources

Sadettin Fidan

July 10, 2024

## 1 Introduction

I have implemented a library in assembly language. The resources I used will be mentioned and presented in this document.

## 2 Functions in the library:

- ft\_strlen (man 3 strlen)
- ft\_strcpy (man 3 strcpy)
- ft\_strcmp (man 3 strcmp)
- ft\_write (man 2 write)
- ft\_read (man 2 read)
- ft\_strdup (man 3 strdup, you can call to malloc)

## 3 Bonus Functions in the library

```
typedef struct s_list
{
    void *data;
    struct s_list *next;
} t_list;
```

Figure 1: Struct list

- ft\_atoi\_base (like the one in the piscine)
- ft\_list\_push\_front (like the one in the piscine)
- ft\_list\_size (like the one in the piscine)
- ft\_list\_sort (like the one in the piscine)
- ft\_list\_remove\_if (like the one in the piscine)

## 4 Resources

### 4.1 General purpose Registers for Intel

64-bit register	Lower 32 bits	Lower 16 bits	Lower 8 bits
rax	eax	ax	al
rbx	ebx	bx	bl
rcx	ecx	cx	cl
rdx	edx	dx	dl
rsi	esi	si	sil
rdi	edi	di	dil
rbp	ebp	bp	bpl
rsp	esp	sp	spl
<b>r8</b>	r8d	r8w	r8b (r8l)
<b>r9</b>	r9d	r9w	r9b (r9l)
<b>r10</b>	r10d	r10w	r10b (r10l)
<b>r11</b>	r11d	r11w	r11b (r11l)
<b>r12</b>	r12d	r12w	r12b (r12l)
<b>r13</b>	r13d	r13w	r13b (r13l)
<b>r14</b>	r14d	r14w	r14b (r14l)
<b>r15</b>	r15d	r15w	r15b (r15l)
<i>r16 (with APX)</i>	r16d	r16w	r16b (r16l)
<i>r17 (with APX)</i>	r17d	r17w	r17b (r17l)
...	...	...	...
<i>r31 (with APX)</i>	r31d	r31w	r31b (r31l)

Figure 2: General purpose Registers for Intel

You can find the image in 2 at: <https://stackoverflow.com/questions/20637569/assembly-registers-in-64-bit-architecture>

## 4.2 Virtual Memory

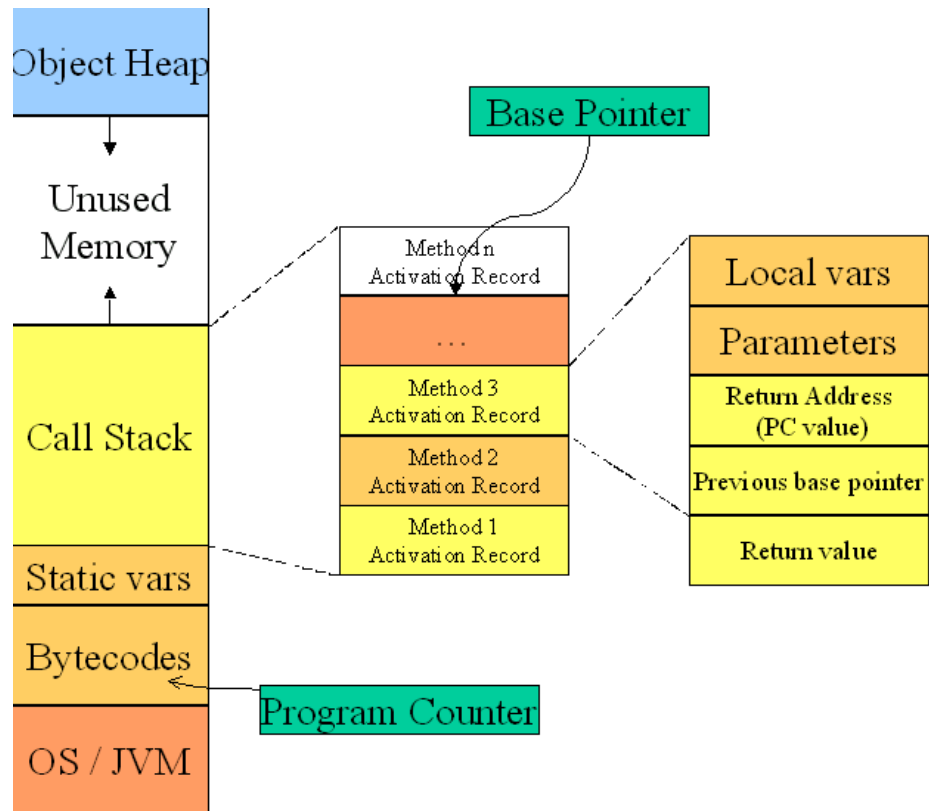


Figure 3: Virtual Memory

Using the figure 3 as a reference, I used local variables inside functions. I get it from <https://learn.microsoft.com/en-us/cpp/build/stack-usage?view=msvc-170>

### 4.3 x64 Intel Stack

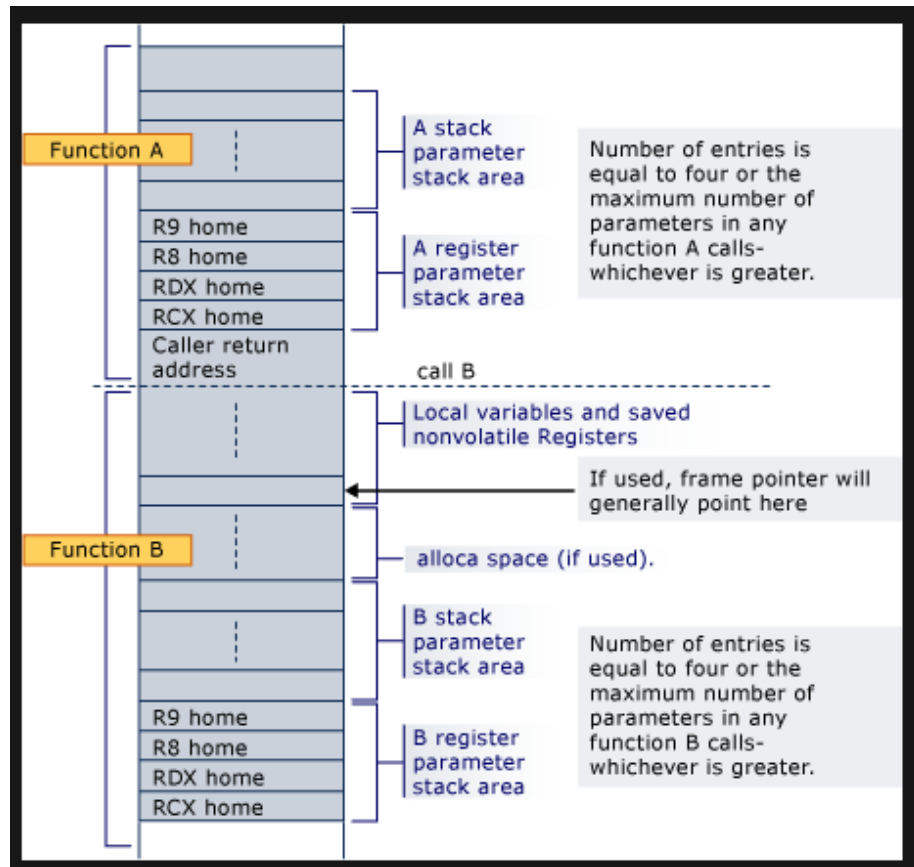
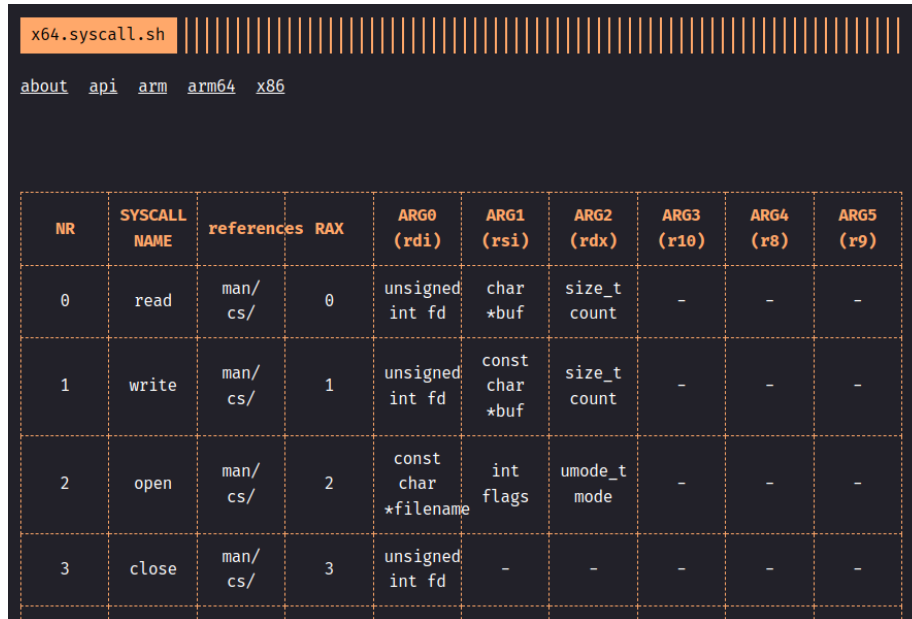


Figure 4: Stack in x64 Intel, as Function A and B

I used the figure 4 as a reference for the stack in x64 Intel. I get it from [https://en.wikipedia.org/wiki/X86\\_calling\\_conventions](https://en.wikipedia.org/wiki/X86_calling_conventions)

## 4.4 System Calls



The image shows a screenshot of the `x64.syscall.sh` website. At the top, there is a navigation bar with links: `about`, `api`, `arm`, `arm64`, and `x86`. Below the navigation bar is a table of system calls. The table has 10 columns: `NR`, `SYSCALL NAME`, `references`, `RAX`, `ARG0 (rdi)`, `ARG1 (rsi)`, `ARG2 (rdx)`, `ARG3 (r10)`, `ARG4 (r8)`, and `ARG5 (r9)`. The table lists four system calls: `read` (NR 0), `write` (NR 1), `open` (NR 2), and `close` (NR 3).

NR	SYSCALL NAME	references	RAX	ARG0 (rdi)	ARG1 (rsi)	ARG2 (rdx)	ARG3 (r10)	ARG4 (r8)	ARG5 (r9)
0	read	man/ cs/	0	unsigned int fd	char *buf	size_t count	-	-	-
1	write	man/ cs/	1	unsigned int fd	const char *buf	size_t count	-	-	-
2	open	man/ cs/	2	const char *filename	int flags	umode_t mode	-	-	-
3	close	man/ cs/	3	unsigned int fd	-	-	-	-	-

Figure 5: System Calls

I used the figure 5 as a reference for system calls. I get it from <https://x64.syscall.sh/>

## 4.5 Calling Convention

Parameter type	fifth and higher	fourth	third	second	leftmost
floating-point	stack	XMM3	XMM2	XMM1	XMM0
integer	stack	R9	R8	RDX	RCX
Aggregates (8, 16, 32, or 64 bits) and <code>m64</code>	stack	R9	R8	RDX	RCX
Other aggregates, as pointers	stack	R9	R8	RDX	RCX
<code>m128</code> , as a pointer	stack	R9	R8	RDX	RCX

**Example of argument passing 1 - all integers**

```
C++  
func1(int a, int b, int c, int d, int e, int f);  
// a in RCX, b in RDX, c in R8, d in R9, f then e pushed on stack
```

**Example of argument passing 2 - all floats**

```
C++  
func2(float a, double b, float c, double d, float e, float f);  
// a in XMM0, b in XMM1, c in XMM2, d in XMM3, f then e pushed on
```

**Example of argument passing 3 - mixed ints and floats**

```
C++  
func3(int a, double b, int c, float d, int e, float f);  
// a in RCX, b in XMM1, c in R8, d in XMM3, f then e pushed on sta
```

Figure 6: x64 Intel calling convention

I used the figure 6 as a reference for calling convention. I get it from <https://learn.microsoft.com/en-us/cpp/build/x64-calling-convention?view=msvc-170>

## 4.6 Assembly Code

"Hello world!" program for 64-bit mode Linux in NASM style assembly [\[edit\]](#)

This example is in modern 64-bit mode.

```
; build: nasm -f elf64 -F dwarf hello.asm
; link: ld -o hello hello.o

DEFAULT REL ; use RIP-relative addressing modes by default, so [foo] = [rel foo]

SECTION .rodata ; read-only data should go in the .rodata section on GNU/Linux, like .rodata on
Windows
Hello: db "Hello world!", 10 ; Ending with a byte 10 = newline (ASCII LF)
len_Hello: equ $-Hello ; Get NASM to calculate the length as an assembly-time constant
; the '$' symbol means 'here'. write() takes a length so that
; a zero-terminated C-style string isn't needed.
; It would be for C puts()

SECTION .rodata ; read-only data can go in the .rodata section on GNU/Linux, like .rodata on Windows
Hello: db "Hello world!",10 ; 10 = '\n'.
len_Hello: equ $-Hello ; get NASM to calculate the length as an assembly-time constant
;; write() takes a length so a 0-terminated C-style string isn't needed. It would be for puts

SECTION .text

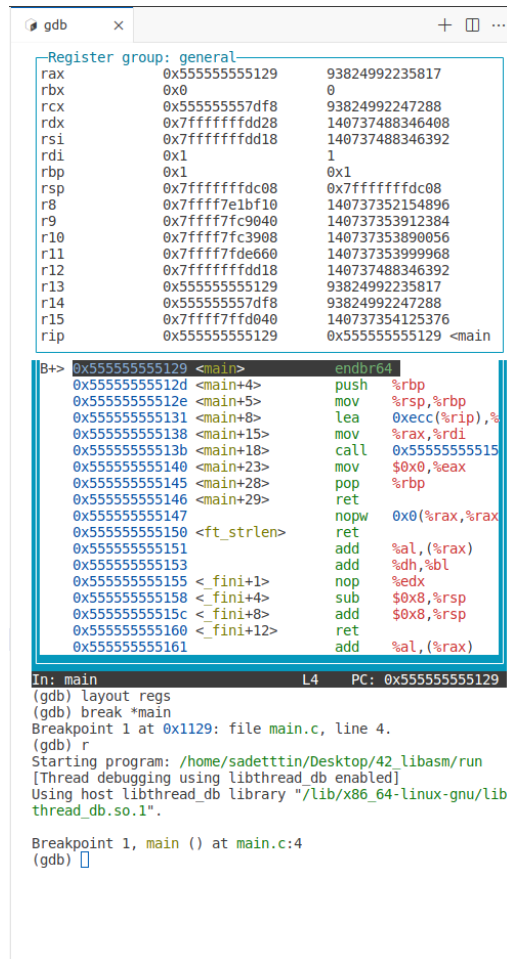
global _start
_start:
    mov eax, 1 ; _NR write syscall number from Linux asm/unistd_64.h (x86_64)
    mov edi, 1 ; int fd = STDOUT_FILENO
    lea rsi, [rel Hello] ; x86-64 uses RIP-relative LEA to put static addresses into regs
    mov rdx, len_Hello ; size_t count = len_Hello
    syscall ; write(1, Hello, len_Hello); call into the kernel to actually do the system
call
;; return value in RAX. RCX and R11 are also overwritten by syscall

    mov eax, 60 ; _NR_exit call number (x86_64) is stored in register eax.
    xor edi, edi ; This zeros edi and also rdi.
; This xor-self trick is the preferred common idiom for zeroing
; a register, and is always by far the fastest method.
; When a 32-bit value is stored into eg edx, the high bits 63:32 are
; automatically zeroed too in every case. This saves you having to set
; the bits with an extra instruction, as this is a case very commonly
; needed, for an entire 64-bit register to be filled with a 32-bit value.
; This sets our routine's exit status = 0 (exit normally)
    syscall ; _exit(0)
```

Figure 7: Assembly Code

I used the figure 7 as a reference for assembly code. I get it from [https://en.wikipedia.org/wiki/X86\\_assembly\\_language](https://en.wikipedia.org/wiki/X86_assembly_language)

## 4.7 Debugging with GDB



The screenshot shows the GDB interface with the following content:

```
gdb x + [] ...

Register group: general
rax      0x55555555129  93824992235817
rbx      0x0            0
rcx      0x555555557df8  93824992247288
rdx      0x7fffffffdd28  140737488346408
rsi      0x7fffffffdd18  140737488346392
rdi      0x1            1
rbp      0x1            0x1
rsp      0x7fffffffddc08 0x7fffffffddc08
r8       0x7ffff7e1bf10  140737352154896
r9       0x7ffff7fc9040  140737353912384
r10      0x7ffff7fc3908  140737353890056
r11      0x7ffff7fde660  140737353999968
r12      0x7fffffffdd18  140737488346392
r13      0x55555555129  93824992235817
r14      0x555555557df8  93824992247288
r15      0x7ffff7ffd040  140737354125376
rip      0x55555555129  0x55555555129 <main>

(gdb) b*main
Breakpoint 1 at 0x1129: file main.c, line 4.
(gdb) r
Starting program: /home/sadettin/Desktop/42_libasm/run
[Thread debugging using libthread_db enabled]
Using host libthread_db library "/lib/x86_64-linux-gnu/libthread_db.so.1".

Breakpoint 1, main () at main.c:4
(gdb) []
```

The assembly code window shows the following instructions:

```
0x55555555129 <main>      endbr64
0x5555555512d <main+4>    push    %rbp
0x5555555512e <main+5>    mov     %rsp,%rbp
0x55555555131 <main+8>    lea     0xccc(%rip),%
0x55555555138 <main+15>   mov     %rax,%rdi
0x5555555513b <main+18>   call    0x5555555515
0x55555555140 <main+23>   mov     $0x0,%eax
0x55555555145 <main+28>   pop     %rbp
0x55555555146 <main+29>   ret
0x55555555147            nopw    0x0(%rax,%rax
0x55555555150 <ft_strlen>    ret
0x55555555151            add     %al, (%rax)
0x55555555153            add     %dh, %bl
0x55555555155 <_fini+1>    nop
0x55555555158 <_fini+4>    sub     $0x8,%rsp
0x5555555515c <_fini+8>    add     $0x8,%rsp
0x55555555160 <_fini+12>   ret
0x55555555161            add     %al, (%rax)
```

Figure 8: Debugging Assembly Code with GDB

I used the figure 8 as a reference for debugging assembly code with GDB.

I run the following commands to debug the assembly code:

```
make run
gdb ./run
(gdb) layout asm
(gdb) layout regs
(gdb) break *main
(gdb) run
```



## 5 Tricks

### 5.1 argument passing in x64 Intel

```
0x114b <main+34>      mov     -0x8(%rbp),%rdx
0x114f <main+38>      mov     -0x10(%rbp),%rax
0x1153 <main+42>      mov     %rdx,%rsi
0x1156 <main+45>      mov     %rax,%rdi
0x1159 <main+48>      call    0x1170 <ft_strcpy>
```

Figure 9: Argument passing for ft\_strcpy

I noticed that when compiled with gcc (gcc main.c + libasm.a, libasm.a was compiled using nasm already) the first argument is passed in both rdx and rsi registers, and the second argument is passed in both rdi and rsi registers. I used the advantage this trick in my implementation by moving a register value and then subtraction with fixed valued register and ta da.

### 5.2 debuggin malloc

```
-Register group: general
rax      0x4ce780      5040000
rbx      0x7fffffffdfa8 140737488347048
rcx      0x21         33
rdx      0x0          0
rsi      0x4ce790      5040016
rdi      0x0          0
rbp      0x7fffffffdda0 0x7fffffffdda0
rsp      0x7fffffffdd80 0x7fffffffdd80
r8       0x4c7d70      5012848
r9       0x4ce780      5040000
r10      0x80          128
r11      0x4c5840      5003328
r12      0x1          1
r13      0x7fffffffdf98 140737488347032
r14      0x4c17d0      4986832
r15      0x1          1

0x401990 <ft_strdup>      call    0x401920 <ft_strlen>
0x401995 <ft_strdup+5>     push    %rdi
0x401996 <ft_strdup+6>     mov     %rax,%rdi
0x401999 <ft_strdup+9>     inc     %rdi
0x40199c <ft_strdup+12>    call    0x4019810 <malloc>
> 0x4019a1 <ft_strdup+17> pop     %rsi
```

Figure 10: Registers affected by malloc

### 5.3 leave instruction

```
, rsi = rdx = inc (-1)
push rbp
mov rbp, rsp
sub rsp, 0x10
mov [rbp - 0x8], rdi
mov [rbp - 0x10], rsi
```

Figure 11: Leave instruction reverses this

I used the leave instruction in the end of the function to reverse the stored up memory. The stored up memory is allocated for the local variables in the function as seen in the figure 11.

### 5.4 offset calculation

```
[750] ; displacement only
[rbp] ; base register only
[rcx + rsi*4] ; base + index * scale
[rbp + rdx] ; scale is 1
[rbx - 8] ; displacement is -8
[rax + rdi*8 + 500] ; all four components
[rbx + counter] ; uses the address of the variable 'counter' as the displacement
```

Figure 12: Offset calculation