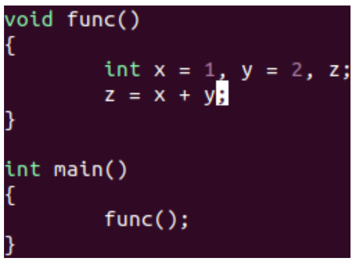
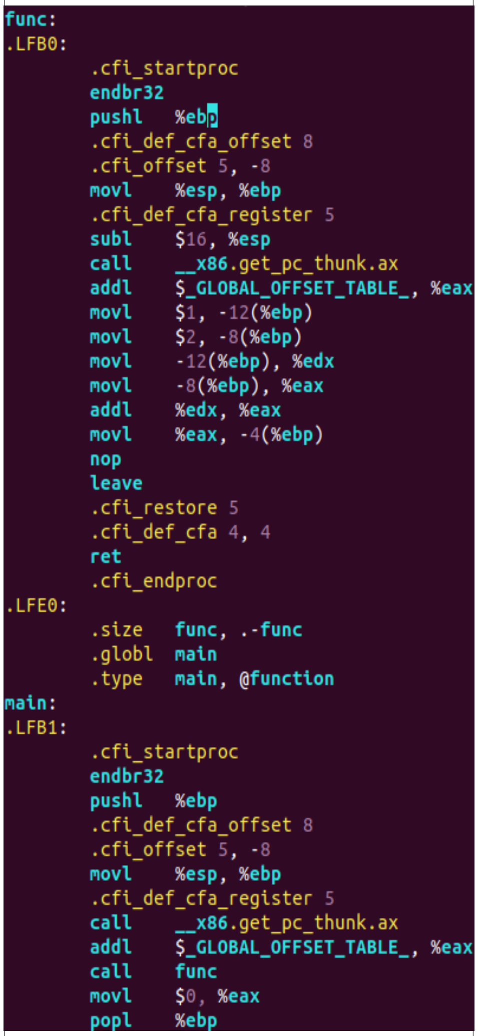
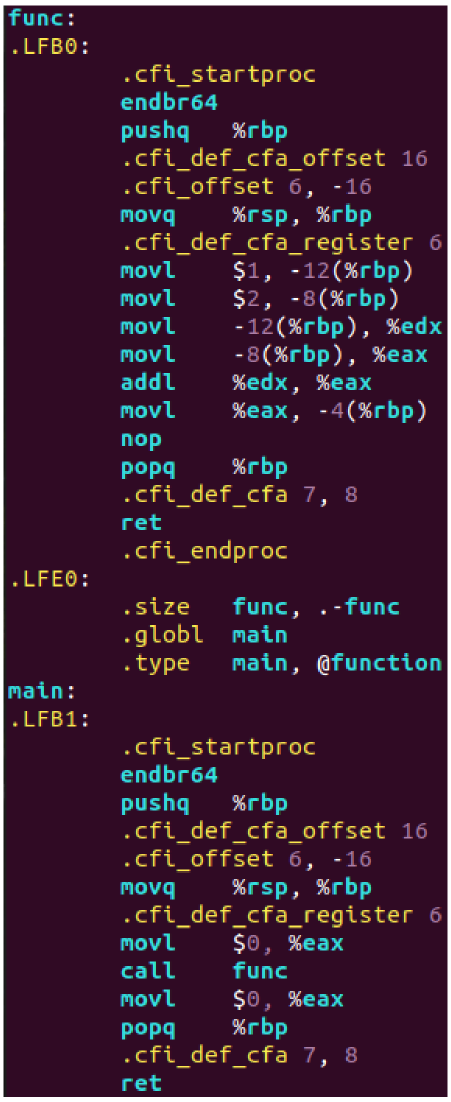
Lab 3

1. Functions

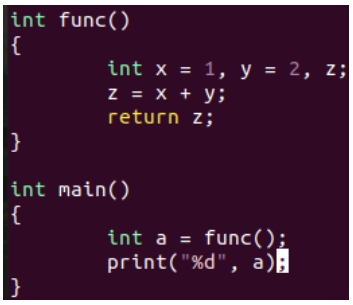
point	C	32bit	64bit
a. No args no ret			

```
void func()
{
        int x = 1, y = 2, z;
        z = x + y;
}

int main()
{
        func();
}
```

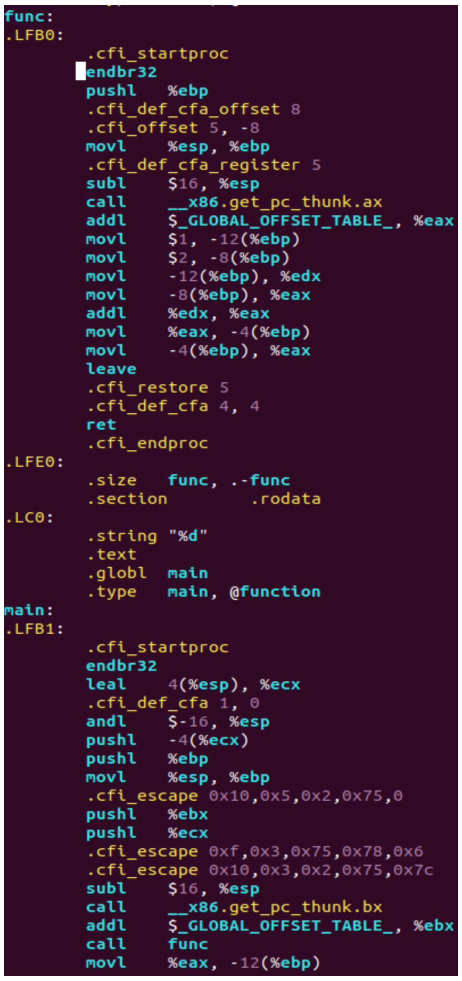
```
func:
.LFB0:
        .cfi_startproc
        endbr32
        pushl   %ebp
        .cfi_def_cfa_offset 8
        .cfi_offset 5, -8
        movl    %esp, %ebp
        .cfi_def_cfa_register 5
        subl    $16, %esp
        call    __x86.get_pc_thunk.ax
        addl    $_GLOBAL_OFFSET_TABLE_, %eax
        movl    $1, -12(%ebp)
        movl    $2, -8(%ebp)
        movl    -12(%ebp), %edx
        movl    -8(%ebp), %eax
        addl    %edx, %eax
        movl    %eax, -4(%ebp)
        nop
        leave
        .cfi_restore 5
        .cfi_def_cfa 4, 4
        ret
        .cfi_endproc
.LFE0:
        .size   func, .-func
        .globl  main
        .type   main, @function
main:
.LFB1:
        .cfi_startproc
        endbr32
        pushl   %ebp
        .cfi_def_cfa_offset 8
        .cfi_offset 5, -8
        movl    %esp, %ebp
        .cfi_def_cfa_register 5
        call    __x86.get_pc_thunk.ax
        addl    $_GLOBAL_OFFSET_TABLE_, %eax
        call    func
        movl    $0, %eax
        popl    %ebp
```

```
func:
.LFB0:
        .cfi_startproc
        endbr64
        pushq   %rbp
        .cfi_def_cfa_offset 16
        .cfi_offset 6, -16
        movq    %rsp, %rbp
        .cfi_def_cfa_register 6
        movl    $1, -12(%rbp)
        movl    $2, -8(%rbp)
        movl    -12(%rbp), %edx
        movl    -8(%rbp), %eax
        addl    %edx, %eax
        movl    %eax, -4(%rbp)
        nop
        popq    %rbp
        .cfi_def_cfa 7, 8
        ret
        .cfi_endproc
.LFE0:
        .size   func, .-func
        .globl  main
        .type   main, @function
main:
.LFB1:
        .cfi_startproc
        endbr64
        pushq   %rbp
        .cfi_def_cfa_offset 16
        .cfi_offset 6, -16
        movq    %rsp, %rbp
        .cfi_def_cfa_register 6
        movl    $0, %eax
        call    func
        movl    $0, %eax
        popq    %rbp
        .cfi_def_cfa 7, 8
        ret
```

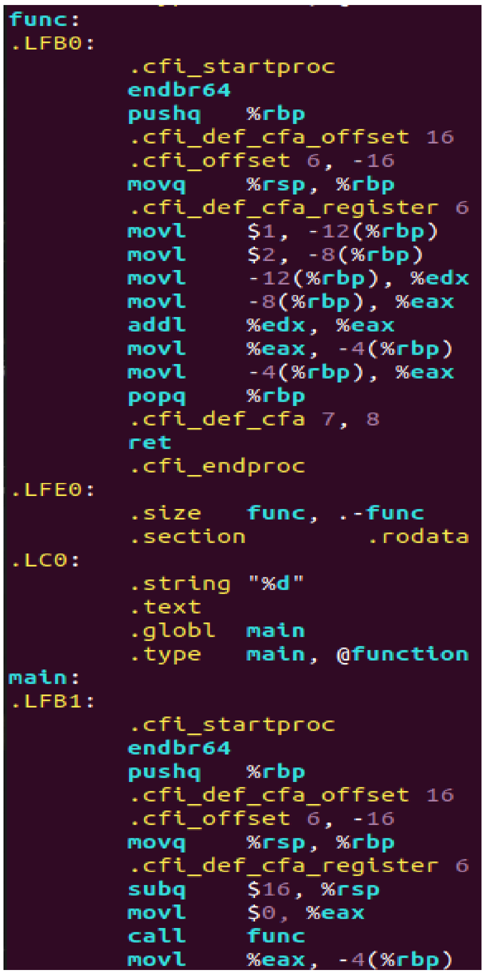
b. No args, ret



```
int func()
{
        int x = 1, y = 2, z;
        z = x + y;
        return z;
}

int main()
{
        int a = func();
        print("%d", a);
}
```

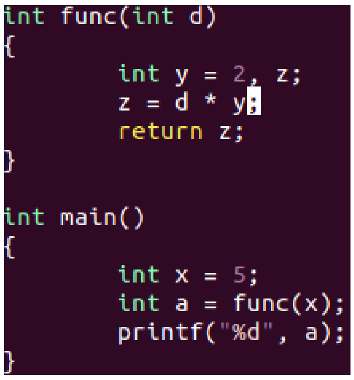


```
func:
.LFB0:
        .cfi_startproc
        endbr32
        pushl   %ebp
        .cfi_def_cfa_offset 8
        .cfi_offset 5, -8
        movl    %esp, %ebp
        .cfi_def_cfa_register 5
        subl    $16, %esp
        call    __x86.get_pc_thunk.ax
        addl    $_GLOBAL_OFFSET_TABLE_, %eax
        movl    $1, -12(%ebp)
        movl    $2, -8(%ebp)
        movl    -12(%ebp), %edx
        movl    -8(%ebp), %eax
        addl    %edx, %eax
        movl    %eax, -4(%ebp)
        movl    -4(%ebp), %eax
        leave
        .cfi_restore 5
        .cfi_def_cfa 4, 4
        ret
        .cfi_endproc
.LFE0:
        .size   func, .-func
        .section        .rodata
.LC0:
        .string "%d"
        .text
        .globl  main
        .type   main, @function
main:
.LFB1:
        .cfi_startproc
        endbr32
        leal    4(%esp), %ecx
        .cfi_def_cfa 1, 0
        andl    $-16, %esp
        pushl   -4(%ecx)
        pushl   %ebp
        movl    %esp, %ebp
        .cfi_escape 0x10,0x5,0x2,0x75,0
        pushl   %ebx
        pushl   %ecx
        .cfi_escape 0xf,0x3,0x75,0x78,0x6
        .cfi_escape 0x10,0x3,0x2,0x75,0x7c
        subl    $16, %esp
        call    __x86.get_pc_thunk.bx
        addl    $_GLOBAL_OFFSET_TABLE_, %ebx
        call    func
        movl    %eax, -12(%ebp)
```

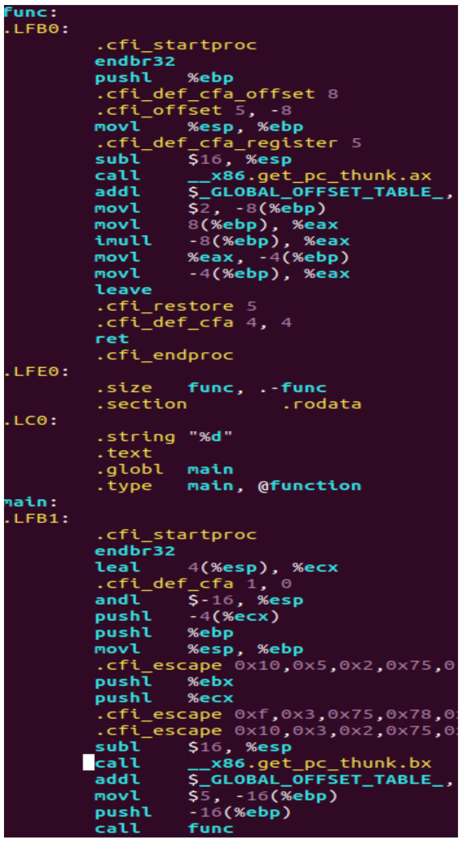


```
func:
.LFB0:
        .cfi_startproc
        endbr64
        pushq   %rbp
        .cfi_def_cfa_offset 16
        .cfi_offset 6, -16
        movq    %rsp, %rbp
        .cfi_def_cfa_register 6
        movl    $1, -12(%rbp)
        movl    $2, -8(%rbp)
        movl    -12(%rbp), %edx
        movl    -8(%rbp), %eax
        addl    %edx, %eax
        movl    %eax, -4(%rbp)
        movl    -4(%rbp), %eax
        popq    %rbp
        .cfi_def_cfa 7, 8
        ret
        .cfi_endproc
.LFE0:
        .size   func, .-func
        .section        .rodata
.LC0:
        .string "%d"
        .text
        .globl  main
        .type   main, @function
main:
.LFB1:
        .cfi_startproc
        endbr64
        pushq   %rbp
        .cfi_def_cfa_offset 16
        .cfi_offset 6, -16
        movq    %rsp, %rbp
        .cfi_def_cfa_register 6
        subq    $16, %rsp
        movl    $0, %eax
        call    func
        movl    %eax, -4(%rbp)
```

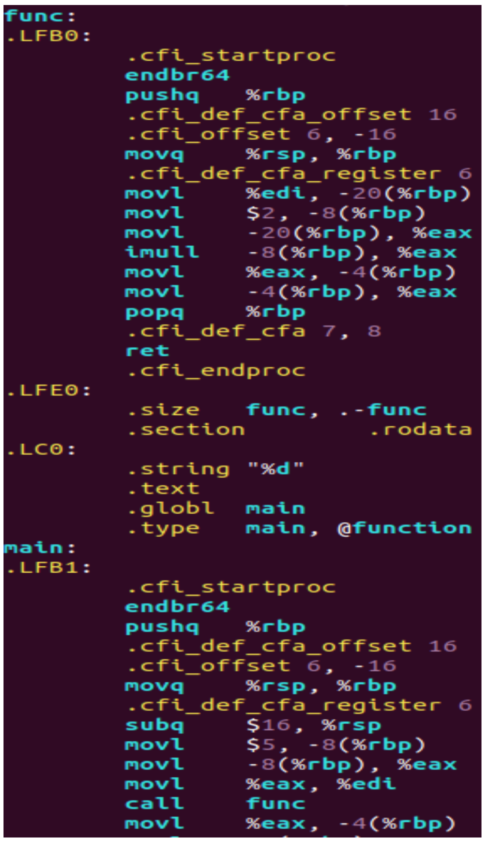
c.1 arg



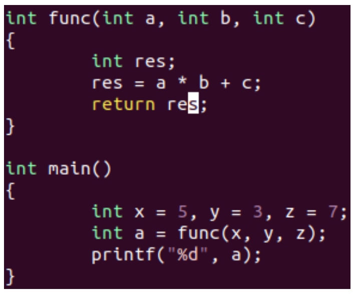
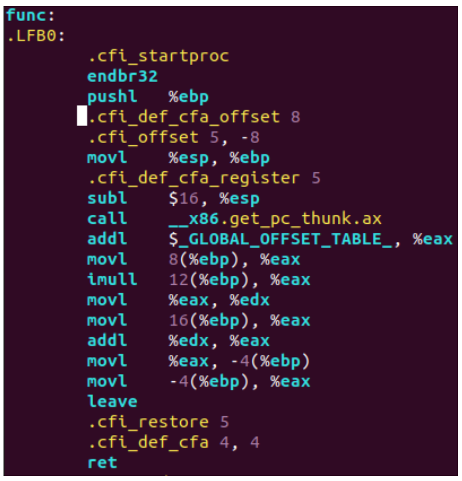
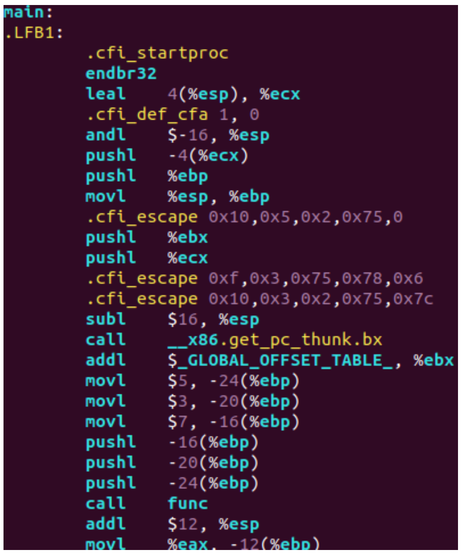
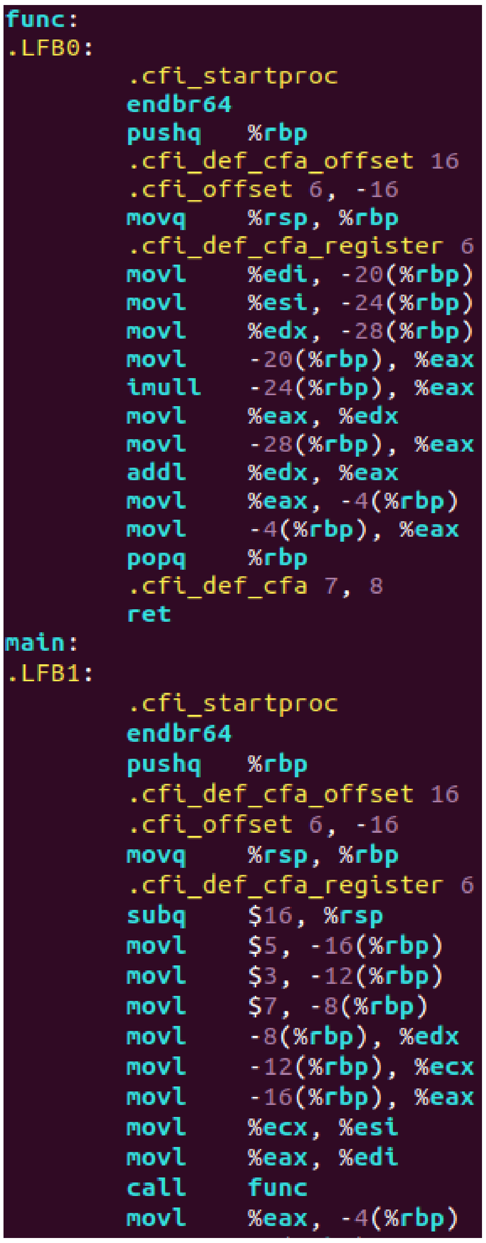
```
int func(int d)
{
        int y = 2, z;
        z = d * y;
        return z;
}

int main()
{
        int x = 5;
        int a = func(x);
        printf("%d", a);
}
```



```
func:
.LFB0:
        .cfi_startproc
        endbr32
        pushl   %ebp
        .cfi_def_cfa_offset 8
        .cfi_offset 5, -8
        movl    %esp, %ebp
        .cfi_def_cfa_register 5
        subl    $16, %esp
        call    __x86.get_pc_thunk.ax
        addl    $_GLOBAL_OFFSET_TABLE_,
        movl    $2, -8(%ebp)
        movl    8(%ebp), %eax
        imull   -8(%ebp), %eax
        movl    %eax, -4(%ebp)
        movl    -4(%ebp), %eax
        leave
        .cfi_restore 5
        .cfi_def_cfa 4, 4
        ret
        .cfi_endproc
.LFE0:
        .size   func, .-func
        .section        .rodata
.LC0:
        .string "%d"
        .text
        .globl  main
        .type   main, @function
main:
.LFB1:
        .cfi_startproc
        endbr32
        leal    4(%esp), %ecx
        .cfi_def_cfa 1, 0
        andl    $-16, %esp
        pushl   -4(%ecx)
        pushl   %ebp
        movl    %esp, %ebp
        .cfi_escape 0x10,0x5,0x2,0x75,0
        pushl   %ebx
        pushl   %ecx
        .cfi_escape 0xf,0x3,0x75,0x78,0
        .cfi_escape 0x10,0x3,0x2,0x75,0
        subl    $16, %esp
        call    __x86.get_pc_thunk.bx
        addl    $_GLOBAL_OFFSET_TABLE_,
        movl    $5, -16(%ebp)
        pushl   -16(%ebp)
        call    func
```



```
func:
.LFB0:
        .cfi_startproc
        endbr64
        pushq   %rbp
        .cfi_def_cfa_offset 16
        .cfi_offset 6, -16
        movq    %rsp, %rbp
        .cfi_def_cfa_register 6
        movl    %edi, -20(%rbp)
        movl    $2, -8(%rbp)
        movl    -20(%rbp), %eax
        imull   -8(%rbp), %eax
        movl    %eax, -4(%rbp)
        movl    -4(%rbp), %eax
        popq    %rbp
        .cfi_def_cfa 7, 8
        ret
        .cfi_endproc
.LFE0:
        .size   func, .-func
        .section        .rodata
.LC0:
        .string "%d"
        .text
        .globl  main
        .type   main, @function
main:
.LFB1:
        .cfi_startproc
        endbr64
        pushq   %rbp
        .cfi_def_cfa_offset 16
        .cfi_offset 6, -16
        movq    %rsp, %rbp
        .cfi_def_cfa_register 6
        subq    $16, %rsp
        movl    $5, -8(%rbp)
        movl    -8(%rbp), %eax
        movl    %eax, %edi
        call    func
        movl    %eax, -4(%rbp)
```

d. many args		 	

```
int func(int a, int b, int c)
{
        int res;
        res = a * b + c;
        return res;
}

int main()
{
        int x = 5, y = 3, z = 7;
        int a = func(x, y, z);
        printf("%d", a);
}
```

```
func:
.LFB0:
        .cfi_startproc
        endbr32
        pushl   %ebp
        .cfi_def_cfa_offset 8
        .cfi_offset 5, -8
        movl    %esp, %ebp
        .cfi_def_cfa_register 5
        subl    $16, %esp
        call    __x86.get_pc_thunk.ax
        addl    $_GLOBAL_OFFSET_TABLE_, %eax
        movl    8(%ebp), %eax
        imull   12(%ebp), %eax
        movl    %eax, %edx
        movl    16(%ebp), %eax
        addl    %edx, %eax
        movl    %eax, -4(%ebp)
        movl    -4(%ebp), %eax
        leave
        .cfi_restore 5
        .cfi_def_cfa 4, 4
        ret
```

```
main:
.LFB1:
        .cfi_startproc
        endbr32
        leal    4(%esp), %ecx
        .cfi_def_cfa 1, 0
        andl    $-16, %esp
        pushl   -4(%ecx)
        pushl   %ebp
        movl    %esp, %ebp
        .cfi_escape 0x10,0x5,0x2,0x75,0
        pushl   %ebx
        pushl   %ecx
        .cfi_escape 0xf,0x3,0x75,0x78,0x6
        .cfi_escape 0x10,0x3,0x2,0x75,0x7c
        subl    $16, %esp
        call    __x86.get_pc_thunk.bx
        addl    $_GLOBAL_OFFSET_TABLE_, %ebx
        movl    $5, -24(%ebp)
        movl    $3, -20(%ebp)
        movl    $7, -16(%ebp)
        pushl   -16(%ebp)
        pushl   -20(%ebp)
        pushl   -24(%ebp)
        call    func
        addl    $12, %esp
        movl    %eax, -12(%ebp)
```

```
func:
.LFB0:
        .cfi_startproc
        endbr64
        pushq   %rbp
        .cfi_def_cfa_offset 16
        .cfi_offset 6, -16
        movq    %rsp, %rbp
        .cfi_def_cfa_register 6
        movl    %edi, -20(%rbp)
        movl    %esi, -24(%rbp)
        movl    %edx, -28(%rbp)
        movl    -20(%rbp), %eax
        imull   -24(%rbp), %eax
        movl    %eax, %edx
        movl    -28(%rbp), %eax
        addl    %edx, %eax
        movl    %eax, -4(%rbp)
        movl    -4(%rbp), %eax
        popq    %rbp
        .cfi_def_cfa 7, 8
        ret
main:
.LFB1:
        .cfi_startproc
        endbr64
        pushq   %rbp
        .cfi_def_cfa_offset 16
        .cfi_offset 6, -16
        movq    %rsp, %rbp
        .cfi_def_cfa_register 6
        subq    $16, %rsp
        movl    $5, -16(%rbp)
        movl    $3, -12(%rbp)
        movl    $7, -8(%rbp)
        movl    -8(%rbp), %edx
        movl    -12(%rbp), %ecx
        movl    -16(%rbp), %eax
        movl    %ecx, %esi
        movl    %eax, %edi
        call    func
        movl    %eax, -4(%rbp)
```

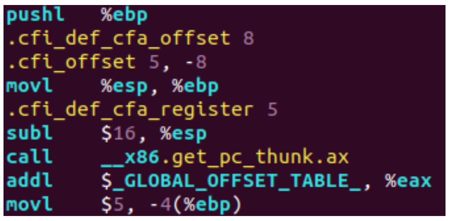
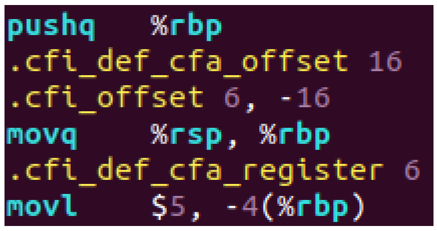
General observations:

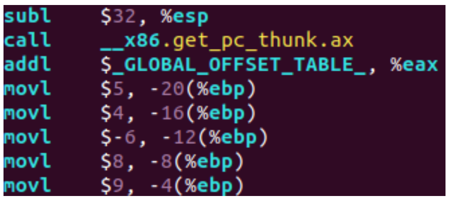
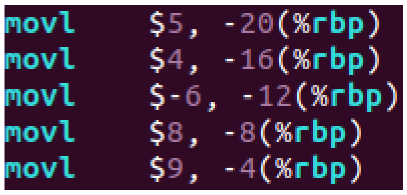
- register %eax is used as a return value
- 32bit and 64bit systems operate the setup and cleanup of stack frame differently(i.g. 32bit uses leave(equals movl + popl), 64bit operate with just popq
- another feature of 64bit system is that, unlike 32bit system, which allocate memory for local variables using, i.g., subl $16, %esp in both main and leaf function, there is a “red zone” of 128 bytes below %rsp. These 128 bytes belong to

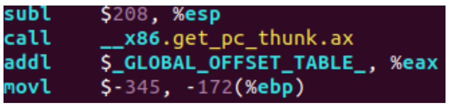
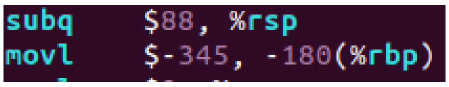
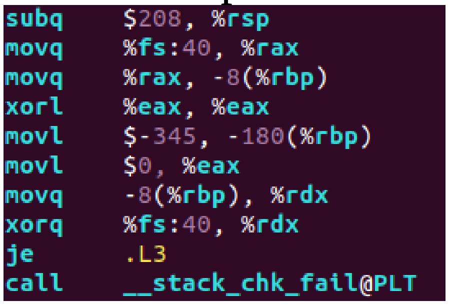
the function as long as it’s a leaf function. Thus, all of local variables of a leaf function fit into the red zone, so no adjustment of %rsp needed (no instructions such as subq $16, %rsp).

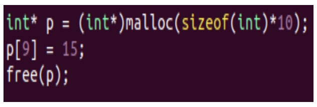
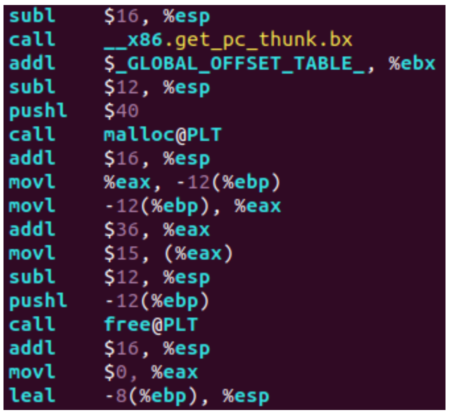
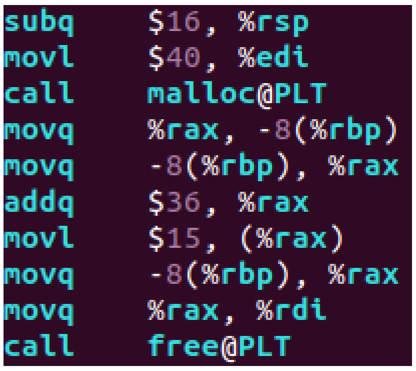
2. Local variables.

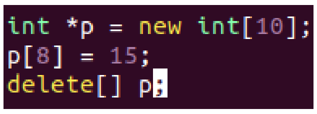
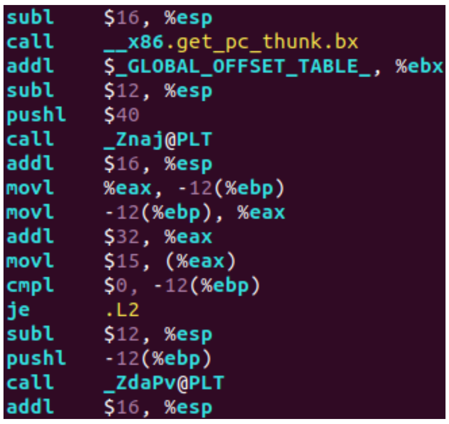
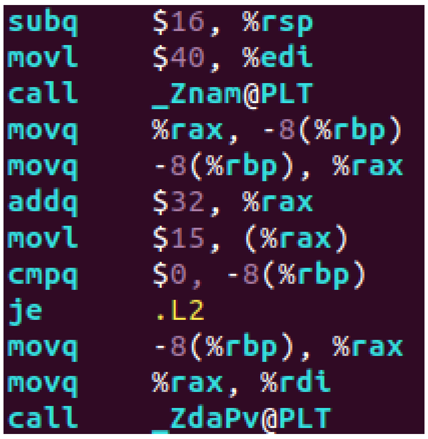
point	C	32bit	64bit

a. 1 loc var	int x = 5	 `pushl %ebp`
		`.cfi_def_cfa_offset 8`
		`.cfi_offset 5, -8`
		`movl %esp, %ebp`
		`.cfi_def_cfa_register 5`
		`subl $16, %esp`
		`call __x86.get_pc_thunk.ax`
		`addl $_GLOBAL_OFFSET_TABLE_, %eax`
		`movl $5, -4(%ebp)`
			 `pushq %rbp`
			`.cfi_def_cfa_offset 16`
			`.cfi_offset 6, -16`
			`movq %rsp, %rbp`
			`.cfi_def_cfa_register 6`
			`movl $5, -4(%rbp)`

b. 5 loc var	int a = 5, b = 4, c = -6, d = 8, i = 9;	 `subl $32, %esp`
		`call __x86.get_pc_thunk.ax`
		`addl $_GLOBAL_OFFSET_TABLE_, %eax`
		`movl $5, -20(%ebp)`
		`movl $4, -16(%ebp)`
		`movl $-6, -12(%ebp)`
		`movl $8, -8(%ebp)`
		`movl $9, -4(%ebp)`
			 `movl $5, -20(%rbp)`
			`movl $4, -16(%rbp)`
			`movl $-6, -12(%rbp)`
			`movl $8, -8(%rbp)`
			`movl $9, -4(%rbp)`

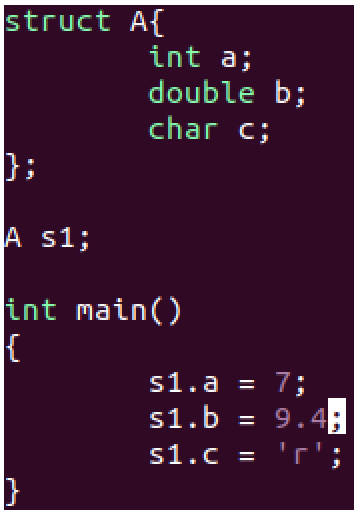
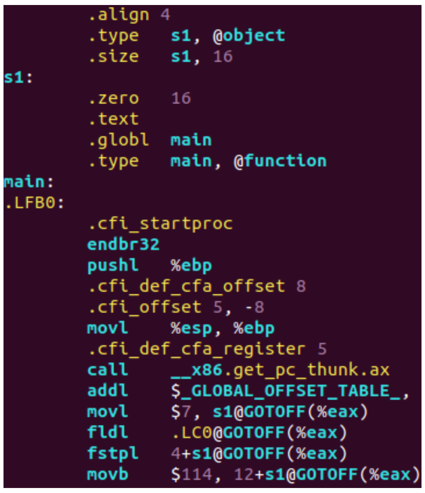
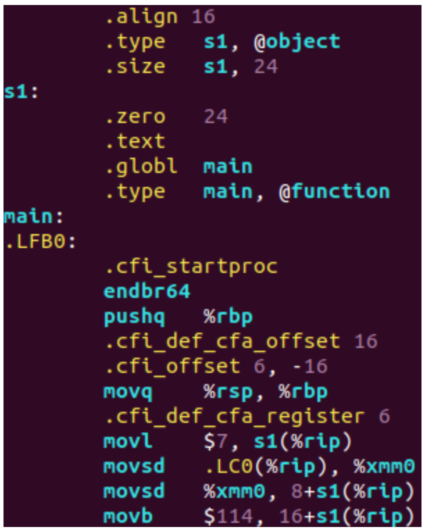
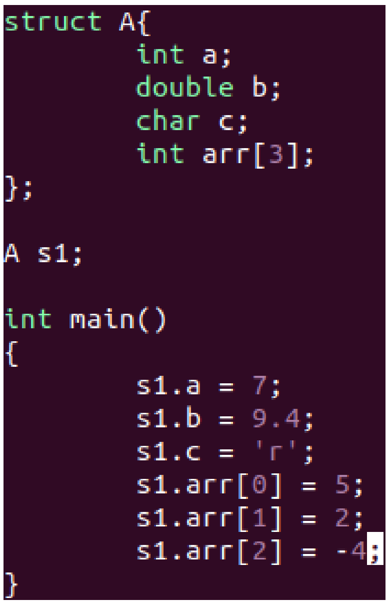
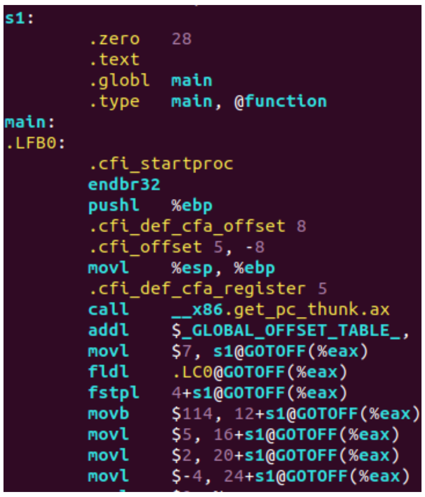
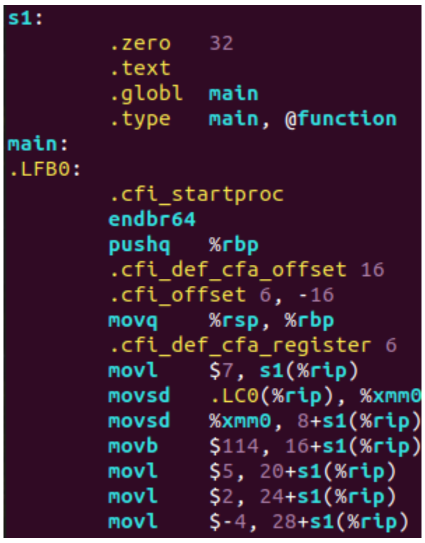
c. static array	int arr[50];
	arr[7] = -345;
		 `subl $208, %esp`
		`call __x86.get_pc_thunk.ax`
		`addl $_GLOBAL_OFFSET_TABLE_, %eax`
		`movl $-345, -172(%ebp)`
			Without stack protector
			 `subq $88, %rsp`
			`movl $-345, -180(%rbp)`
			With stack protector
			 `subq $208, %rsp`
			`movq %fs:40, %rax`
			`movq %rax, -8(%rbp)`
			`xorl %eax, %eax`
			`movl $-345, -180(%rbp)`
			`movl $0, %eax`
			`movq -8(%rbp), %rdx`
			`xorq %fs:40, %rdx`
			`je .L3`
			`call __stack_chk_fail@PLT`

d. dynamic array(C)	 `int* p = (int*)malloc(sizeof(int)*10);`
	`p[9] = 15;`
	`free(p);`
		 `subl    $16, %esp`
		`call    __x86.get_pc_thunk.bx`
		`addl    $_GLOBAL_OFFSET_TABLE_, %ebx`
		`subl    $12, %esp`
		`pushl   $40`
		`call    malloc@PLT`
		`addl    $16, %esp`
		`movl    %eax, -12(%ebp)`
		`movl    -12(%ebp), %eax`
		`addl    $36, %eax`
		`movl    $15, (%eax)`
		`subl    $12, %esp`
		`pushl   -12(%ebp)`
		`call    free@PLT`
		`addl    $16, %esp`
		`movl    $0, %eax`
		`leal    -8(%ebp), %esp`
			 `subq    $16, %rsp`
			`movl    $40, %edi`
			`call    malloc@PLT`
			`movq    %rax, -8(%rbp)`
			`movq    -8(%rbp), %rax`
			`addq    $36, %rax`
			`movl    $15, (%rax)`
			`movq    -8(%rbp), %rax`
			`movq    %rax, %rdi`
			`call    free@PLT`

d. dynamic array(C++)	 `int *p = new int[10];`
	`p[8] = 15;`
	`delete[] p;`
		 `subl    $16, %esp`
		`call    __x86.get_pc_thunk.bx`
		`addl    $_GLOBAL_OFFSET_TABLE_, %ebx`
		`subl    $12, %esp`
		`pushl   $40`
		`call    _Znaj@PLT`
		`addl    $16, %esp`
		`movl    %eax, -12(%ebp)`
		`movl    -12(%ebp), %eax`
		`addl    $32, %eax`
		`movl    $15, (%eax)`
		`cmpl    $0, -12(%ebp)`
		`je      .L2`
		`subl    $12, %esp`
		`pushl   -12(%ebp)`
		`call    _ZdaPv@PLT`
		`addl    $16, %esp`
			 `subq    $16, %rsp`
			`movl    $40, %edi`
			`call    _Znam@PLT`
			`movq    %rax, -8(%rbp)`
			`movq    -8(%rbp), %rax`
			`addq    $32, %rax`
			`movl    $15, (%rax)`
			`cmpq    $0, -8(%rbp)`
			`je      .L2`
			`movq    -8(%rbp), %rax`
			`movq    %rax, %rdi`
			`call    _ZdaPv@PLT`
			_Znam@PLT = new[]
			_ZdaPV@PLT = delete[]

- static array in 64bit shift %rsp to a less amount, than the size of array, perhaps, because of the red zone.
- In 32bit system size of dynamic array is pushed in stack; in 64bit is moved to %edi
- %eax/%rax initially refers to the first element of dynamic array(it must be so because after we call malloc/new[], the result of function, i.e. pointer to the first element, is written in %eax)

3. Structures

point	C++	32bit	64bit
b. global struct			
c. static array as a member			

b. global struct — C++:

```
struct A{
        int a;
        double b;
        char c;
};

A s1;

int main()
{
        s1.a = 7;
        s1.b = 9.4;
        s1.c = 'r';
}
```

b. global struct — 32bit:

```
        .align 4
        .type   s1, @object
        .size   s1, 16
s1:
        .zero   16
        .text
        .globl  main
        .type   main, @function
main:
.LFB0:
        .cfi_startproc
        endbr32
        pushl   %ebp
        .cfi_def_cfa_offset 8
        .cfi_offset 5, -8
        movl    %esp, %ebp
        .cfi_def_cfa_register 5
        call    __x86.get_pc_thunk.ax
        addl    $_GLOBAL_OFFSET_TABLE_,
        movl    $7, s1@GOTOFF(%eax)
        fldl    .LC0@GOTOFF(%eax)
        fstpl   4+s1@GOTOFF(%eax)
        movb    $114, 12+s1@GOTOFF(%eax)
```

b. global struct — 64bit:

```
        .align 16
        .type   s1, @object
        .size   s1, 24
s1:
        .zero   24
        .text
        .globl  main
        .type   main, @function
main:
.LFB0:
        .cfi_startproc
        endbr64
        pushq   %rbp
        .cfi_def_cfa_offset 16
        .cfi_offset 6, -16
        movq    %rsp, %rbp
        .cfi_def_cfa_register 6
        movl    $7, s1(%rip)
        movsd   .LC0(%rip), %xmm0
        movsd   %xmm0, 8+s1(%rip)
        movb    $114, 16+s1(%rip)
```

c. static array as a member — C++:

```
struct A{
        int a;
        double b;
        char c;
        int arr[3];
};

A s1;

int main()
{
        s1.a = 7;
        s1.b = 9.4;
        s1.c = 'r';
        s1.arr[0] = 5;
        s1.arr[1] = 2;
        s1.arr[2] = -4;
}
```

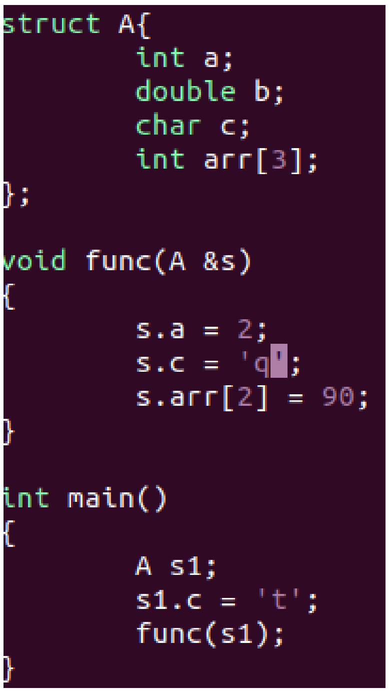
c. static array as a member — 32bit:

```
s1:
        .zero   28
        .text
        .globl  main
        .type   main, @function
main:
.LFB0:
        .cfi_startproc
        endbr32
        pushl   %ebp
        .cfi_def_cfa_offset 8
        .cfi_offset 5, -8
        movl    %esp, %ebp
        .cfi_def_cfa_register 5
        call    __x86.get_pc_thunk.ax
        addl    $_GLOBAL_OFFSET_TABLE_,
        movl    $7, s1@GOTOFF(%eax)
        fldl    .LC0@GOTOFF(%eax)
        fstpl   4+s1@GOTOFF(%eax)
        movb    $114, 12+s1@GOTOFF(%eax)
        movl    $5, 16+s1@GOTOFF(%eax)
        movl    $2, 20+s1@GOTOFF(%eax)
        movl    $-4, 24+s1@GOTOFF(%eax)
```

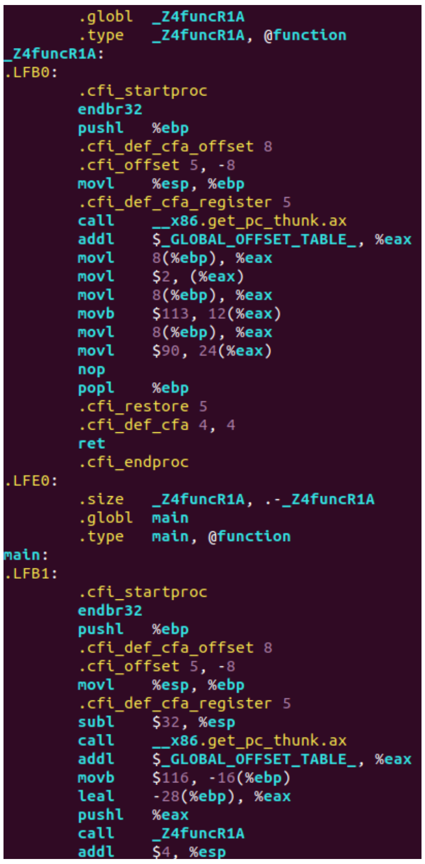
c. static array as a member — 64bit:

```
s1:
        .zero   32
        .text
        .globl  main
        .type   main, @function
main:
.LFB0:
        .cfi_startproc
        endbr64
        pushq   %rbp
        .cfi_def_cfa_offset 16
        .cfi_offset 6, -16
        movq    %rsp, %rbp
        .cfi_def_cfa_register 6
        movl    $7, s1(%rip)
        movsd   .LC0(%rip), %xmm0
        movsd   %xmm0, 8+s1(%rip)
        movb    $114, 16+s1(%rip)
        movl    $5, 20+s1(%rip)
        movl    $2, 24+s1(%rip)
        movl    $-4, 28+s1(%rip)
```

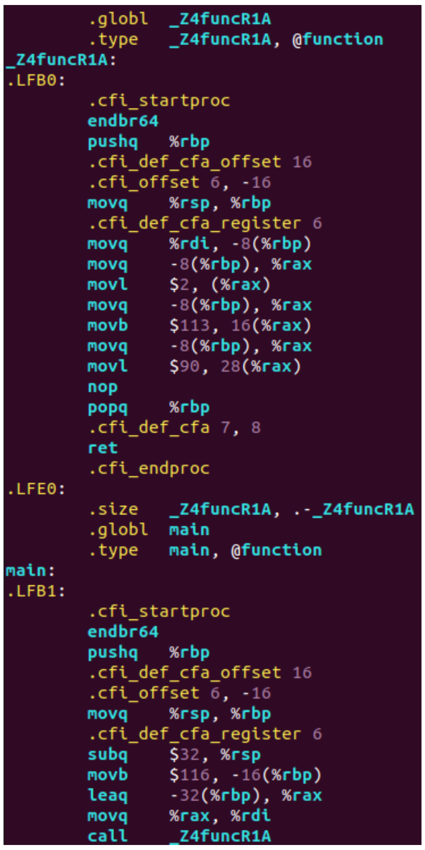
d. struct as an arg in function



```
struct A{
        int a;
        double b;
        char c;
        int arr[3];
};

void func(A &s)
{
        s.a = 2;
        s.c = 'q';
        s.arr[2] = 90;
}

int main()
{
        A s1;
        s1.c = 't';
        func(s1);
}
```

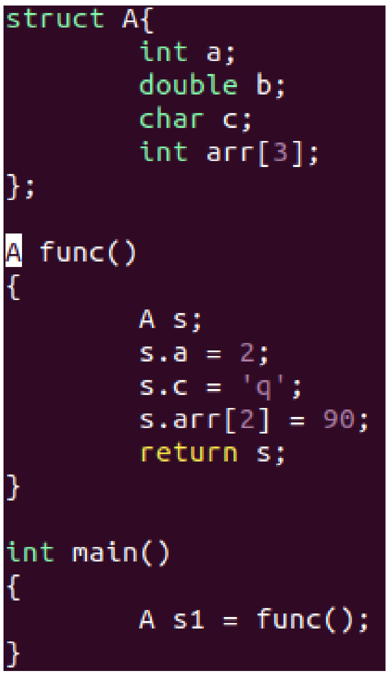


```
        .globl  _Z4funcR1A
        .type   _Z4funcR1A, @function
_Z4funcR1A:
.LFB0:
        .cfi_startproc
        endbr32
        pushl   %ebp
        .cfi_def_cfa_offset 8
        .cfi_offset 5, -8
        movl    %esp, %ebp
        .cfi_def_cfa_register 5
        call    __x86.get_pc_thunk.ax
        addl    $_GLOBAL_OFFSET_TABLE_, %eax
        movl    8(%ebp), %eax
        movl    $2, (%eax)
        movl    8(%ebp), %eax
        movb    $113, 12(%eax)
        movl    8(%ebp), %eax
        movl    $90, 24(%eax)
        nop
        popl    %ebp
        .cfi_restore 5
        .cfi_def_cfa 4, 4
        ret
        .cfi_endproc
.LFE0:
        .size   _Z4funcR1A, .-_Z4funcR1A
        .globl  main
        .type   main, @function
main:
.LFB1:
        .cfi_startproc
        endbr32
        pushl   %ebp
        .cfi_def_cfa_offset 8
        .cfi_offset 5, -8
        movl    %esp, %ebp
        .cfi_def_cfa_register 5
        subl    $32, %esp
        call    __x86.get_pc_thunk.ax
        addl    $_GLOBAL_OFFSET_TABLE_, %eax
        movb    $116, -16(%ebp)
        leal    -28(%ebp), %eax
        pushl   %eax
        call    _Z4funcR1A
        addl    $4, %esp
```

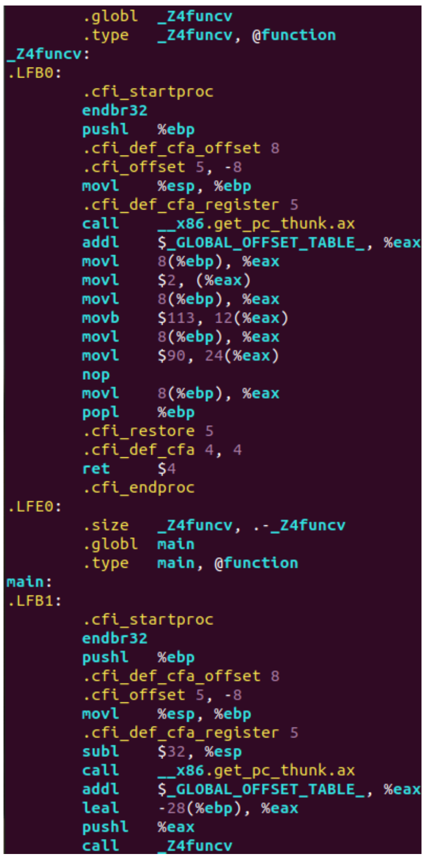


```
        .globl  _Z4funcR1A
        .type   _Z4funcR1A, @function
_Z4funcR1A:
.LFB0:
        .cfi_startproc
        endbr64
        pushq   %rbp
        .cfi_def_cfa_offset 16
        .cfi_offset 6, -16
        movq    %rsp, %rbp
        .cfi_def_cfa_register 6
        movq    %rdi, -8(%rbp)
        movq    -8(%rbp), %rax
        movl    $2, (%rax)
        movq    -8(%rbp), %rax
        movb    $113, 16(%rax)
        movq    -8(%rbp), %rax
        movl    $90, 28(%rax)
        nop
        popq    %rbp
        .cfi_def_cfa 7, 8
        ret
        .cfi_endproc
.LFE0:
        .size   _Z4funcR1A, .-_Z4funcR1A
        .globl  main
        .type   main, @function
main:
.LFB1:
        .cfi_startproc
        endbr64
        pushq   %rbp
        .cfi_def_cfa_offset 16
        .cfi_offset 6, -16
        movq    %rsp, %rbp
        .cfi_def_cfa_register 6
        subq    $32, %rsp
        movb    $116, -16(%rbp)
        leaq    -32(%rbp), %rax
        movq    %rax, %rdi
        call    _Z4funcR1A
```

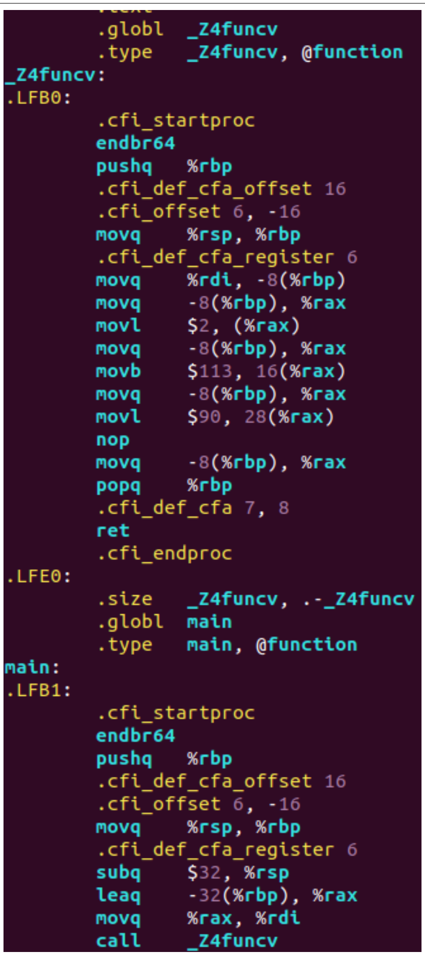
e. struct as a return value



```
struct A{
        int a;
        double b;
        char c;
        int arr[3];
};

A func()
{
        A s;
        s.a = 2;
        s.c = 'q';
        s.arr[2] = 90;
        return s;
}

int main()
{
        A s1 = func();
}
```



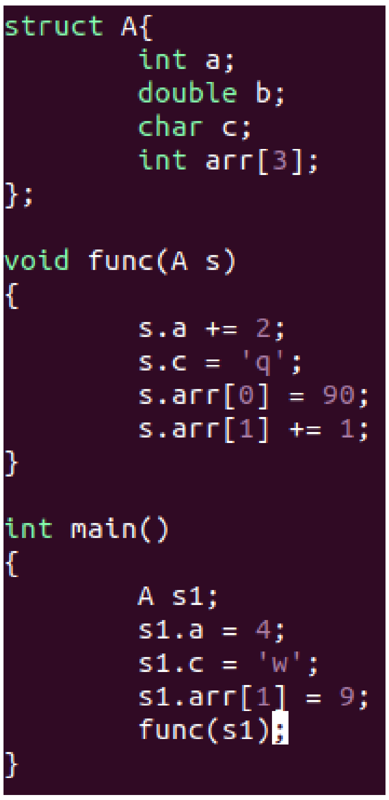
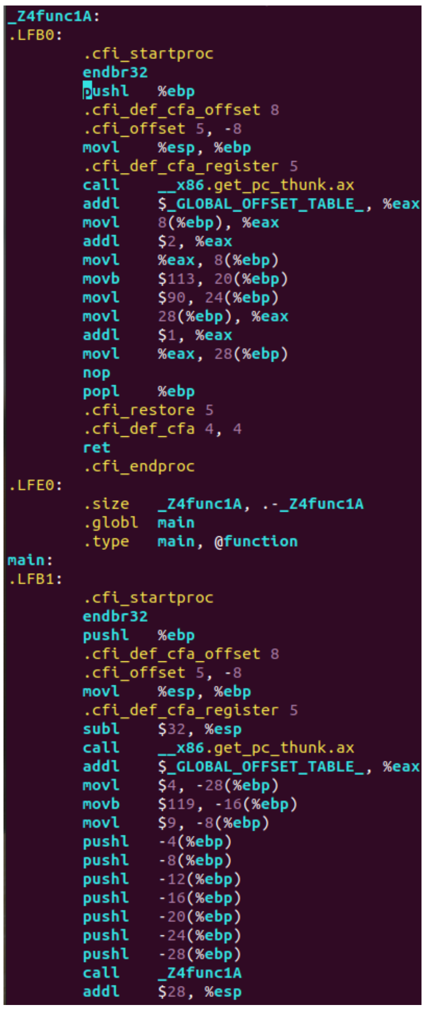
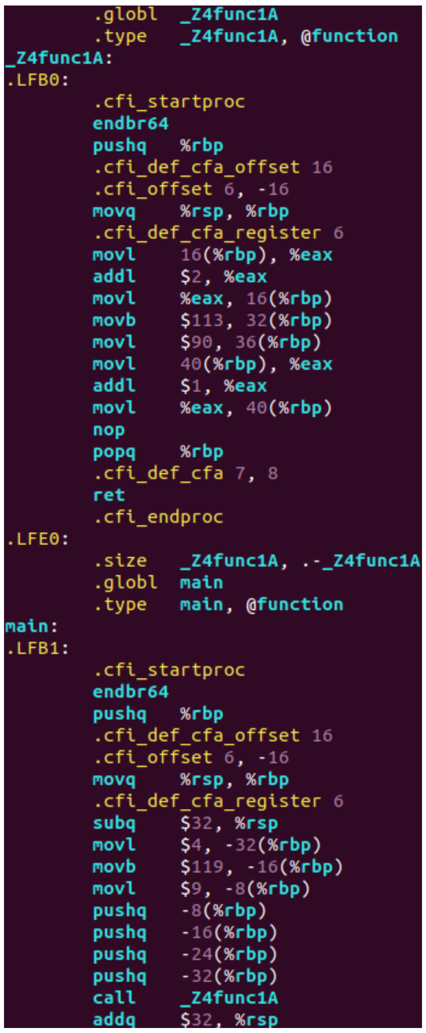
```
        .globl  _Z4funcv
        .type   _Z4funcv, @function
_Z4funcv:
.LFB0:
        .cfi_startproc
        endbr32
        pushl   %ebp
        .cfi_def_cfa_offset 8
        .cfi_offset 5, -8
        movl    %esp, %ebp
        .cfi_def_cfa_register 5
        call    __x86.get_pc_thunk.ax
        addl    $_GLOBAL_OFFSET_TABLE_, %eax
        movl    8(%ebp), %eax
        movl    $2, (%eax)
        movl    8(%ebp), %eax
        movb    $113, 12(%eax)
        movl    8(%ebp), %eax
        movl    $90, 24(%eax)
        nop
        movl    8(%ebp), %eax
        popl    %ebp
        .cfi_restore 5
        .cfi_def_cfa 4, 4
        ret     $4
        .cfi_endproc
.LFE0:
        .size   _Z4funcv, .-_Z4funcv
        .globl  main
        .type   main, @function
main:
.LFB1:
        .cfi_startproc
        endbr32
        pushl   %ebp
        .cfi_def_cfa_offset 8
        .cfi_offset 5, -8
        movl    %esp, %ebp
        .cfi_def_cfa_register 5
        subl    $32, %esp
        call    __x86.get_pc_thunk.ax
        addl    $_GLOBAL_OFFSET_TABLE_, %eax
        leal    -28(%ebp), %eax
        pushl   %eax
        call    _Z4funcv
```



```
        .globl  _Z4funcv
        .type   _Z4funcv, @function
_Z4funcv:
.LFB0:
        .cfi_startproc
        endbr64
        pushq   %rbp
        .cfi_def_cfa_offset 16
        .cfi_offset 6, -16
        movq    %rsp, %rbp
        .cfi_def_cfa_register 6
        movq    %rdi, -8(%rbp)
        movq    -8(%rbp), %rax
        movl    $2, (%rax)
        movq    -8(%rbp), %rax
        movb    $113, 16(%rax)
        movq    -8(%rbp), %rax
        movl    $90, 28(%rax)
        nop
        movq    -8(%rbp), %rax
        popq    %rbp
        .cfi_def_cfa 7, 8
        ret
        .cfi_endproc
.LFE0:
        .size   _Z4funcv, .-_Z4funcv
        .globl  main
        .type   main, @function
main:
.LFB1:
        .cfi_startproc
        endbr64
        pushq   %rbp
        .cfi_def_cfa_offset 16
        .cfi_offset 6, -16
        movq    %rsp, %rbp
        .cfi_def_cfa_register 6
        subq    $32, %rsp
        leaq    -32(%rbp), %rax
        movq    %rax, %rdi
        call    _Z4funcv
```

- in 32bit system Global offset table is used to dynamically access structures(in this task) . In a. and b. @GOTOFF is used for global structures – perhaps it stands for GOT Offset, meaning making an offset from GOT address. In 64bit system register %rip was responsible for that.

4. Pointers and references

point	C++	32bit	64bit
a. struct			

C++:

```cpp
struct A{
        int a;
        double b;
        char c;
        int arr[3];
};

void func(A s)
{
        s.a += 2;
        s.c = 'q';
        s.arr[0] = 90;
        s.arr[1] += 1;
}

int main()
{
        A s1;
        s1.a = 4;
        s1.c = 'w';
        s1.arr[1] = 9;
        func(s1);
}
```

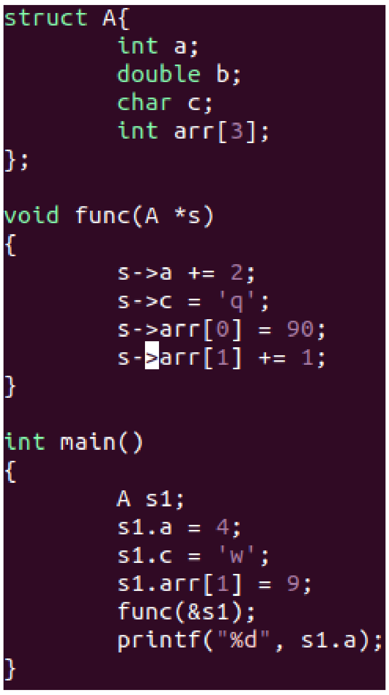
32bit:

```
_Z4func1A:
.LFB0:
        .cfi_startproc
        endbr32
        pushl   %ebp
        .cfi_def_cfa_offset 8
        .cfi_offset 5, -8
        movl    %esp, %ebp
        .cfi_def_cfa_register 5
        call    __x86.get_pc_thunk.ax
        addl    $_GLOBAL_OFFSET_TABLE_, %eax
        movl    8(%ebp), %eax
        addl    $2, %eax
        movl    %eax, 8(%ebp)
        movb    $113, 20(%ebp)
        movl    $90, 24(%ebp)
        movl    28(%ebp), %eax
        addl    $1, %eax
        movl    %eax, 28(%ebp)
        nop
        popl    %ebp
        .cfi_restore 5
        .cfi_def_cfa 4, 4
        ret
        .cfi_endproc
.LFE0:
        .size   _Z4func1A, .-_Z4func1A
        .globl  main
        .type   main, @function
main:
.LFB1:
        .cfi_startproc
        endbr32
        pushl   %ebp
        .cfi_def_cfa_offset 8
        .cfi_offset 5, -8
        movl    %esp, %ebp
        .cfi_def_cfa_register 5
        subl    $32, %esp
        call    __x86.get_pc_thunk.ax
        addl    $_GLOBAL_OFFSET_TABLE_, %eax
        movl    $4, -28(%ebp)
        movb    $119, -16(%ebp)
        movl    $9, -8(%ebp)
        pushl   -4(%ebp)
        pushl   -8(%ebp)
        pushl   -12(%ebp)
        pushl   -16(%ebp)
        pushl   -20(%ebp)
        pushl   -24(%ebp)
        pushl   -28(%ebp)
        call    _Z4func1A
        addl    $28, %esp
```

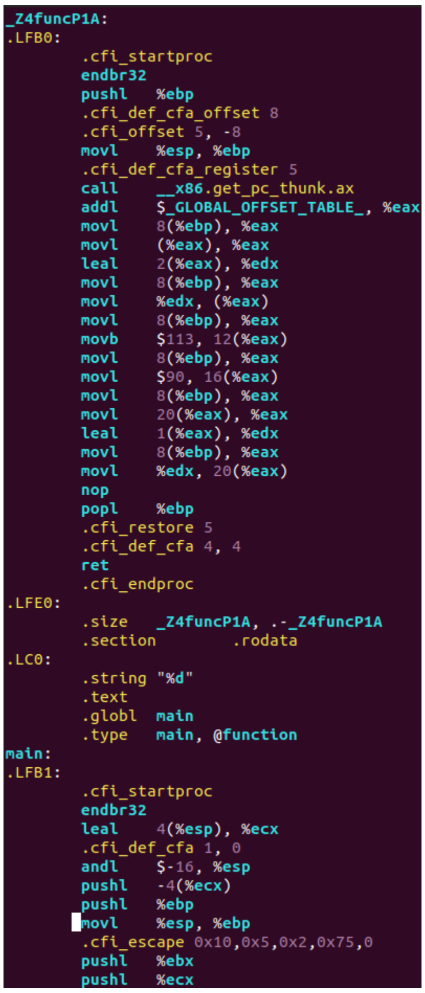
64bit:

```
        .globl  _Z4func1A
        .type   _Z4func1A, @function
_Z4func1A:
.LFB0:
        .cfi_startproc
        endbr64
        pushq   %rbp
        .cfi_def_cfa_offset 16
        .cfi_offset 6, -16
        movq    %rsp, %rbp
        .cfi_def_cfa_register 6
        movl    16(%rbp), %eax
        addl    $2, %eax
        movl    %eax, 16(%rbp)
        movb    $113, 32(%rbp)
        movl    $90, 36(%rbp)
        movl    40(%rbp), %eax
        addl    $1, %eax
        movl    %eax, 40(%rbp)
        nop
        popq    %rbp
        .cfi_def_cfa 7, 8
        ret
        .cfi_endproc
.LFE0:
        .size   _Z4func1A, .-_Z4func1A
        .globl  main
        .type   main, @function
main:
.LFB1:
        .cfi_startproc
        endbr64
        pushq   %rbp
        .cfi_def_cfa_offset 16
        .cfi_offset 6, -16
        movq    %rsp, %rbp
        .cfi_def_cfa_register 6
        subq    $32, %rsp
        movl    $4, -32(%rbp)
        movb    $119, -16(%rbp)
        movl    $9, -8(%rbp)
        pushq   -8(%rbp)
        pushq   -16(%rbp)
        pushq   -24(%rbp)
        pushq   -32(%rbp)
        call    _Z4func1A
        addq    $32, %rsp
```

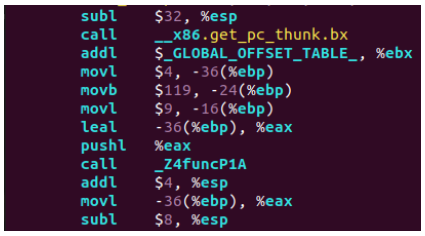
b. struct pointer



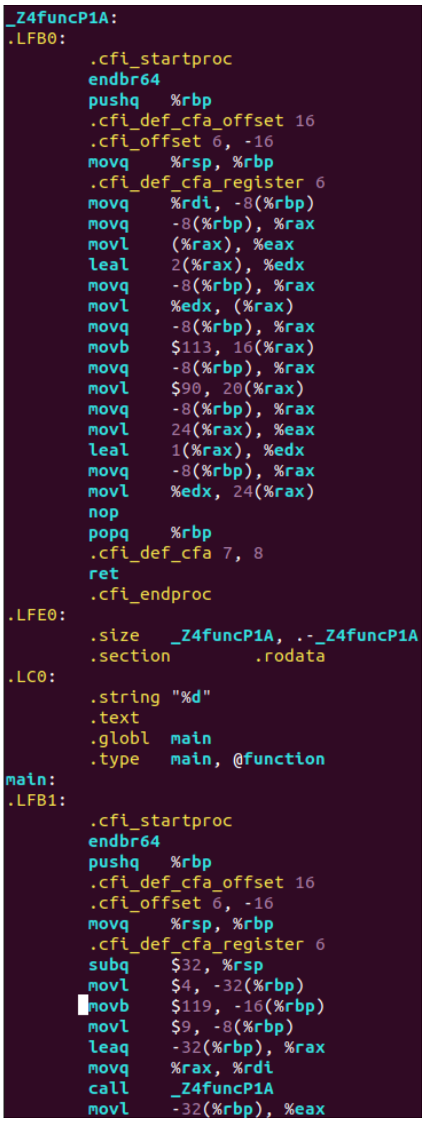
```
struct A{
        int a;
        double b;
        char c;
        int arr[3];
};

void func(A *s)
{
        s->a += 2;
        s->c = 'q';
        s->arr[0] = 90;
        s->arr[1] += 1;
}

int main()
{
        A s1;
        s1.a = 4;
        s1.c = 'w';
        s1.arr[1] = 9;
        func(&s1);
        printf("%d", s1.a);
}
```



```
_Z4funcP1A:
.LFB0:
        .cfi_startproc
        endbr32
        pushl   %ebp
        .cfi_def_cfa_offset 8
        .cfi_offset 5, -8
        movl    %esp, %ebp
        .cfi_def_cfa_register 5
        call    __x86.get_pc_thunk.ax
        addl    $_GLOBAL_OFFSET_TABLE_, %eax
        movl    8(%ebp), %eax
        movl    (%eax), %eax
        leal    2(%eax), %edx
        movl    8(%ebp), %eax
        movl    %edx, (%eax)
        movl    8(%ebp), %eax
        movb    $113, 12(%eax)
        movl    8(%ebp), %eax
        movl    $90, 16(%eax)
        movl    8(%ebp), %eax
        movl    20(%eax), %eax
        leal    1(%eax), %edx
        movl    8(%ebp), %eax
        movl    %edx, 20(%eax)
        nop
        popl    %ebp
        .cfi_restore 5
        .cfi_def_cfa 4, 4
        ret
        .cfi_endproc
.LFE0:
        .size   _Z4funcP1A, .-_Z4funcP1A
        .section        .rodata
.LC0:
        .string "%d"
        .text
        .globl  main
        .type   main, @function
main:
.LFB1:
        .cfi_startproc
        endbr32
        leal    4(%esp), %ecx
        .cfi_def_cfa 1, 0
        andl    $-16, %esp
        pushl   -4(%ecx)
        pushl   %ebp
        movl    %esp, %ebp
        .cfi_escape 0x10,0x5,0x2,0x75,0
        pushl   %ebx
        pushl   %ecx
```

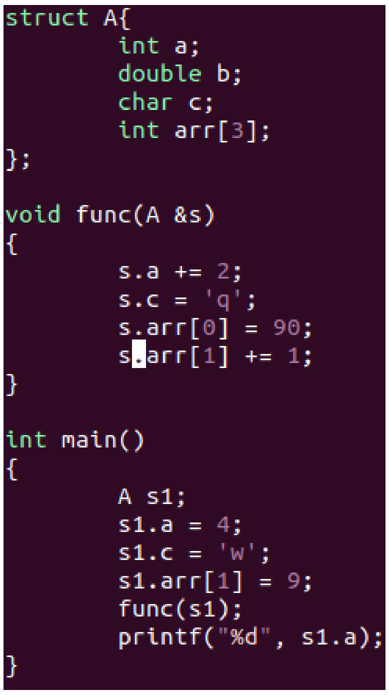


```
        subl    $32, %esp
        call    __x86.get_pc_thunk.bx
        addl    $_GLOBAL_OFFSET_TABLE_, %ebx
        movl    $4, -36(%ebp)
        movb    $119, -24(%ebp)
        movl    $9, -16(%ebp)
        leal    -36(%ebp), %eax
        pushl   %eax
        call    _Z4funcP1A
        addl    $4, %esp
        movl    -36(%ebp), %eax
        subl    $8, %esp
```

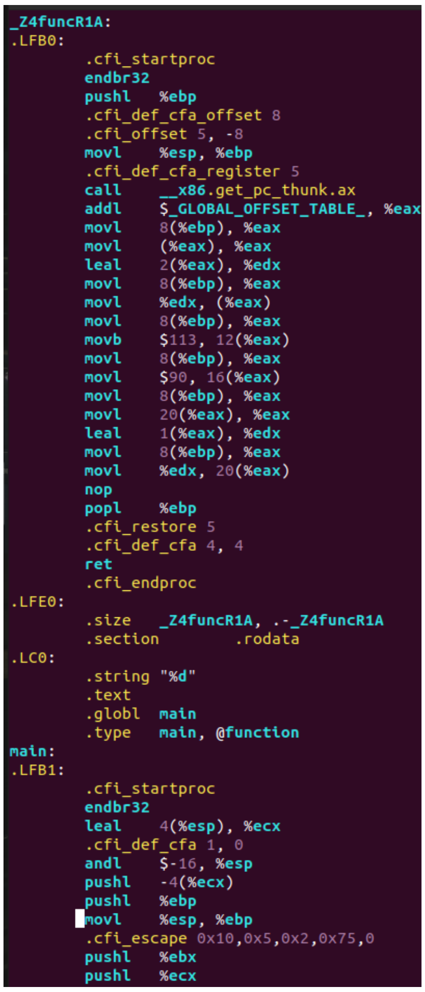


```
_Z4funcP1A:
.LFB0:
        .cfi_startproc
        endbr64
        pushq   %rbp
        .cfi_def_cfa_offset 16
        .cfi_offset 6, -16
        movq    %rsp, %rbp
        .cfi_def_cfa_register 6
        movq    %rdi, -8(%rbp)
        movq    -8(%rbp), %rax
        movl    (%rax), %eax
        leal    2(%rax), %edx
        movq    -8(%rbp), %rax
        movl    %edx, (%rax)
        movq    -8(%rbp), %rax
        movb    $113, 16(%rax)
        movq    -8(%rbp), %rax
        movl    $90, 20(%rax)
        movq    -8(%rbp), %rax
        movl    24(%rax), %eax
        leal    1(%rax), %edx
        movq    -8(%rbp), %rax
        movl    %edx, 24(%rax)
        nop
        popq    %rbp
        .cfi_def_cfa 7, 8
        ret
        .cfi_endproc
.LFE0:
        .size   _Z4funcP1A, .-_Z4funcP1A
        .section        .rodata
.LC0:
        .string "%d"
        .text
        .globl  main
        .type   main, @function
main:
.LFB1:
        .cfi_startproc
        endbr64
        pushq   %rbp
        .cfi_def_cfa_offset 16
        .cfi_offset 6, -16
        movq    %rsp, %rbp
        .cfi_def_cfa_register 6
        subq    $32, %rsp
        movl    $4, -32(%rbp)
        movb    $119, -16(%rbp)
        movl    $9, -8(%rbp)
        leaq    -32(%rbp), %rax
        movq    %rax, %rdi
        call    _Z4funcP1A
        movl    -32(%rbp), %eax
```

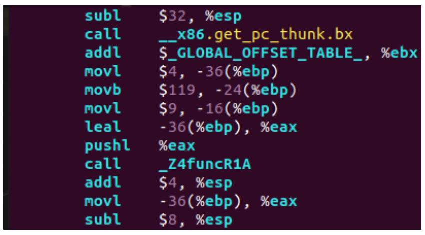
c. struct reference



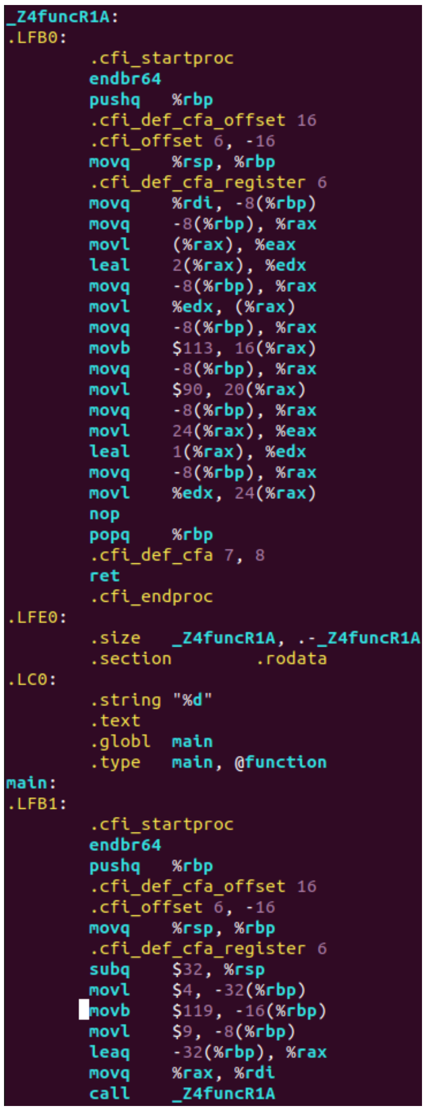
```
struct A{
        int a;
        double b;
        char c;
        int arr[3];
};

void func(A &s)
{
        s.a += 2;
        s.c = 'q';
        s.arr[0] = 90;
        s.arr[1] += 1;
}

int main()
{
        A s1;
        s1.a = 4;
        s1.c = 'w';
        s1.arr[1] = 9;
        func(s1);
        printf("%d", s1.a);
}
```



```
_Z4funcR1A:
.LFB0:
        .cfi_startproc
        endbr32
        pushl   %ebp
        .cfi_def_cfa_offset 8
        .cfi_offset 5, -8
        movl    %esp, %ebp
        .cfi_def_cfa_register 5
        call    __x86.get_pc_thunk.ax
        addl    $_GLOBAL_OFFSET_TABLE_, %eax
        movl    8(%ebp), %eax
        movl    (%eax), %eax
        leal    2(%eax), %edx
        movl    8(%ebp), %eax
        movl    %edx, (%eax)
        movl    8(%ebp), %eax
        movb    $113, 12(%eax)
        movl    8(%ebp), %eax
        movl    $90, 16(%eax)
        movl    8(%ebp), %eax
        movl    20(%eax), %eax
        leal    1(%eax), %edx
        movl    8(%ebp), %eax
        movl    %edx, 20(%eax)
        nop
        popl    %ebp
        .cfi_restore 5
        .cfi_def_cfa 4, 4
        ret
        .cfi_endproc
.LFE0:
        .size   _Z4funcR1A, .-_Z4funcR1A
        .section        .rodata
.LC0:
        .string "%d"
        .text
        .globl  main
        .type   main, @function
main:
.LFB1:
        .cfi_startproc
        endbr32
        leal    4(%esp), %ecx
        .cfi_def_cfa 1, 0
        andl    $-16, %esp
        pushl   -4(%ecx)
        pushl   %ebp
        movl    %esp, %ebp
        .cfi_escape 0x10,0x5,0x2,0x75,0
        pushl   %ebx
        pushl   %ecx
```



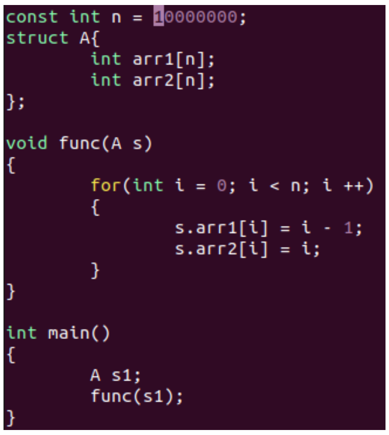
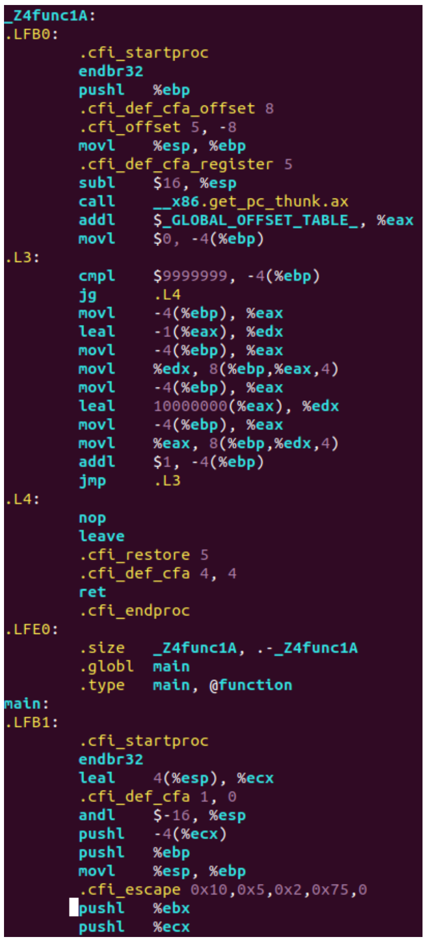
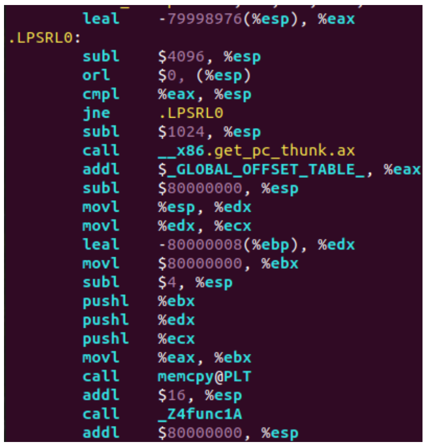
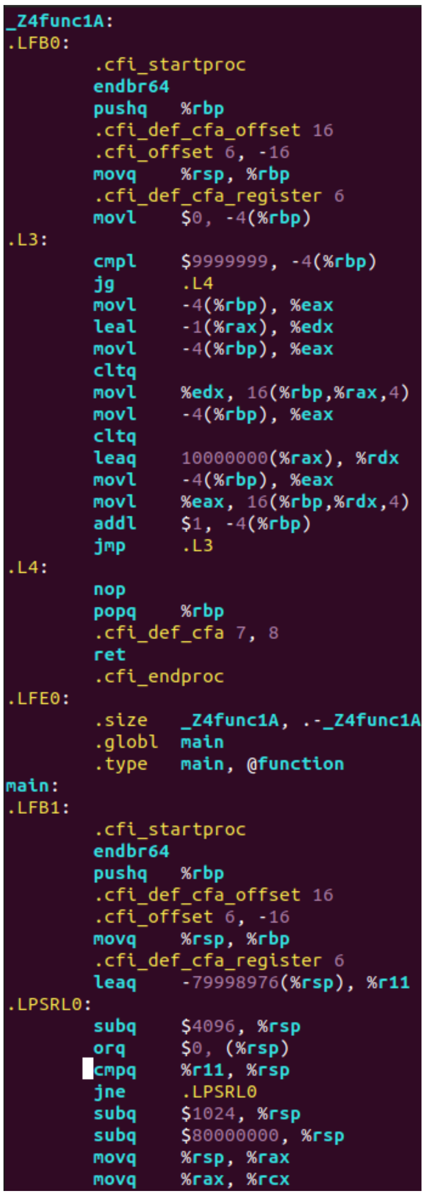
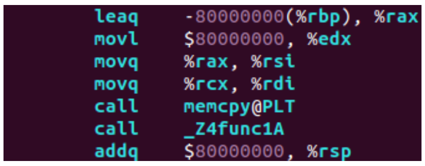
```
        subl    $32, %esp
        call    __x86.get_pc_thunk.bx
        addl    $_GLOBAL_OFFSET_TABLE_, %ebx
        movl    $4, -36(%ebp)
        movb    $119, -24(%ebp)
        movl    $9, -16(%ebp)
        leal    -36(%ebp), %eax
        pushl   %eax
        call    _Z4funcR1A
        addl    $4, %esp
        movl    -36(%ebp), %eax
        subl    $8, %esp
```



```
_Z4funcR1A:
.LFB0:
        .cfi_startproc
        endbr64
        pushq   %rbp
        .cfi_def_cfa_offset 16
        .cfi_offset 6, -16
        movq    %rsp, %rbp
        .cfi_def_cfa_register 6
        movq    %rdi, -8(%rbp)
        movq    -8(%rbp), %rax
        movl    (%rax), %eax
        leal    2(%rax), %edx
        movq    -8(%rbp), %rax
        movl    %edx, (%rax)
        movq    -8(%rbp), %rax
        movb    $113, 16(%rax)
        movq    -8(%rbp), %rax
        movl    $90, 20(%rax)
        movq    -8(%rbp), %rax
        movl    24(%rax), %eax
        leal    1(%rax), %edx
        movq    -8(%rbp), %rax
        movl    %edx, 24(%rax)
        nop
        popq    %rbp
        .cfi_def_cfa 7, 8
        ret
        .cfi_endproc
.LFE0:
        .size   _Z4funcR1A, .-_Z4funcR1A
        .section        .rodata
.LC0:
        .string "%d"
        .text
        .globl  main
        .type   main, @function
main:
.LFB1:
        .cfi_startproc
        endbr64
        pushq   %rbp
        .cfi_def_cfa_offset 16
        .cfi_offset 6, -16
        movq    %rsp, %rbp
        .cfi_def_cfa_register 6
        subq    $32, %rsp
        movl    $4, -32(%rbp)
        movb    $119, -16(%rbp)
        movl    $9, -8(%rbp)
        leaq    -32(%rbp), %rax
        movq    %rax, %rdi
        call    _Z4funcR1A
```

- in a. all struct members are pushed into stack; in b. and c. (pointers and references) struct members are not pushed into stack, only registers and stack frame(via i(%rbp)) are used.

5. Heavy structures

point	C++	32bit	64bit
a. struct as an arg		 	 

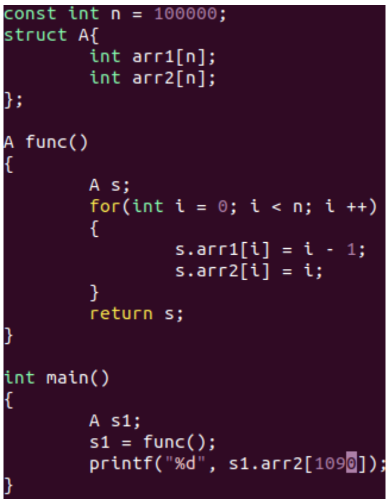
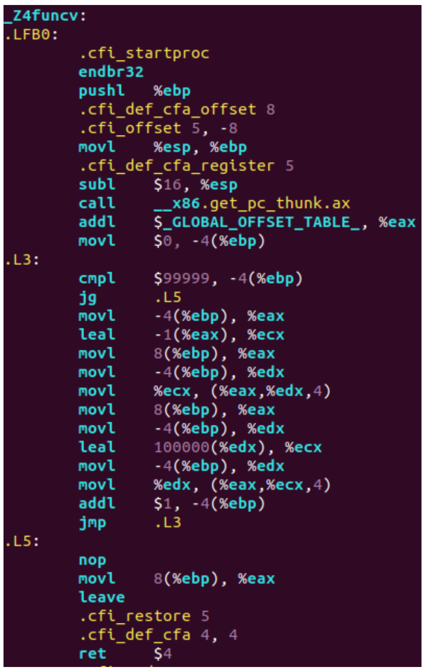
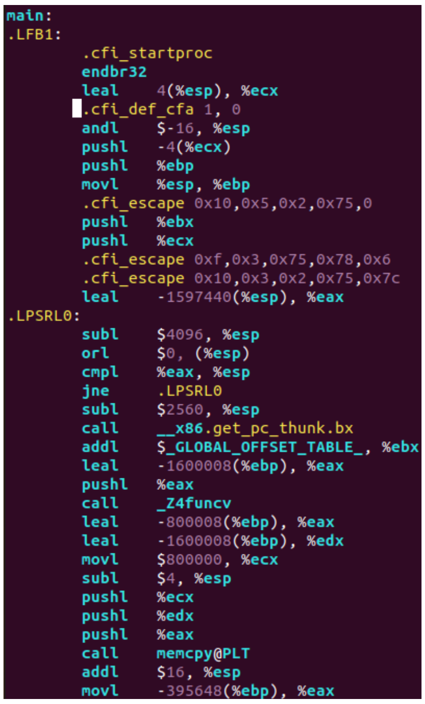
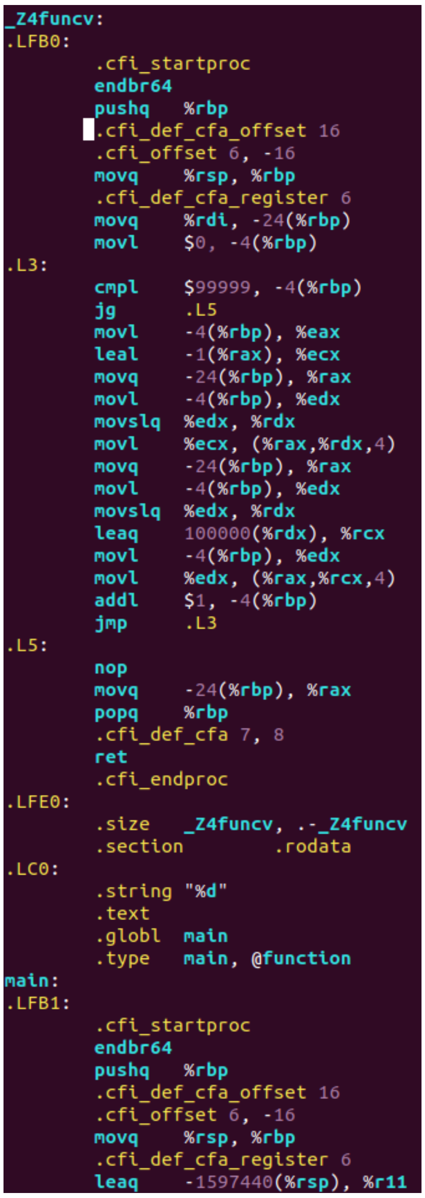
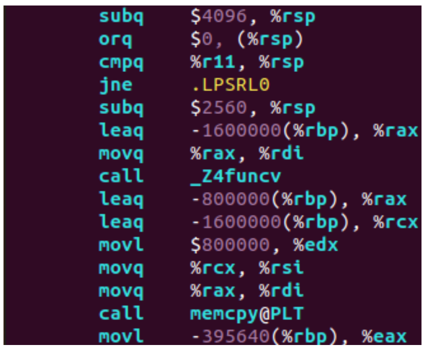
```cpp
const int n = 10000000;
struct A{
        int arr1[n];
        int arr2[n];
};

void func(A s)
{
        for(int i = 0; i < n; i ++)
        {
                s.arr1[i] = i - 1;
                s.arr2[i] = i;
        }
}

int main()
{
        A s1;
        func(s1);
}
```

```
_Z4func1A:
.LFB0:
        .cfi_startproc
        endbr32
        pushl   %ebp
        .cfi_def_cfa_offset 8
        .cfi_offset 5, -8
        movl    %esp, %ebp
        .cfi_def_cfa_register 5
        subl    $16, %esp
        call    __x86.get_pc_thunk.ax
        addl    $_GLOBAL_OFFSET_TABLE_, %eax
        movl    $0, -4(%ebp)
.L3:
        cmpl    $9999999, -4(%ebp)
        jg      .L4
        movl    -4(%ebp), %eax
        leal    -1(%eax), %edx
        movl    -4(%ebp), %eax
        movl    %edx, 8(%ebp,%eax,4)
        movl    -4(%ebp), %eax
        leal    10000000(%eax), %edx
        movl    -4(%ebp), %eax
        movl    %eax, 8(%ebp,%edx,4)
        addl    $1, -4(%ebp)
        jmp     .L3
.L4:
        nop
        leave
        .cfi_restore 5
        .cfi_def_cfa 4, 4
        ret
        .cfi_endproc
.LFE0:
        .size   _Z4func1A, .-_Z4func1A
        .globl  main
        .type   main, @function
main:
.LFB1:
        .cfi_startproc
        endbr32
        leal    4(%esp), %ecx
        .cfi_def_cfa 1, 0
        andl    $-16, %esp
        pushl   -4(%ecx)
        pushl   %ebp
        movl    %esp, %ebp
        .cfi_escape 0x10,0x5,0x2,0x75,0
        pushl   %ebx
        pushl   %ecx
```

```
        leal    -79998976(%esp), %eax
.LPSRL0:
        subl    $4096, %esp
        orl     $0, (%esp)
        cmpl    %eax, %esp
        jne     .LPSRL0
        subl    $1024, %esp
        call    __x86.get_pc_thunk.ax
        addl    $_GLOBAL_OFFSET_TABLE_, %eax
        subl    $80000000, %esp
        movl    %esp, %edx
        movl    %edx, %ecx
        leal    -80000008(%ebp), %edx
        movl    $80000000, %ebx
        subl    $4, %esp
        pushl   %ebx
        pushl   %edx
        pushl   %ecx
        movl    %eax, %ebx
        call    memcpy@PLT
        addl    $16, %esp
        call    _Z4func1A
        addl    $80000000, %esp
```

```
_Z4func1A:
.LFB0:
        .cfi_startproc
        endbr64
        pushq   %rbp
        .cfi_def_cfa_offset 16
        .cfi_offset 6, -16
        movq    %rsp, %rbp
        .cfi_def_cfa_register 6
        movl    $0, -4(%rbp)
.L3:
        cmpl    $9999999, -4(%rbp)
        jg      .L4
        movl    -4(%rbp), %eax
        leal    -1(%rax), %edx
        movl    -4(%rbp), %eax
        cltq
        movl    %edx, 16(%rbp,%rax,4)
        movl    -4(%rbp), %eax
        cltq
        leaq    10000000(%rax), %rdx
        movl    -4(%rbp), %eax
        movl    %eax, 16(%rbp,%rdx,4)
        addl    $1, -4(%rbp)
        jmp     .L3
.L4:
        nop
        popq    %rbp
        .cfi_def_cfa 7, 8
        ret
        .cfi_endproc
.LFE0:
        .size   _Z4func1A, .-_Z4func1A
        .globl  main
        .type   main, @function
main:
.LFB1:
        .cfi_startproc
        endbr64
        pushq   %rbp
        .cfi_def_cfa_offset 16
        .cfi_offset 6, -16
        movq    %rsp, %rbp
        .cfi_def_cfa_register 6
        leaq    -79998976(%rsp), %r11
.LPSRL0:
        subq    $4096, %rsp
        orq     $0, (%rsp)
        cmpq    %r11, %rsp
        jne     .LPSRL0
        subq    $1024, %rsp
        subq    $80000000, %rsp
        movq    %rsp, %rax
        movq    %rax, %rcx
```

```
        leaq    -80000000(%rbp), %rax
        movl    $80000000, %edx
        movq    %rax, %rsi
        movq    %rcx, %rdi
        call    memcpy@PLT
        call    _Z4func1A
        addq    $80000000, %rsp
```

b. struct as a return value		 	 

```
const int n = 100000;
struct A{
        int arr1[n];
        int arr2[n];
};

A func()
{
        A s;
        for(int i = 0; i < n; i ++)
        {
                s.arr1[i] = i - 1;
                s.arr2[i] = i;
        }
        return s;
}

int main()
{
        A s1;
        s1 = func();
        printf("%d", s1.arr2[1090]);
}
```

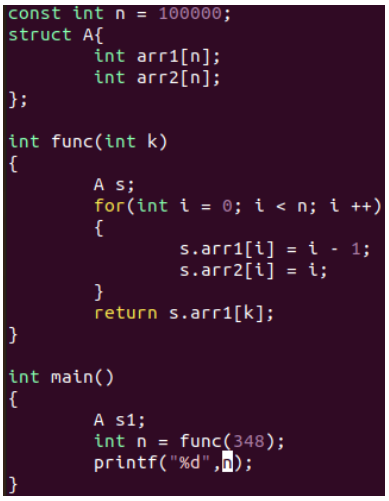
```
_Z4funcv:
.LFB0:
        .cfi_startproc
        endbr32
        pushl   %ebp
        .cfi_def_cfa_offset 8
        .cfi_offset 5, -8
        movl    %esp, %ebp
        .cfi_def_cfa_register 5
        subl    $16, %esp
        call    __x86.get_pc_thunk.ax
        addl    $_GLOBAL_OFFSET_TABLE_, %eax
        movl    $0, -4(%ebp)
.L3:
        cmpl    $99999, -4(%ebp)
        jg      .L5
        movl    -4(%ebp), %eax
        leal    -1(%eax), %ecx
        movl    8(%ebp), %eax
        movl    -4(%ebp), %edx
        movl    %ecx, (%eax,%edx,4)
        movl    8(%ebp), %eax
        movl    -4(%ebp), %edx
        leal    100000(%edx), %ecx
        movl    -4(%ebp), %edx
        movl    %edx, (%eax,%ecx,4)
        addl    $1, -4(%ebp)
        jmp     .L3
.L5:
        nop
        movl    8(%ebp), %eax
        leave
        .cfi_restore 5
        .cfi_def_cfa 4, 4
        ret     $4
```

```
main:
.LFB1:
        .cfi_startproc
        endbr32
        leal    4(%esp), %ecx
        .cfi_def_cfa 1, 0
        andl    $-16, %esp
        pushl   -4(%ecx)
        pushl   %ebp
        movl    %esp, %ebp
        .cfi_escape 0x10,0x5,0x2,0x75,0
        pushl   %ebx
        pushl   %ecx
        .cfi_escape 0xf,0x3,0x75,0x78,0x6
        .cfi_escape 0x10,0x3,0x2,0x75,0x7c
        leal    -1597440(%esp), %eax
.LPSRL0:
        subl    $4096, %esp
        orl     $0, (%esp)
        cmpl    %eax, %esp
        jne     .LPSRL0
        subl    $2560, %esp
        call    __x86.get_pc_thunk.bx
        addl    $_GLOBAL_OFFSET_TABLE_, %ebx
        leal    -1600008(%ebp), %eax
        pushl   %eax
        call    _Z4funcv
        leal    -800008(%ebp), %eax
        leal    -1600008(%ebp), %edx
        movl    $800000, %ecx
        subl    $4, %esp
        pushl   %ecx
        pushl   %edx
        pushl   %eax
        call    memcpy@PLT
        addl    $16, %esp
        movl    -395648(%ebp), %eax
```

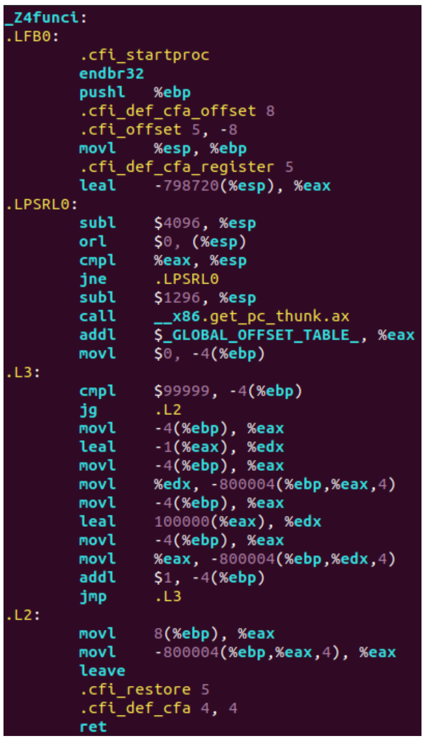
```
_Z4funcv:
.LFB0:
        .cfi_startproc
        endbr64
        pushq   %rbp
        .cfi_def_cfa_offset 16
        .cfi_offset 6, -16
        movq    %rsp, %rbp
        .cfi_def_cfa_register 6
        movq    %rdi, -24(%rbp)
        movl    $0, -4(%rbp)
.L3:
        cmpl    $99999, -4(%rbp)
        jg      .L5
        movl    -4(%rbp), %eax
        leal    -1(%rax), %ecx
        movq    -24(%rbp), %rax
        movl    -4(%rbp), %edx
        movslq  %edx, %rdx
        movl    %ecx, (%rax,%rdx,4)
        movq    -24(%rbp), %rax
        movl    -4(%rbp), %edx
        movslq  %edx, %rdx
        leaq    100000(%rdx), %rcx
        movl    -4(%rbp), %edx
        movl    %edx, (%rax,%rcx,4)
        addl    $1, -4(%rbp)
        jmp     .L3
.L5:
        nop
        movq    -24(%rbp), %rax
        popq    %rbp
        .cfi_def_cfa 7, 8
        ret
        .cfi_endproc
.LFE0:
        .size   _Z4funcv, .-_Z4funcv
        .section        .rodata
.LC0:
        .string "%d"
        .text
        .globl  main
        .type   main, @function
main:
.LFB1:
        .cfi_startproc
        endbr64
        pushq   %rbp
        .cfi_def_cfa_offset 16
        .cfi_offset 6, -16
        movq    %rsp, %rbp
        .cfi_def_cfa_register 6
        leaq    -1597440(%rsp), %r11
```

```
        subq    $4096, %rsp
        orq     $0, (%rsp)
        cmpq    %r11, %rsp
        jne     .LPSRL0
        subq    $2560, %rsp
        leaq    -1600000(%rbp), %rax
        movq    %rax, %rdi
        call    _Z4funcv
        leaq    -800000(%rbp), %rax
        leaq    -1600000(%rbp), %rcx
        movl    $800000, %edx
        movq    %rcx, %rsi
        movq    %rax, %rdi
        call    memcpy@PLT
        movl    -395640(%rbp), %eax
```

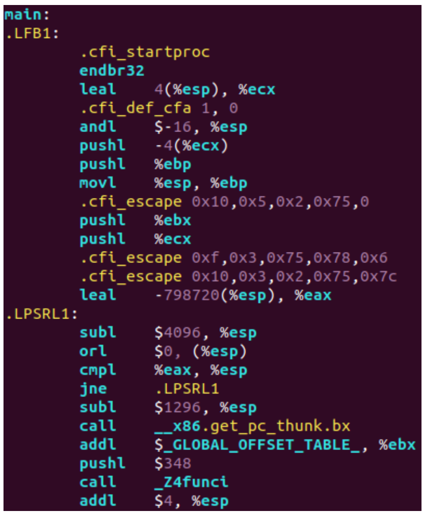
c. struct as local var



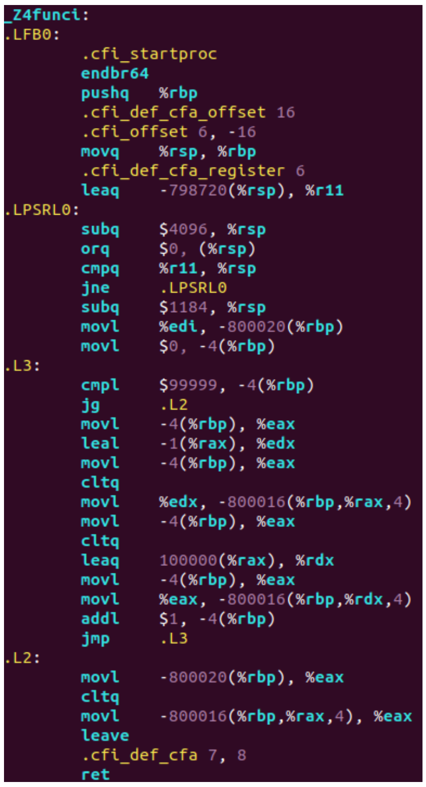
```
const int n = 100000;
struct A{
        int arr1[n];
        int arr2[n];
};

int func(int k)
{
        A s;
        for(int i = 0; i < n; i ++)
        {
                s.arr1[i] = i - 1;
                s.arr2[i] = i;
        }
        return s.arr1[k];
}

int main()
{
        A s1;
        int n = func(348);
        printf("%d",n);
}
```



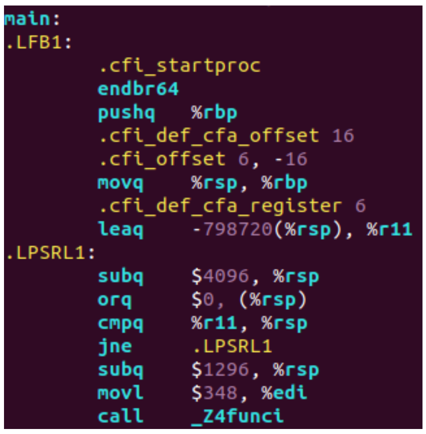
```
_Z4funci:
.LFB0:
        .cfi_startproc
        endbr32
        pushl   %ebp
        .cfi_def_cfa_offset 8
        .cfi_offset 5, -8
        movl    %esp, %ebp
        .cfi_def_cfa_register 5
        leal    -798720(%esp), %eax
.LPSRL0:
        subl    $4096, %esp
        orl     $0, (%esp)
        cmpl    %eax, %esp
        jne     .LPSRL0
        subl    $1296, %esp
        call    __x86.get_pc_thunk.ax
        addl    $_GLOBAL_OFFSET_TABLE_, %eax
        movl    $0, -4(%ebp)
.L3:
        cmpl    $99999, -4(%ebp)
        jg      .L2
        movl    -4(%ebp), %eax
        leal    -1(%eax), %edx
        movl    -4(%ebp), %eax
        movl    %edx, -800004(%ebp,%eax,4)
        movl    -4(%ebp), %eax
        leal    100000(%eax), %edx
        movl    -4(%ebp), %eax
        movl    %eax, -800004(%ebp,%edx,4)
        addl    $1, -4(%ebp)
        jmp     .L3
.L2:
        movl    8(%ebp), %eax
        movl    -800004(%ebp,%eax,4), %eax
        leave
        .cfi_restore 5
        .cfi_def_cfa 4, 4
        ret
```



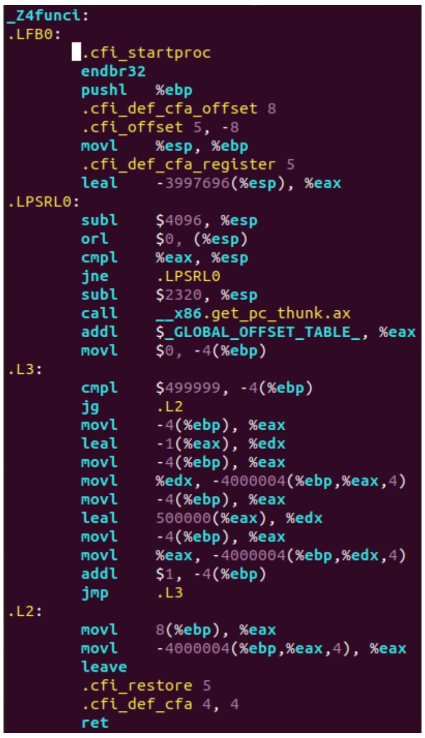
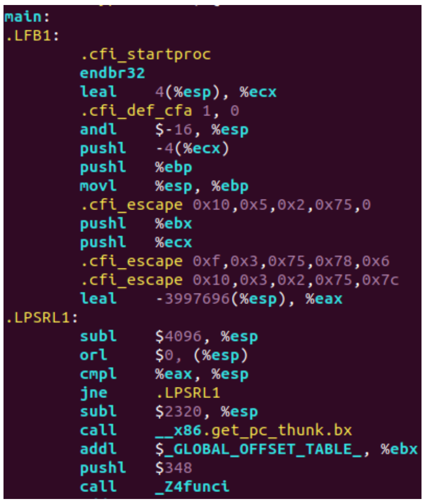
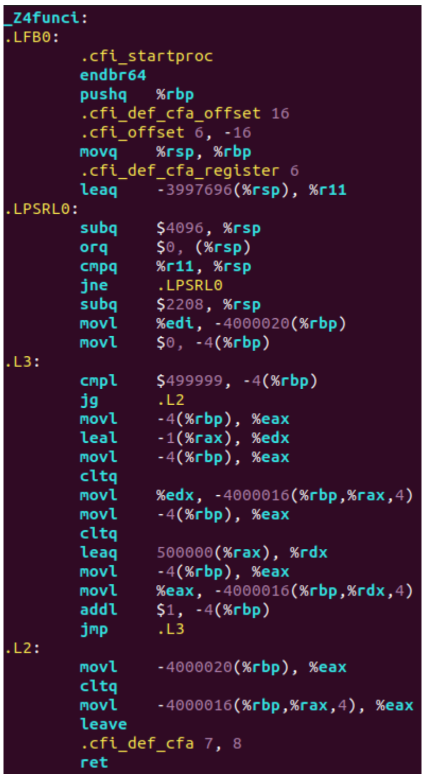
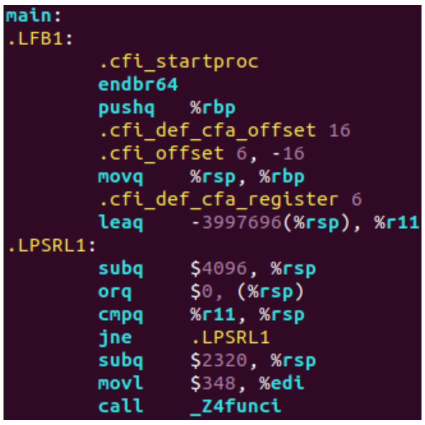
```
main:
.LFB1:
        .cfi_startproc
        endbr32
        leal    4(%esp), %ecx
        .cfi_def_cfa 1, 0
        andl    $-16, %esp
        pushl   -4(%ecx)
        pushl   %ebp
        movl    %esp, %ebp
        .cfi_escape 0x10,0x5,0x2,0x75,0
        pushl   %ebx
        pushl   %ecx
        .cfi_escape 0xf,0x3,0x75,0x78,0x6
        .cfi_escape 0x10,0x3,0x2,0x75,0x7c
        leal    -798720(%esp), %eax
.LPSRL1:
        subl    $4096, %esp
        orl     $0, (%esp)
        cmpl    %eax, %esp
        jne     .LPSRL1
        subl    $1296, %esp
        call    __x86.get_pc_thunk.bx
        addl    $_GLOBAL_OFFSET_TABLE_, %ebx
        pushl   $348
        call    _Z4funci
        addl    $4, %esp
```



```
_Z4funci:
.LFB0:
        .cfi_startproc
        endbr64
        pushq   %rbp
        .cfi_def_cfa_offset 16
        .cfi_offset 6, -16
        movq    %rsp, %rbp
        .cfi_def_cfa_register 6
        leaq    -798720(%rsp), %r11
.LPSRL0:
        subq    $4096, %rsp
        orq     $0, (%rsp)
        cmpq    %r11, %rsp
        jne     .LPSRL0
        subq    $1184, %rsp
        movl    %edi, -800020(%rbp)
        movl    $0, -4(%rbp)
.L3:
        cmpl    $99999, -4(%rbp)
        jg      .L2
        movl    -4(%rbp), %eax
        leal    -1(%rax), %edx
        movl    -4(%rbp), %eax
        cltq
        movl    %edx, -800016(%rbp,%rax,4)
        movl    -4(%rbp), %eax
        cltq
        leaq    100000(%rax), %rdx
        movl    -4(%rbp), %eax
        movl    %eax, -800016(%rbp,%rdx,4)
        addl    $1, -4(%rbp)
        jmp     .L3
.L2:
        movl    -800020(%rbp), %eax
        cltq
        movl    -800016(%rbp,%rax,4), %eax
        leave
        .cfi_def_cfa 7, 8
        ret
```



```
main:
.LFB1:
        .cfi_startproc
        endbr64
        pushq   %rbp
        .cfi_def_cfa_offset 16
        .cfi_offset 6, -16
        movq    %rsp, %rbp
        .cfi_def_cfa_register 6
        leaq    -798720(%rsp), %r11
.LPSRL1:
        subq    $4096, %rsp
        orq     $0, (%rsp)
        cmpq    %r11, %rsp
        jne     .LPSRL1
        subq    $1296, %rsp
        movl    $348, %edi
        call    _Z4funci
```

d. changing size(relative to c.)	Size = 500000	 	 

```
_Z4funci:
.LFB0:
        .cfi_startproc
        endbr32
        pushl   %ebp
        .cfi_def_cfa_offset 8
        .cfi_offset 5, -8
        movl    %esp, %ebp
        .cfi_def_cfa_register 5
        leal    -3997696(%esp), %eax
.LPSRL0:
        subl    $4096, %esp
        orl     $0, (%esp)
        cmpl    %eax, %esp
        jne     .LPSRL0
        subl    $2320, %esp
        call    __x86.get_pc_thunk.ax
        addl    $_GLOBAL_OFFSET_TABLE_, %eax
        movl    $0, -4(%ebp)
.L3:
        cmpl    $499999, -4(%ebp)
        jg      .L2
        movl    -4(%ebp), %eax
        leal    -1(%eax), %edx
        movl    -4(%ebp), %eax
        movl    %edx, -4000004(%ebp,%eax,4)
        movl    -4(%ebp), %eax
        leal    500000(%eax), %edx
        movl    -4(%ebp), %eax
        movl    %eax, -4000004(%ebp,%edx,4)
        addl    $1, -4(%ebp)
        jmp     .L3
.L2:
        movl    8(%ebp), %eax
        movl    -4000004(%ebp,%eax,4), %eax
        leave
        .cfi_restore 5
        .cfi_def_cfa 4, 4
        ret
```

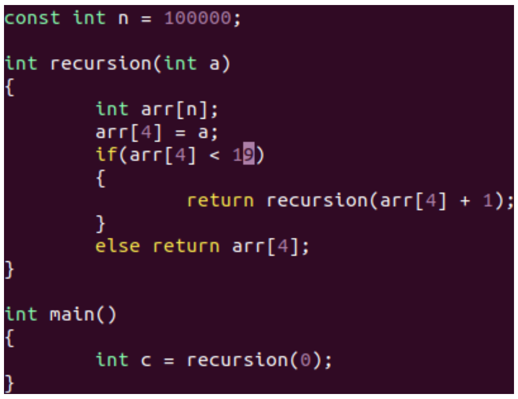
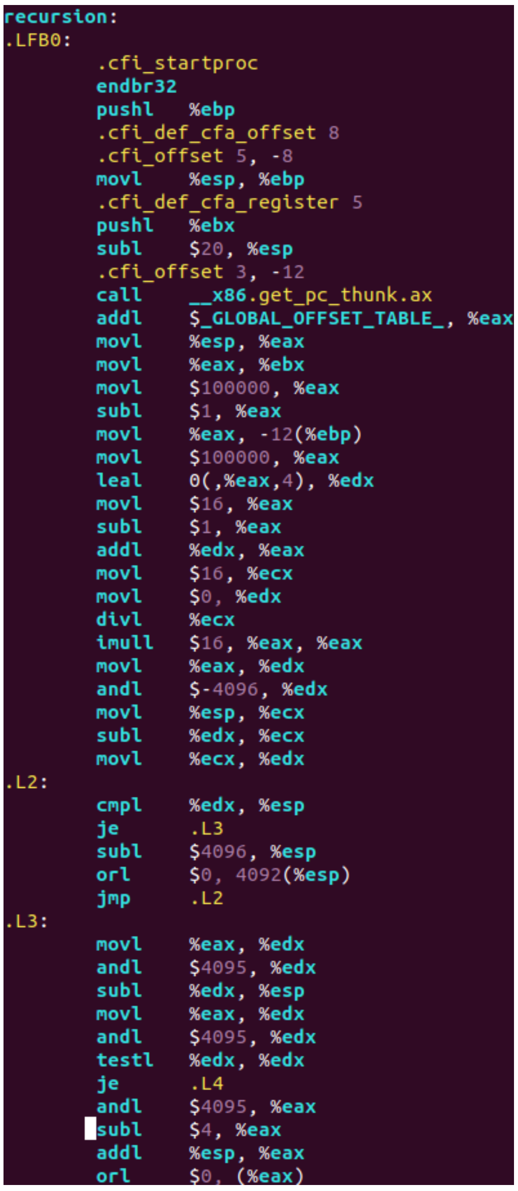
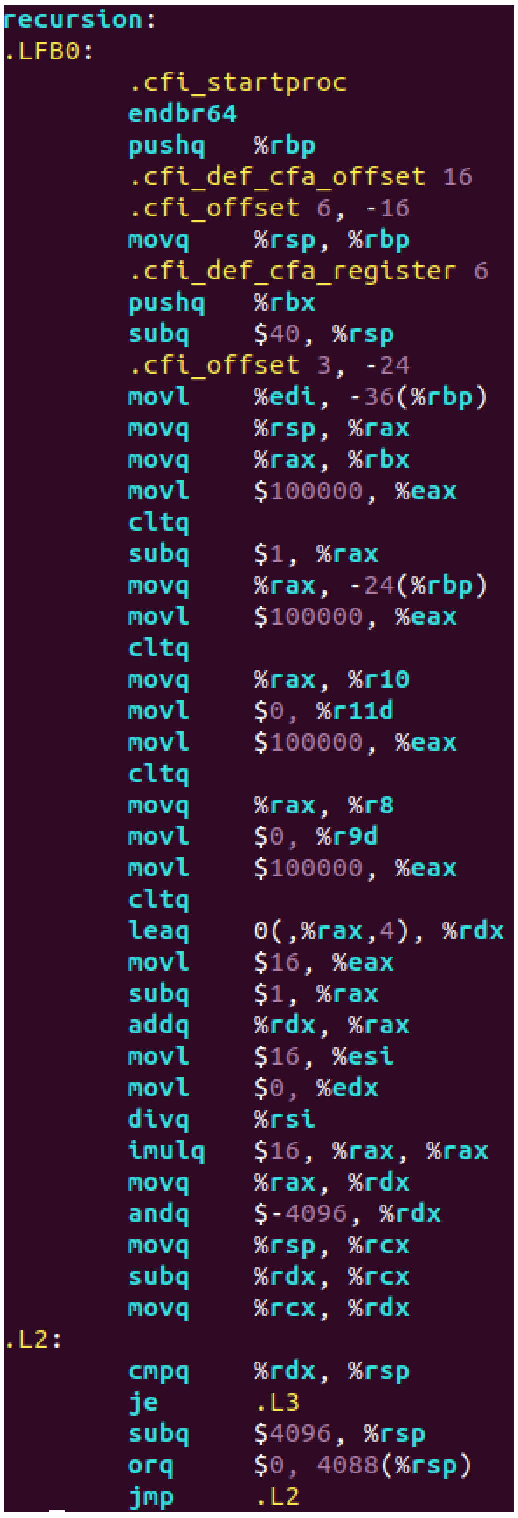
```
main:
.LFB1:
        .cfi_startproc
        endbr32
        leal    4(%esp), %ecx
        .cfi_def_cfa 1, 0
        andl    $-16, %esp
        pushl   -4(%ecx)
        pushl   %ebp
        movl    %esp, %ebp
        .cfi_escape 0x10,0x5,0x2,0x75,0
        pushl   %ebx
        pushl   %ecx
        .cfi_escape 0xf,0x3,0x75,0x78,0x6
        .cfi_escape 0x10,0x3,0x2,0x75,0x7c
        leal    -3997696(%esp), %eax
.LPSRL1:
        subl    $4096, %esp
        orl     $0, (%esp)
        cmpl    %eax, %esp
        jne     .LPSRL1
        subl    $2320, %esp
        call    __x86.get_pc_thunk.bx
        addl    $_GLOBAL_OFFSET_TABLE_, %ebx
        pushl   $348
        call    _Z4funci
```

```
_Z4funci:
.LFB0:
        .cfi_startproc
        endbr64
        pushq   %rbp
        .cfi_def_cfa_offset 16
        .cfi_offset 6, -16
        movq    %rsp, %rbp
        .cfi_def_cfa_register 6
        leaq    -3997696(%rsp), %r11
.LPSRL0:
        subq    $4096, %rsp
        orq     $0, (%rsp)
        cmpq    %r11, %rsp
        jne     .LPSRL0
        subq    $2208, %rsp
        movl    %edi, -4000020(%rbp)
        movl    $0, -4(%rbp)
.L3:
        cmpl    $499999, -4(%rbp)
        jg      .L2
        movl    -4(%rbp), %eax
        leal    -1(%rax), %edx
        movl    -4(%rbp), %eax
        cltq
        movl    %edx, -4000016(%rbp,%rax,4)
        movl    -4(%rbp), %eax
        cltq
        leaq    500000(%rax), %rdx
        movl    -4(%rbp), %eax
        movl    %eax, -4000016(%rbp,%rdx,4)
        addl    $1, -4(%rbp)
        jmp     .L3
.L2:
        movl    -4000020(%rbp), %eax
        cltq
        movl    -4000016(%rbp,%rax,4), %eax
        leave
        .cfi_def_cfa 7, 8
        ret
```

```
main:
.LFB1:
        .cfi_startproc
        endbr64
        pushq   %rbp
        .cfi_def_cfa_offset 16
        .cfi_offset 6, -16
        movq    %rsp, %rbp
        .cfi_def_cfa_register 6
        leaq    -3997696(%rsp), %r11
.LPSRL1:
        subq    $4096, %rsp
        orq     $0, (%rsp)
        cmpq    %r11, %rsp
        jne     .LPSRL1
        subq    $2320, %rsp
        movl    $348, %edi
        call    _Z4funci
```

- just big numbers of allocated memory appear
- also it seems that %rsp cannot be reduced by a bigger number than 4096, thus there is a cycle .LPSRL1, which decrements %rsp only by 4096. After that %rsp is once again decremented for lacking bytes.

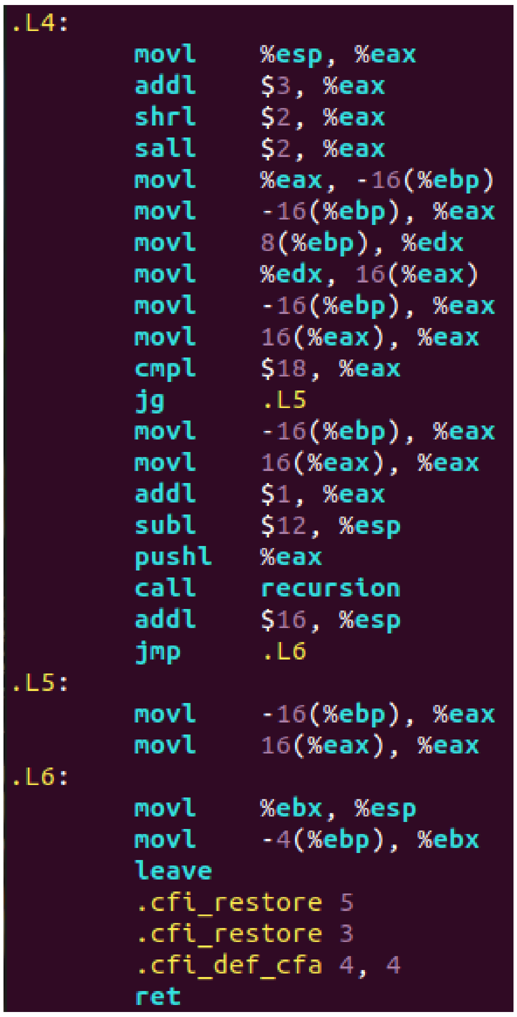
6. Recursion

C	32bit	64bit
		

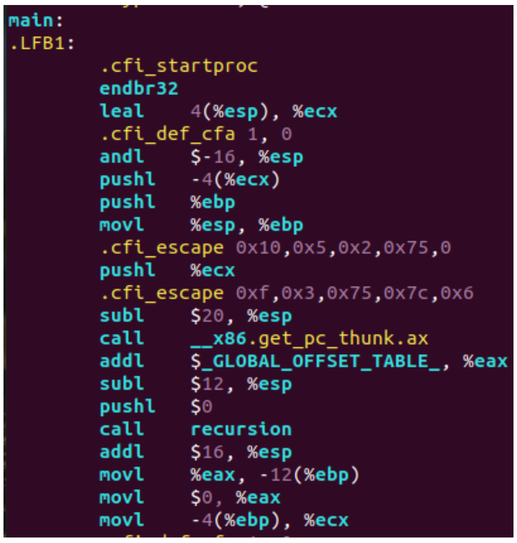
```c
const int n = 100000;

int recursion(int a)
{
        int arr[n];
        arr[4] = a;
        if(arr[4] < 19)
        {
                return recursion(arr[4] + 1);
        }
        else return arr[4];
}

int main()
{
        int c = recursion(0);
}
```

```
recursion:
.LFB0:
        .cfi_startproc
        endbr32
        pushl   %ebp
        .cfi_def_cfa_offset 8
        .cfi_offset 5, -8
        movl    %esp, %ebp
        .cfi_def_cfa_register 5
        pushl   %ebx
        subl    $20, %esp
        .cfi_offset 3, -12
        call    __x86.get_pc_thunk.ax
        addl    $_GLOBAL_OFFSET_TABLE_, %eax
        movl    %esp, %eax
        movl    %eax, %ebx
        movl    $100000, %eax
        subl    $1, %eax
        movl    %eax, -12(%ebp)
        movl    $100000, %eax
        leal    0(,%eax,4), %edx
        movl    $16, %eax
        subl    $1, %eax
        addl    %edx, %eax
        movl    $16, %ecx
        movl    $0, %edx
        divl    %ecx
        imull   $16, %eax, %eax
        movl    %eax, %edx
        andl    $-4096, %edx
        movl    %esp, %ecx
        subl    %edx, %ecx
        movl    %ecx, %edx
.L2:
        cmpl    %edx, %esp
        je      .L3
        subl    $4096, %esp
        orl     $0, 4092(%esp)
        jmp     .L2
.L3:
        movl    %eax, %edx
        andl    $4095, %edx
        subl    %edx, %esp
        movl    %eax, %edx
        andl    $4095, %edx
        testl   %edx, %edx
        je      .L4
        andl    $4095, %eax
        subl    $4, %eax
        addl    %esp, %eax
        orl     $0, (%eax)
```

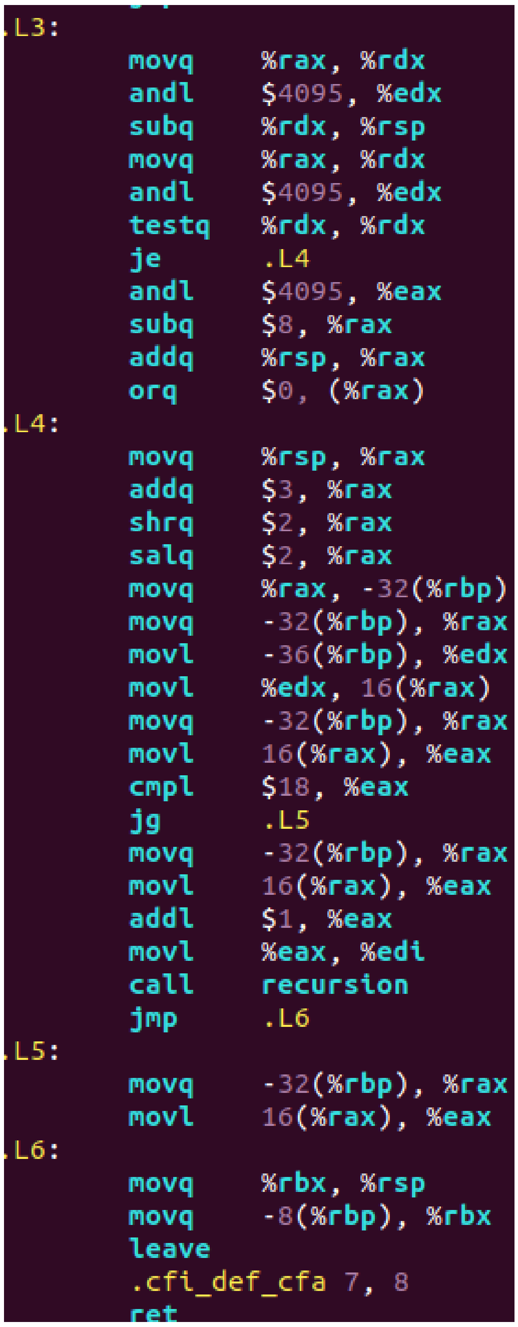
```
recursion:
.LFB0:
        .cfi_startproc
        endbr64
        pushq   %rbp
        .cfi_def_cfa_offset 16
        .cfi_offset 6, -16
        movq    %rsp, %rbp
        .cfi_def_cfa_register 6
        pushq   %rbx
        subq    $40, %rsp
        .cfi_offset 3, -24
        movl    %edi, -36(%rbp)
        movq    %rsp, %rax
        movq    %rax, %rbx
        movl    $100000, %eax
        cltq
        subq    $1, %rax
        movq    %rax, -24(%rbp)
        movl    $100000, %eax
        cltq
        movq    %rax, %r10
        movl    $0, %r11d
        movl    $100000, %eax
        cltq
        movq    %rax, %r8
        movl    $0, %r9d
        movl    $100000, %eax
        cltq
        leaq    0(,%rax,4), %rdx
        movl    $16, %eax
        subq    $1, %rax
        addq    %rdx, %rax
        movl    $16, %esi
        movl    $0, %edx
        divq    %rsi
        imulq   $16, %rax, %rax
        movq    %rax, %rdx
        andq    $-4096, %rdx
        movq    %rsp, %rcx
        subq    %rdx, %rcx
        movq    %rcx, %rdx
.L2:
        cmpq    %rdx, %rsp
        je      .L3
        subq    $4096, %rsp
        orq     $0, 4088(%rsp)
        jmp     .L2
```



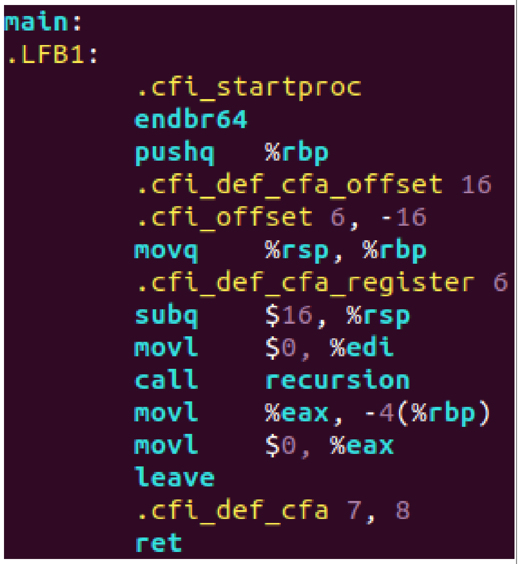
```
.L4:
        movl    %esp, %eax
        addl    $3, %eax
        shrl    $2, %eax
        sall    $2, %eax
        movl    %eax, -16(%ebp)
        movl    -16(%ebp), %eax
        movl    8(%ebp), %edx
        movl    %edx, 16(%eax)
        movl    -16(%ebp), %eax
        movl    16(%eax), %eax
        cmpl    $18, %eax
        jg      .L5
        movl    -16(%ebp), %eax
        movl    16(%eax), %eax
        addl    $1, %eax
        subl    $12, %esp
        pushl   %eax
        call    recursion
        addl    $16, %esp
        jmp     .L6
.L5:
        movl    -16(%ebp), %eax
        movl    16(%eax), %eax
.L6:
        movl    %ebx, %esp
        movl    -4(%ebp), %ebx
        leave
        .cfi_restore 5
        .cfi_restore 3
        .cfi_def_cfa 4, 4
        ret
```



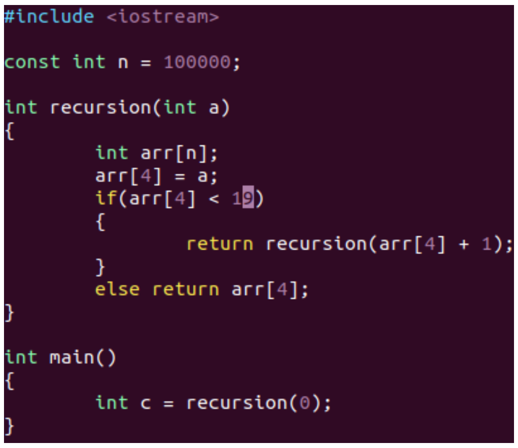
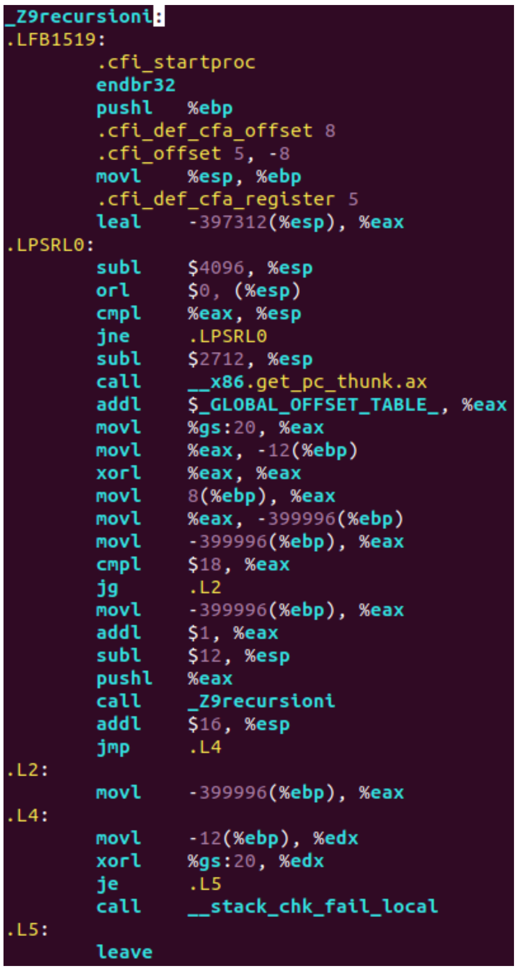
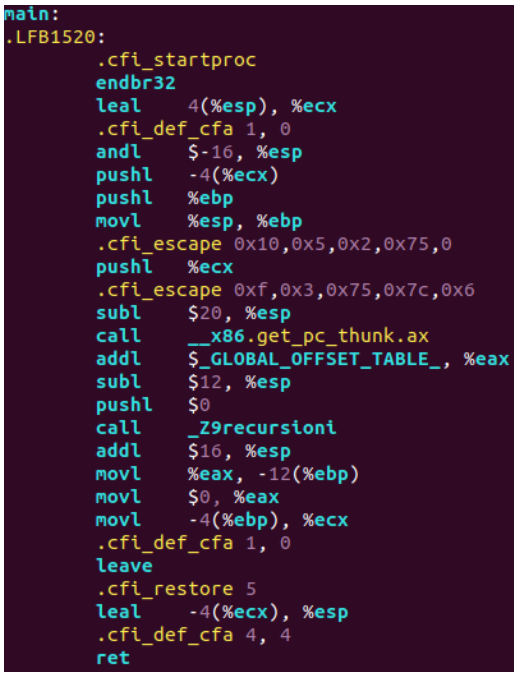
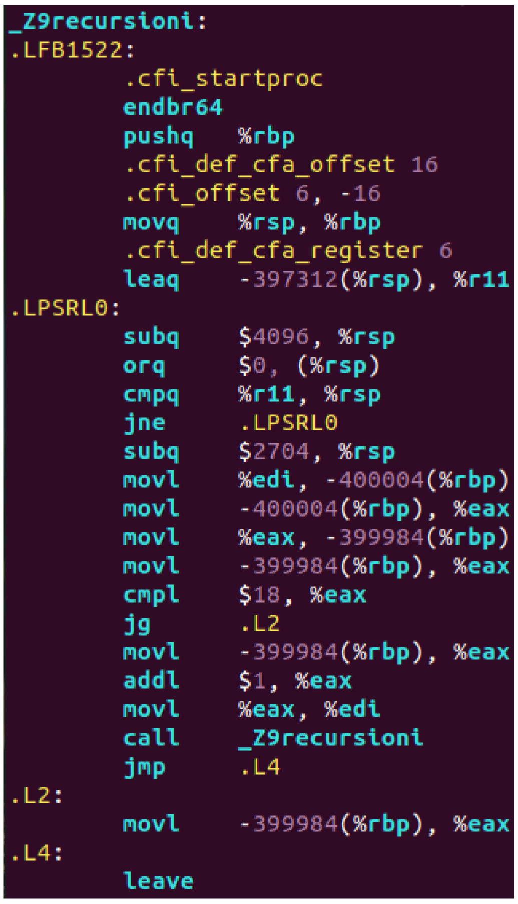
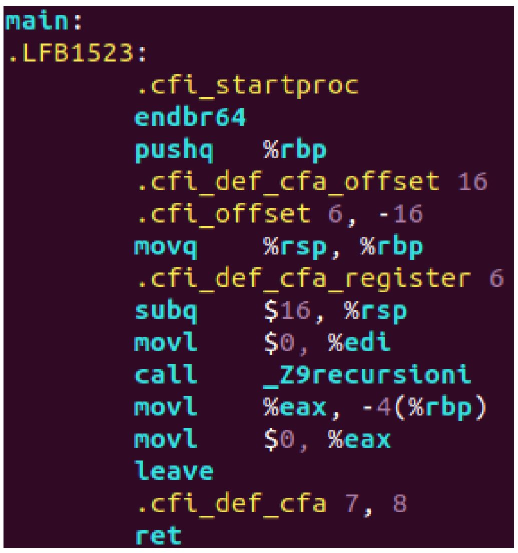
```
main:
.LFB1:
        .cfi_startproc
        endbr32
        leal    4(%esp), %ecx
        .cfi_def_cfa 1, 0
        andl    $-16, %esp
        pushl   -4(%ecx)
        pushl   %ebp
        movl    %esp, %ebp
        .cfi_escape 0x10,0x5,0x2,0x75,0
        pushl   %ecx
        .cfi_escape 0xf,0x3,0x75,0x7c,0x6
        subl    $20, %esp
        call    __x86.get_pc_thunk.ax
        addl    $_GLOBAL_OFFSET_TABLE_, %eax
        subl    $12, %esp
        pushl   $0
        call    recursion
        addl    $16, %esp
        movl    %eax, -12(%ebp)
        movl    $0, %eax
        movl    -4(%ebp), %ecx
```



```
.L3:
        movq    %rax, %rdx
        andl    $4095, %edx
        subq    %rdx, %rsp
        movq    %rax, %rdx
        andl    $4095, %edx
        testq   %rdx, %rdx
        je      .L4
        andl    $4095, %eax
        subq    $8, %rax
        addq    %rsp, %rax
        orq     $0, (%rax)
.L4:
        movq    %rsp, %rax
        addq    $3, %rax
        shrq    $2, %rax
        salq    $2, %rax
        movq    %rax, -32(%rbp)
        movq    -32(%rbp), %rax
        movl    -36(%rbp), %edx
        movl    %edx, 16(%rax)
        movq    -32(%rbp), %rax
        movl    16(%rax), %eax
        cmpl    $18, %eax
        jg      .L5
        movq    -32(%rbp), %rax
        movl    16(%rax), %eax
        addl    $1, %eax
        movl    %eax, %edi
        call    recursion
        jmp     .L6
.L5:
        movq    -32(%rbp), %rax
        movl    16(%rax), %eax
.L6:
        movq    %rbx, %rsp
        movq    -8(%rbp), %rbx
        leave
        .cfi_def_cfa 7, 8
        ret
```



```
main:
.LFB1:
        .cfi_startproc
        endbr64
        pushq   %rbp
        .cfi_def_cfa_offset 16
        .cfi_offset 6, -16
        movq    %rsp, %rbp
        .cfi_def_cfa_register 6
        subq    $16, %rsp
        movl    $0, %edi
        call    recursion
        movl    %eax, -4(%rbp)
        movl    $0, %eax
        leave
        .cfi_def_cfa 7, 8
        ret
```

C++	32bit	64bit
	 	 

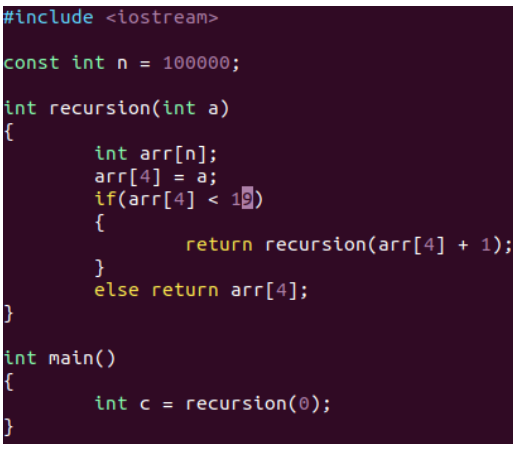
```cpp
#include <iostream>

const int n = 100000;

int recursion(int a)
{
	int arr[n];
	arr[4] = a;
	if(arr[4] < 19)
	{
		return recursion(arr[4] + 1);
	}
	else return arr[4];
}

int main()
{
	int c = recursion(0);
}
```

```
_Z9recursioni:
.LFB1519:
	.cfi_startproc
	endbr32
	pushl	%ebp
	.cfi_def_cfa_offset 8
	.cfi_offset 5, -8
	movl	%esp, %ebp
	.cfi_def_cfa_register 5
	leal	-397312(%esp), %eax
.LPSRL0:
	subl	$4096, %esp
	orl	$0, (%esp)
	cmpl	%eax, %esp
	jne	.LPSRL0
	subl	$2712, %esp
	call	__x86.get_pc_thunk.ax
	addl	$_GLOBAL_OFFSET_TABLE_, %eax
	movl	%gs:20, %eax
	movl	%eax, -12(%ebp)
	xorl	%eax, %eax
	movl	8(%ebp), %eax
	movl	%eax, -399996(%ebp)
	movl	-399996(%ebp), %eax
	cmpl	$18, %eax
	jg	.L2
	movl	-399996(%ebp), %eax
	addl	$1, %eax
	subl	$12, %esp
	pushl	%eax
	call	_Z9recursioni
	addl	$16, %esp
	jmp	.L4
.L2:
	movl	-399996(%ebp), %eax
.L4:
	movl	-12(%ebp), %edx
	xorl	%gs:20, %edx
	je	.L5
	call	__stack_chk_fail_local
.L5:
	leave
```

```
main:
.LFB1520:
	.cfi_startproc
	endbr32
	leal	4(%esp), %ecx
	.cfi_def_cfa 1, 0
	andl	$-16, %esp
	pushl	-4(%ecx)
	pushl	%ebp
	movl	%esp, %ebp
	.cfi_escape 0x10,0x5,0x2,0x75,0
	pushl	%ecx
	.cfi_escape 0xf,0x3,0x75,0x7c,0x6
	subl	$20, %esp
	call	__x86.get_pc_thunk.ax
	addl	$_GLOBAL_OFFSET_TABLE_, %eax
	subl	$12, %esp
	pushl	$0
	call	_Z9recursioni
	addl	$16, %esp
	movl	%eax, -12(%ebp)
	movl	$0, %eax
	movl	-4(%ebp), %ecx
	.cfi_def_cfa 1, 0
	leave
	.cfi_restore 5
	leal	-4(%ecx), %esp
	.cfi_def_cfa 4, 4
	ret
```

```
_Z9recursioni:
.LFB1522:
	.cfi_startproc
	endbr64
	pushq	%rbp
	.cfi_def_cfa_offset 16
	.cfi_offset 6, -16
	movq	%rsp, %rbp
	.cfi_def_cfa_register 6
	leaq	-397312(%rsp), %r11
.LPSRL0:
	subq	$4096, %rsp
	orq	$0, (%rsp)
	cmpq	%r11, %rsp
	jne	.LPSRL0
	subq	$2704, %rsp
	movl	%edi, -400004(%rbp)
	movl	-400004(%rbp), %eax
	movl	%eax, -399984(%rbp)
	movl	-399984(%rbp), %eax
	cmpl	$18, %eax
	jg	.L2
	movl	-399984(%rbp), %eax
	addl	$1, %eax
	movl	%eax, %edi
	call	_Z9recursioni
	jmp	.L4
.L2:
	movl	-399984(%rbp), %eax
.L4:
	leave
```

```
main:
.LFB1523:
	.cfi_startproc
	endbr64
	pushq	%rbp
	.cfi_def_cfa_offset 16
	.cfi_offset 6, -16
	movq	%rsp, %rbp
	.cfi_def_cfa_register 6
	subq	$16, %rsp
	movl	$0, %edi
	call	_Z9recursioni
	movl	%eax, -4(%rbp)
	movl	$0, %eax
	leave
	.cfi_def_cfa 7, 8
	ret
```

- Differences between 32bit and 64bit are not that significant, just the amount of memory allocated for arrays(differs by approximately 0-20 bytes)
- 

```
#include <iostream>

const int n = 100000;

int recursion(int a)
{
        int arr[n];
        arr[4] = a;
        if(arr[4] < 19)
        {
                return recursion(arr[4] + 1);
        }
        else return arr[4];
}

int main()
{
        int c = recursion(0);
}
```

  program executes correctly, when arr[4] < 19, so for 20 recursion calls. If I write arr[4] < 20 – stack overflow occurs. So the estimated stack size is between 20*100000*4 bytes ≈ 7800KB and 8200KB. So assuming that stack size is a good looking number, it’s around 8MB.