Princeton University
COS 217: Introduction to Programming Systems
GDB Tutorial for Assembly Language Programs (Part 2)

Motivation

Suppose you are developing the assembly language **`BigInt_add()`** function. Further suppose that the function assembles and links cleanly, but executes incorrectly. How can you use **`gdb`** to debug the function?

The **`BigInt_add()`** function is somewhat difficult to debug because it uses the stack, structures, and arrays. This is an appropriate sequence...

Building for GDB

To prepare to use **`gdb`**, build your program with the **`-g`** option.

```
% gcc217 -g fib.c bigint.c bigintadd.s -o fib
```

Running GDB

Run **`gdb`** from within **`emacs`**.

```
% emacs
<Esc key> x gdb <Enter key> fib <Enter key>
```

Setting Breakpoints

Set breakpoints at appropriate places. Breakpoints at the beginning of the **`main()`** and **`BigInt_add()`** functions would be appropriate.

```
(gdb) break main
(gdb) break BigInt_add
```

Running Your Program

Run the program, specifying some command-line argument.

```
(gdb) run 500000
```

Continue past the breakpoint at the beginning of the **`main()`** function.

```
(gdb) continue
```

Execution is paused after the two-instruction prolog of the first call of the **`BigInt_add()`** function. Issue the **`continue`** command nine more times. At this point the **`BigInt_add()`** function is being called to add the numbers 55 and 34.

Examining Memory

Use the **`print`** command to determine the contents of the EBP register:

```
(gdb) print/a $ebp
0xff9f2158
```

Thus you know the address of the base of the current stack frame. (That address might be different each time you run the program.) Now use the **`x`** command repeatedly to examine the function's parameters as they exist in the stack and the heap.

Examine the function's stack frame, interpreting each value as an address:

```
(gdb) x/a 0xff9f2158                  (or:  x/a $ebp)
0xff9f2158:     0xff9f21a8
(gdb) x/a 0xff9f215c                  (or:  x/a $ebp+4)
0xff9f215c:     0x80486b9 <main+357>
(gdb) x/a 0xff9f2160                  (or:  x/a $ebp+8)
0xff9f2160:     0xf7fb0008
(gdb) x/a 0xff9f2164                  (or:  x/a $ebp+12)
```

```
0xff9f2164:     0xf7fd1008
(gdb) x/a 0xff9f2168                  (or:  x/a $ebp+16)
0xff9f2168:     0xf7f84008
```

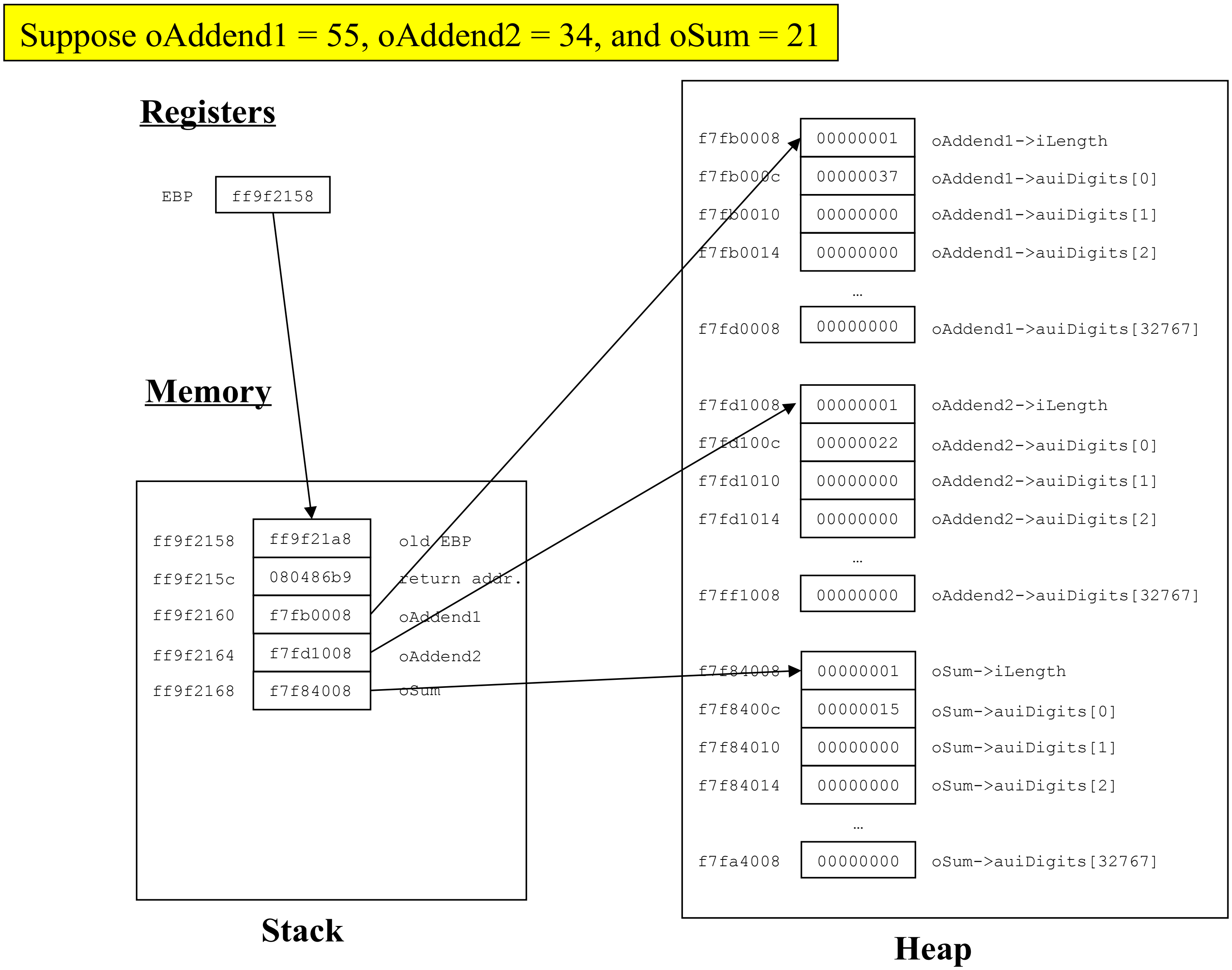
Examine the heap, interpreting each value as a decimal integer:

```
(gdb) x/d 0xf7fb0008
0xf7fb0008:     1
(gdb) x/d 0xf7fb000c
0xf7fb000c:     55      (That's 37 in hexadecimal)
(gdb) x/d 0xf7fb0010
0xf7fb0010:     0
(gdb) x/d 0xf7fb0014
0xf7fb0014:     0
(gdb) x/d 0xf7fb0018
0xf7fb0018:     0

(gdb) x/d 0xf7fd1008
0xf7fd1008:     1
(gdb) x/d 0xf7fd100c
0xf7fd100c:     34      (That's 22 in hexadecimal)
(gdb) x/d 0xf7fd1010
0xf7fd1010:     0
(gdb) x/d 0xf7fd1014
0xf7fd1014:     0
(gdb) x/d 0xf7ff1004
0xf7ff1004:     0

(gdb) x/d 0xf7f84008
0xf7f84008:     1
(gdb) x/d 0xf7f8400c
0xf7f8400c:     21      (That's 15 in hexadecimal)
(gdb) x/d 0xf7f84010
0xf7f84010:     0
(gdb) x/d 0xf7f84014
0xf7f84014:     0
(gdb) x/d 0xf7fa4004
0xf7fa4004:     0
```

As you traverse memory, draw a map of it as shown on the next page.


Suppose oAddend1 = 55, oAddend2 = 34, and oSum = 21
Registers
EBP
ff9f2158
Memory
ff9f2158
ff9f21a8
old EBP
ff9f215c
080486b9
return addr.
ff9f2160
f7fb0008
oAddend1
ff9f2164
f7fd1008
oAddend2
ff9f2168
f7f84008
oSum
Stack
f7fb0008
00000001
oAddend1->iLength
f7fb000c
00000037
oAddend1->auiDigits[0]
f7fb0010
00000000
oAddend1->auiDigits[1]
f7fb0014
00000000
oAddend1->auiDigits[2]
…
f7fd0008
00000000
oAddend1->auiDigits[32767]
f7fd1008
00000001
oAddend2->iLength
f7fd100c
00000022
oAddend2->auiDigits[0]
f7fd1010
00000000
oAddend2->auiDigits[1]
f7fd1014
00000000
oAddend2->auiDigits[2]
…
f7ff1008
00000000
oAddend2->auiDigits[32767]
f7f84008
00000001
oSum->iLength
f7f8400c
00000015
oSum->auiDigits[0]
f7f84010
00000000
oSum->auiDigits[1]
f7f84014
00000000
oSum->auiDigits[2]
…
f7fa4008
00000000
oSum->auiDigits[32767]
Heap

Using the Memory Map

Such a memory map can help with debugging. Moreover, such a memory map can help with composing assembly language code in the first place. Indeed if you did not have such a memory map, you probably would find it helpful/necessary to create one using pretend memory addresses before composing your assembly language code.

For example, suppose you must compose assembly language code to access **`oAddend2->auiDigits[2]`**. Using the memory map, it is easy to see that either of these instruction sequences would work:

Using indirect addressing:

```
movl %ebp, %eax   # EAX contains ff9f2158
addl $12,  %eax   # EAX contains ff9f2164, alias &oAddend2
movl (%eax), %eax # EAX contains f7fd1008, alias oAddend2
addl $4, %eax     # EAX contains f7fd100c, alias oAddend2->auiDigits
movl $2, %ecx     # ECX contains 2, alias the index
sall $2, %ecx     # ECX contains 8, alias a byte offset
addl %ecx, %eax   # EAX contains f7fd1014, alias oAddend2->auiDigits + 2
movl (%eax), %eax # EAX contains 00000000, alias *(oAddend2->auiDigits + 2), alias oAddend2->auiDigits[2]
```

Using base-pointer and indexed addressing:

```
movl 12(%ebp), %eax         # EAX contains f7fd1008, alias oAddend2
movl $2, %ecx               # ECX contains 2, alias the index
movl 4(%eax, %ecx, 4), %eax # EAX contains 00000000, alias oAddend2->auiDigits[2]
```