frida-boot 👢

a binary instrumentation workshop, using Frida, for beginners

2020

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```
let whoami = (w) => {
  w.name      = Leon Jacobs;
  w.hacks_at = {
    company: SensePost,
    part_of: Orange Cyberdefense
  };
  w.twitter  = @leonjza;
}
```

```
let disclaimer = (me) ⇒ {
  me.noob     = True;
  me.learning = True;
}
```

```
let objectives = () ⇒ {
  return [
    hands on frida 101,
    explore some internals,
    !mobile (but relevant),
    build tools & explore
  ];
}
```

```
let applies_to = (p) => {
  return [windows, macos, linux,
    android, ios].includes(p)
}
```

```
while(workshop) {
  follow_by_doing();
}
```

toc

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overview - chapter 0×1

0×1 hooking with LD_PRELOAD

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overview - chapter 0×3

0×3 frida tools, agents and modes

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```
   {
   {   }
    }_{ __{
 .-{   }   }-.
(   }     {   )
|`-.._____..-'|
|             ;--.
|            (__  \
|             | )  )
|             |/  /
|             /  /
|            (  /
\             y'
 `-.._____..-'
```

environment setup

- everything you need is pre-installed in the docker container
- you can pull the container from docker hub or build it yourself (i suggest you just pull)

```
git clone github.com/leonjza/frida-boot
```

a helper script to pull, run and get new shells in the container can be found in the frida-boot repository

```
./docker.sh pull
./docker.sh run
./docker.sh shell # container has tmux
```

code/ storage on your computer

running the container created a code/ directory. if the container dies, your code will be safe

shells in the container

- you may need multiple sessions
- tmux is installed in the container
- otherwise, run docker exec -it frida-boot /bin/bash in a new terminal (or use the shell script)

chapter 0×1

part 0×1

we'll start small. copy pew.c to your code/ folder.

```
~$ cp software/pew.c code/
~$ cd code/
~/code$ ls
pew.c
```

reduced pew.c source code

```c
int main() {

    while(1) {
        d = rand_range(1, 5);
        sleep(d);
    }
}
```

now, compile pew.c with gcc

```
~/code$ gcc pew.c -o pew
~/code$ ls
pew   pew.c
```

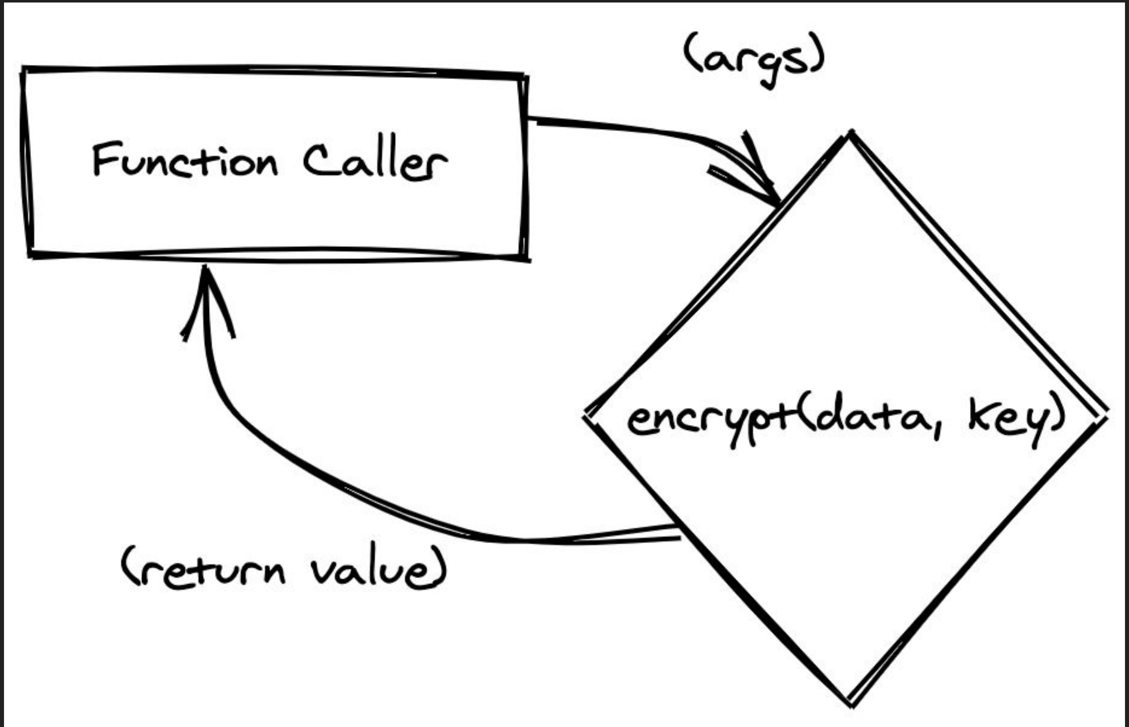
next, run pew

```
~/code$ ./pew
[+] Starting up!
[+] Sleeping for 5 seconds
[+] Sleeping for 3 seconds
^C
```

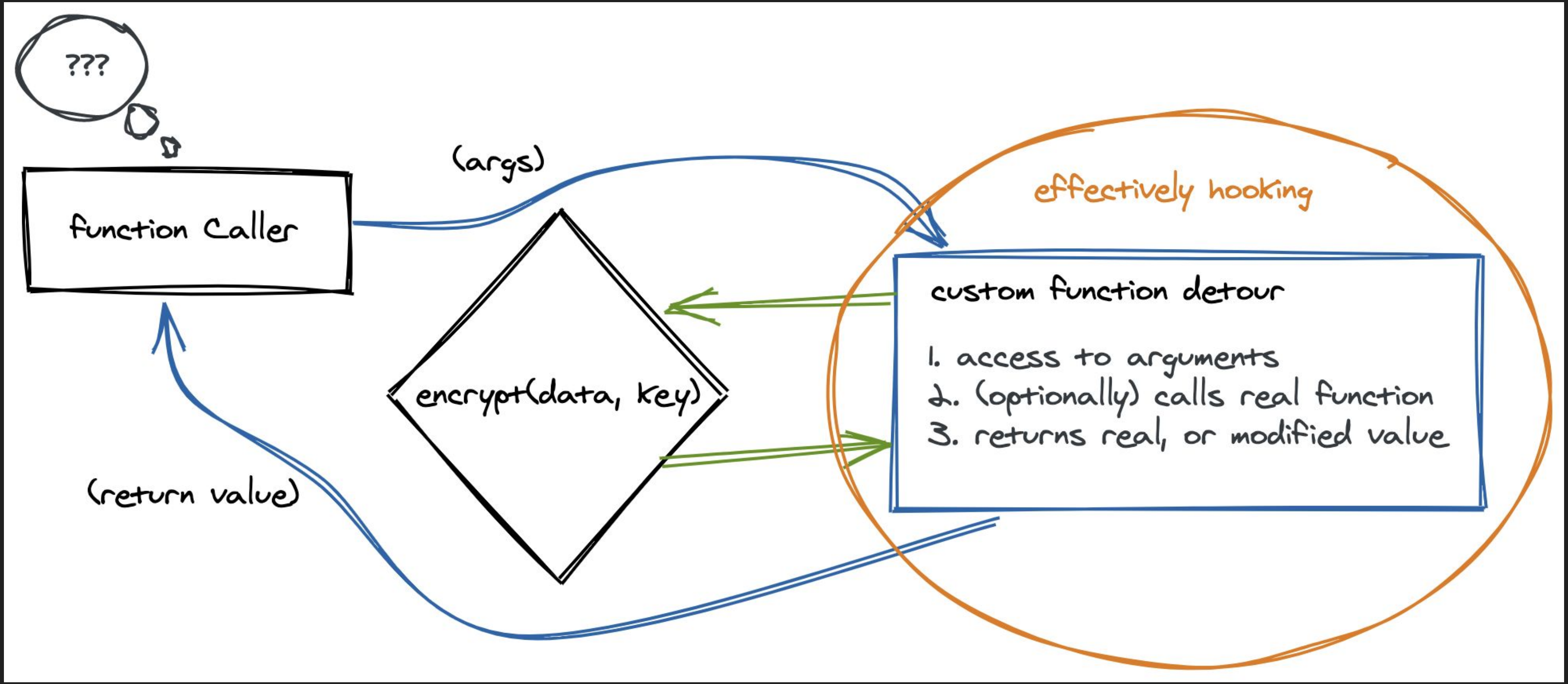
hooking in general

```
void encrypt(int *data, char *key);

char * getKey();
```


(args)
Function Caller
encrypt(data, key)
(return value)

a hooked function call



LD_PRELOAD (man 8 ld.so)

A list of additional, user-specified, ELF shared objects to be loaded before all others. This feature can be used to selectively override functions in other shared objects.

shared libraries in pew.

```
~/code$ ldd pew
    linux-vdso.so.1 (0x00007ffd5b1f5000)
    libc.so.6 => /lib/x86_64-linux-gnu/libc.so.6 (0x00007f8b4ae0e000)
    /lib64/ld-linux-x86-64.so.2 (0x00007f8b4afdc000)
```

shared libraries in a static bin.

```
~/code$ gcc -static pew.c -o pew-static
~/code$ ldd pew-static
   not a dynamic executable
```

our pew program makes use of some standard libc functions.

- sleep()
- printf()

SLEEP(3) Linux Programmer's Manual SLEEP(3)

NAME

sleep - sleep for a specified number of seconds

SYNOPSIS

```c
#include <unistd.h>

unsigned int sleep(unsigned int seconds);
```

DESCRIPTION

sleep() causes the calling thread to sleep either until the number of real-time seconds specified in seconds have elapsed or until a signal arrives which is not ignored.

real source code for libc sleep()

... more than 100 LoC ...

https://github.com/sgallagher/glibc/blob/master/sysdeps/unix/sysv/linux/sleep.c our own implementation for sleep() saved to fake_sleep.c

```c
#include <stdio.h>

unsigned int sleep(unsigned int seconds) {

    printf("[-] sleep goes brrr\n");
    return 0;
}
```

get the first step for fake_sleep.c into your code folder

```
~/code$ cp ../software/fake_sleep.c.1 fake_sleep.c
~/code$ ls
fake_sleep.c  pew  pew.c
```

compile the fake_sleep shared library

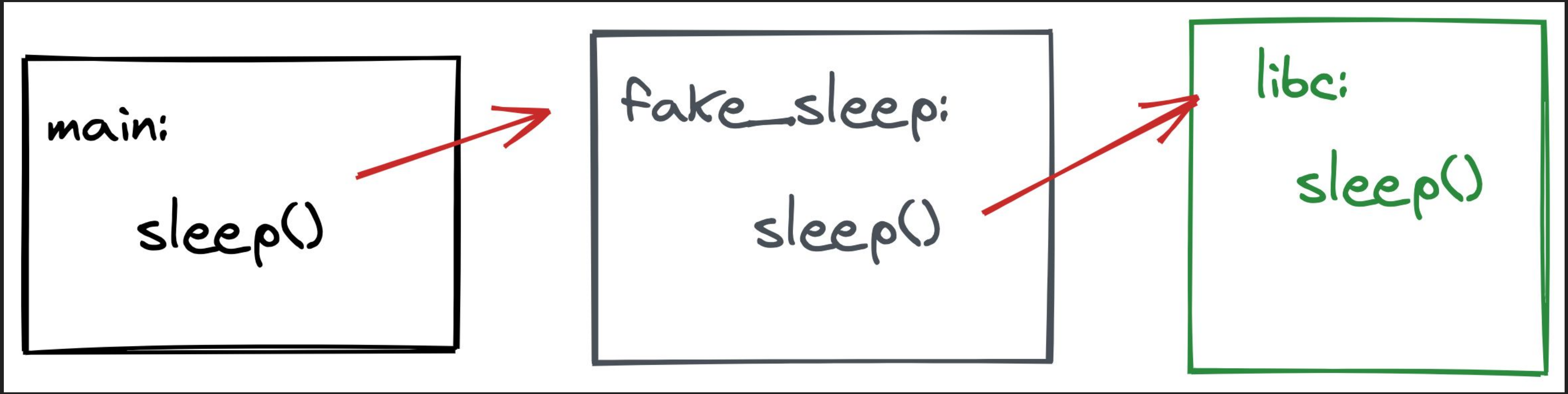
```
~/code$ gcc -fPIC -shared fake_sleep.c
-o fake_sleep.so
~/code$ ls
fake_sleep.c  fake_sleep.so  pew  pew.c
```

run pew loading our new shared library

it's going to fly past, we not sleeping anymore...

```
~/code$ LD_PRELOAD=./fake_sleep.so ./pew
[+] Starting up!
[+] Sleeping for 1 seconds
[-] sleep goes brrr
[+] Sleeping for 5 seconds
[-] sleep goes brrr
^C
```

building a sleep() "proxy"



finding the real sleep()

```
DLSYM(3)    Linux Programmer's Manual   DLSYM(3)

NAME
       dlsym, dlvsym - obtain address of a symbol in a shared object or
executable

SYNOPSIS
       #include <dlfcn.h>

       void *dlsym(void *handle, const char *symbol);
```

get fake_sleep.c.2 into your code folder now

```
~/code$ cp ../software/fake_sleep.c.2 fake_sleep.c
~/code$ ls
fake_sleep.c  pew  pew.c
```

```c
unsigned int sleep(unsigned int seconds) {

    seconds = 1;

    unsigned int (*original_sleep)(unsigned int);
    original_sleep = dlsym(RTLD_NEXT, "sleep");

    return (original_sleep)(seconds);
}
```

let’s compile a new fake_sleep to link ld-linux for dlsym

```
~/code$ gcc -fPIC -shared fake_sleep.c -o fake_sleep.so -ldl
~/code$ ls
fake_sleep.c  fake_sleep.so  pew  pew.c
```

```
~/code$ LD_PRELOAD=./fake_sleep.so ./pew
[+] Starting up!
[+] Sleeping for 4 seconds
[-] sleep goes brrr
[+] Sleeping for 1 seconds
[-] sleep goes brrr
[+] Sleeping for 5 seconds
[-] sleep goes brrr
^C
```

recap - hooking with LD_PRELOAD

- shared libraries can override functions.
- overriding functions lets you spy on and alter arguments and return values
- the real, intended function can be called in the function “proxy”

chapter 0×1

part 0×2

enumerate pew with nm, luke

```
~/code$ nm -D pew
        U __libc_start_main
        U printf
        U puts
        U rand
        U sleep
        U srand
        U time
```

under the hood of LD_PRELOAD using gdb

```
q    - quit gdb
r    - run the program
b    - set a breakpoint
s    - step over an instruction
si   - step into an instruction
```

under the hood of LD_PRELOAD using gdb

```
info func    - show available functions
info break   - show available breakpoints
del <index> - delete a breakpoint
```

start debugging pew with gdb

```
~/code$ gdb -q ./pew
```

```
frida-boot:~/code$ gdb -q ./pew
GEF for linux ready, type `gef' to start, `gef config' to configure
75 commands loaded for GDB 9.1 using Python engine 3.8
[*] 5 commands could not be loaded, run `gef missing` to know why.
Reading symbols from ./pew...
(No debugging symbols found in ./pew)
gef➤
```

get known function information in gdb

```
gef➤  info func
All defined functions:

Non-debugging symbols:
 ...
0x0000000000001000  _init
0x0000000000001070  sleep@plt
0x0000000000001080  rand@plt
 ...
```

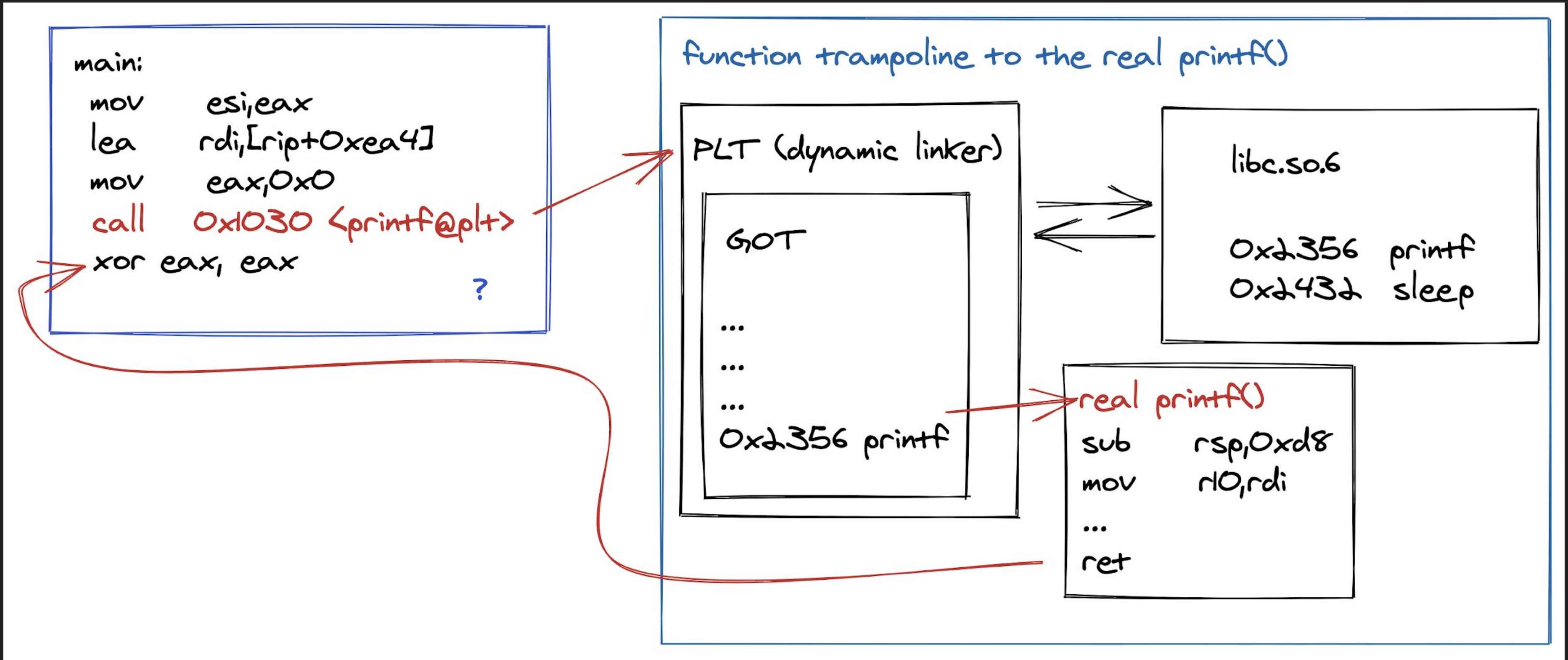
disassemble main, look for call's

```
gef➤  disas main
Dump of assembler code for function main:

 [ … ]

   0x00000000000011f5 <+72>:  call   0x1040 <printf@plt>
   0x00000000000011fa <+77>:  mov    eax,DWORD PTR [rbp-0x4]
   0x00000000000011fd <+80>:  mov    edi,eax
   0x00000000000011ff <+82>:  call   0x1070 <sleep@plt>
   0x0000000000001204 <+87>:  jmp    0x11d2 <main+37>
End of assembler dump.
```

the plt && got



main:
mov esi,eax
lea rdi,[rip+0xea4]
mov eax,0x0
call 0x1030 <printf@plt>
xor eax, eax
?
function trampoline to the real printf()
PLT (dynamic linker)
GOT
...
...
...
0x2356 printf
libc.so.6
0x2356 printf
0x2432 sleep
real printf()
sub rsp,0xd8
mov r10,rdi
...
ret

run pew in gdb, breaking on *main

```
gef➤  b *main
Breakpoint 1 at 0x11ad
gef➤  info br
Num     Type           Disp Enb Address
What
1       breakpoint     keep y   0x11ad <main>
gef➤  r
```

```
gef➤  r
Starting program: /root/code/pew
warning: Error disabling address space randomization: Operation not permitted

Breakpoint 1, 0x0000555e9e1a31ad in main ()
[ Legend: Modified register | Code | Heap | Stack | String ]
──────────────────────────────────────────────────────────────── registers ────
$rax   : 0x0000555e9e1a31ad  →  <main+0> push rbp
$rbx   : 0x0
$rcx   : 0x00007fafbc6d7718  →  0x00007fafbc6d9980  →  0x0000000000000000
$rdx   : 0x00007ffc857f9488  →  0x00007ffc857f9ecd  →  "LANGUAGE=en_US:en"
$rsp   : 0x00007ffc857f9398  →  0x00007fafbc541e0b  →  <__libc_start_main+235> mov edi, eax
$rbp   : 0x0000555e9e1a3210  →  <__libc_csu_init+0> push r15
$rsi   : 0x00007ffc857f9478  →  0x00007ffc857f9ebe  →  "/root/code/pew"
$rdi   : 0x1
$rip   : 0x0000555e9e1a31ad  →  <main+0> push rbp
$r8    : 0x0
$r9    : 0x00007fafbc6f3530  →   push rbp
$r10   : 0x0
$r11   : 0x0
$r12   : 0x0000555e9e1a30a0  →  <_start+0> xor ebp, ebp
$r13   : 0x00007ffc857f9470  →  0x0000000000000001
$r14   : 0x0
$r15   : 0x0
$eflags: [ZERO carry PARITY adjust sign trap INTERRUPT direction overflow resume virtualx86 identification]
$cs: 0x0033 $ss: 0x002b $ds: 0x0000 $es: 0x0000 $fs: 0x0000 $gs: 0x0000
──────────────────────────────────────────────────────────────────── stack ────
0x00007ffc857f9398│+0x0000: 0x00007fafbc541e0b  →  <__libc_start_main+235> mov edi, eax  ← $rsp
0x00007ffc857f93a0│+0x0008: 0x0000000000000000
0x00007ffc857f93a8│+0x0010: 0x00007ffc857f9478  →  0x00007ffc857f9ebe  →  "/root/code/pew"
0x00007ffc857f93b0│+0x0018: 0x0000000100040000
0x00007ffc857f93b8│+0x0020: 0x0000555e9e1a31ad  →  <main+0> push rbp
0x00007ffc857f93c0│+0x0028: 0x0000000000000000
0x00007ffc857f93c8│+0x0030: 0xd42f69660b9cf43a
0x00007ffc857f93d0│+0x0038: 0x0000555e9e1a30a0  →  <_start+0> xor ebp, ebp
```

we only care about the code and stack regions for now

```
──────────────────────────────────────────────────────────────── code:x86:64 ────
   0x555e9e1a31a9 <rand_range+36>  add    eax, edx
   0x555e9e1a31ab <rand_range+38>  leave
   0x555e9e1a31ac <rand_range+39>  ret
 → 0x555e9e1a31ad <main+0>         push   rbp
   0x555e9e1a31ae <main+1>         mov    rbp, rsp
   0x555e9e1a31b1 <main+4>         sub    rsp, 0x10
   0x555e9e1a31b5 <main+8>         lea    rdi, [rip+0xe48]        # 0x555e9e1a4004
   0x555e9e1a31bc <main+15>        call   0x555e9e1a3030 <puts@plt>
   0x555e9e1a31c1 <main+20>        mov    edi, 0x0
──────────────────────────────────────────────────────────────────── threads ────
[#0] Id 1, Name: "pew", stopped 0x555e9e1a31ad in main (), reason: BREAKPOINT
────────────────────────────────────────────────────────────────────── trace ────
[#0] 0x555e9e1a31ad → main()
─────────────────────────────────────────────────────────────────────────────────
gef➤
```

get your hands dirty debugging pew

- step an instruction with si. you should see the code section move on by one line.
- hit enter after issuing the si command. gdb will rerun the previous command when pressing enter.
- retrieve the context view again with the context command.

step instructions with si until after the call to puts@plt (entering it)

```
# code region
...

> 0x8c030 <puts@plt+0>     jmp    QWORD PTR [rip+0x2fe2]  # 0x8f018 <puts@got.plt>
  0x8c036 <puts@plt+6>     push   0x0
  0x8c03b <puts@plt+11>    jmp    0x55702578c020
  0x8c040 <printf@plt+0>   jmp    QWORD PTR [rip+0x2fda]  # 0x8f020 <printf@got.plt>
  0x8c046 <printf@plt+6>   push   0x1
  0x8c04b <printf@plt+11>  jmp    0x55702578c020

...

# trace region

[#0] 0x55702578c030 → puts@plt()
[#1] 0x55702578c1c1 → main()
```

just step to the next instruction with s
for now, taking note of the trace region

```
# code region
…

> 0x2d030 <puts+0>          push   r14
  0x2d032 <puts+2>          push   r13
  0x2d034 <puts+4>          push   r12
  0x2d036 <puts+6>          mov    r12, rdi
  0x2d039 <puts+9>          push   rbp
  0x2d03a <puts+10>         push   rbx

…

# trace region

[#0] 0x7f2298a2d030 → puts()
[#1] 0x55702578c1c1 → main()
```

notice how it's no longer puts@plt in the trace region the dynamic linker resolved the real location to puts in libc.

these locations are recorded in the global offset table.

the next call to puts will jmp to the location in the got and not invoke the linker.

```
gef➤  got

GOT protection: Partial RelRO | GOT functions: 6

[0x55702578f018] puts@GLIBC_2.2.5  →  0x7f2298a2d030
[0x55702578f020] printf@GLIBC_2.2.5  →  0x55702578c046
[0x55702578f028] srand@GLIBC_2.2.5  →  0x55702578c056
[0x55702578f030] time@GLIBC_2.2.5  →  0x55702578c066
[0x55702578f038] sleep@GLIBC_2.2.5  →  0x55702578c076
[0x55702578f040] rand@GLIBC_2.2.5  →  0x55702578c086
```

using the got as reference, we can ask gdb to tell us where a symbol is located

```
gef➤  info symbol 0x7f2298a2d030
puts in section .text of /lib/x86_64-linux-gnu/libc.so.6

gef➤  info symbol 0x55702578c046
printf@plt + 6 in section .plt of /root/code/pew
```

follow the lookup for `printf` a bit closer.

- disassemble the main function with `disas main`.
- find the address where the first call to `printf@plt` occurs.
- set a breakpoint on the address where this happens with `b *addr`.

continue execution with c until the new breakpoint is hit

```
...

  0x8c1f0 <main+67>         mov    eax, 0x0
> 0x8c1f5 <main+72>         call   0x8c040 <printf@plt>
  >  0x8c040 <printf@plt+0>    jmp    QWORD PTR [rip+0x2fda] # 0x8f020 <printf@got.plt>
     0x8c046 <printf@plt+6>    push   0x1
     0x8c04b <printf@plt+11>   jmp    0x8c020
     0x8c050 <srand@plt+0>     jmp    QWORD PTR [rip+0x2fd2] # 0x8f028 <srand@got.plt>
     0x8c056 <srand@plt+6>     push   0x2
     0x8c05b <srand@plt+11>    jmp    0x8c020

...
```

now, just si a few times and watch the call trace grow

```
# trace section
[#0] 0x7efe8320fde1 → cmp eax, 0x30
[#1] 0x7efe831fe665 → test eax, eax
[#2] 0x7efe831feb3b → add rsp, 0x30
[#3] 0x7efe831ff3f1 → add rsp, 0x30
[#4] 0x7efe83203af3 → mov r8, rax
[#5] 0x7efe8320a44a → mov r11, rax
[#6] 0x55a63774e1fa → main()
```

generate a backtrace with bt to get an idea of where those stack frames are from.

```
gef➤  bt
#0  0x00007efe8320fde1 in ?? () from /lib64/ld-linux-x86-64.so.2
#1  0x00007efe831fe665 in ?? () from /lib64/ld-linux-x86-64.so.2
#2  0x00007efe831feb3b in ?? () from /lib64/ld-linux-x86-64.so.2
#3  0x00007efe831ff3f1 in ?? () from /lib64/ld-linux-x86-64.so.2
#4  0x00007efe83203af3 in ?? () from /lib64/ld-linux-x86-64.so.2
#5  0x00007efe8320a44a in ?? () from /lib64/ld-linux-x86-64.so.2
#6  0x000055a63774e1fa in main ()
```

knowing a bit about the dynamic linker should help in understanding how LD_PRELOAD behaves.

debugging pew with LD_PRELOAD set:

- start a fresh gdb session with gdb -q ./pew
- set a breakpoint on the main function with b *main
- set the LD_PRELOAD variable with set environment LD_PRELOAD ./fake_sleep.so
- run with r

confirm fake_sleep.so was loaded using vmmap

```
gef➤  vmmap
[ Legend:  Code | Heap | Stack ]
Start              End                Offset             Perm Path

 ...

0x00007f121ec42000 0x00007f121ec43000 0x0000000000000000 r-- /root/code/fake_sleep.so
0x00007f121ec43000 0x00007f121ec44000 0x0000000000001000 r-x /root/code/fake_sleep.so
0x00007f121ec44000 0x00007f121ec45000 0x0000000000002000 r-- /root/code/fake_sleep.so
0x00007f121ec45000 0x00007f121ec46000 0x0000000000002000 r-- /root/code/fake_sleep.so
0x00007f121ec46000 0x00007f121ec47000 0x0000000000003000 rw- /root/code/fake_sleep.so

 ...
```

break after the call to sleep so we can inspect the got

- disassemble the main function with `disas main`
- break on the instruction after the call to `sleep@plt` (should be a `jmp` call because of our infinite loop)
- continue the programs execution with `c`

check where the symbol for sleep() now points according to the got

```
gef➤  got

GOT protection: Partial RelRO | GOT functions: 6

[0x55d5c325d018] puts@GLIBC_2.2.5  →  0x7f121eaf1030
[0x55d5c325d020] printf@GLIBC_2.2.5  →  0x7f121ead1470
[0x55d5c325d028] srand@GLIBC_2.2.5  →  0x7f121eab9a10
[0x55d5c325d030] time@GLIBC_2.2.5  →  0x7ffded6dfee0
[0x55d5c325d038] sleep@GLIBC_2.2.5  →  0x7f121ec43115
[0x55d5c325d040] rand@GLIBC_2.2.5  →  0x7f121eaba110

gef➤  info symbol 0x7f121ec43115
sleep in section .text of ./fake_sleep.so
```

what about the call to the *real* sleep()

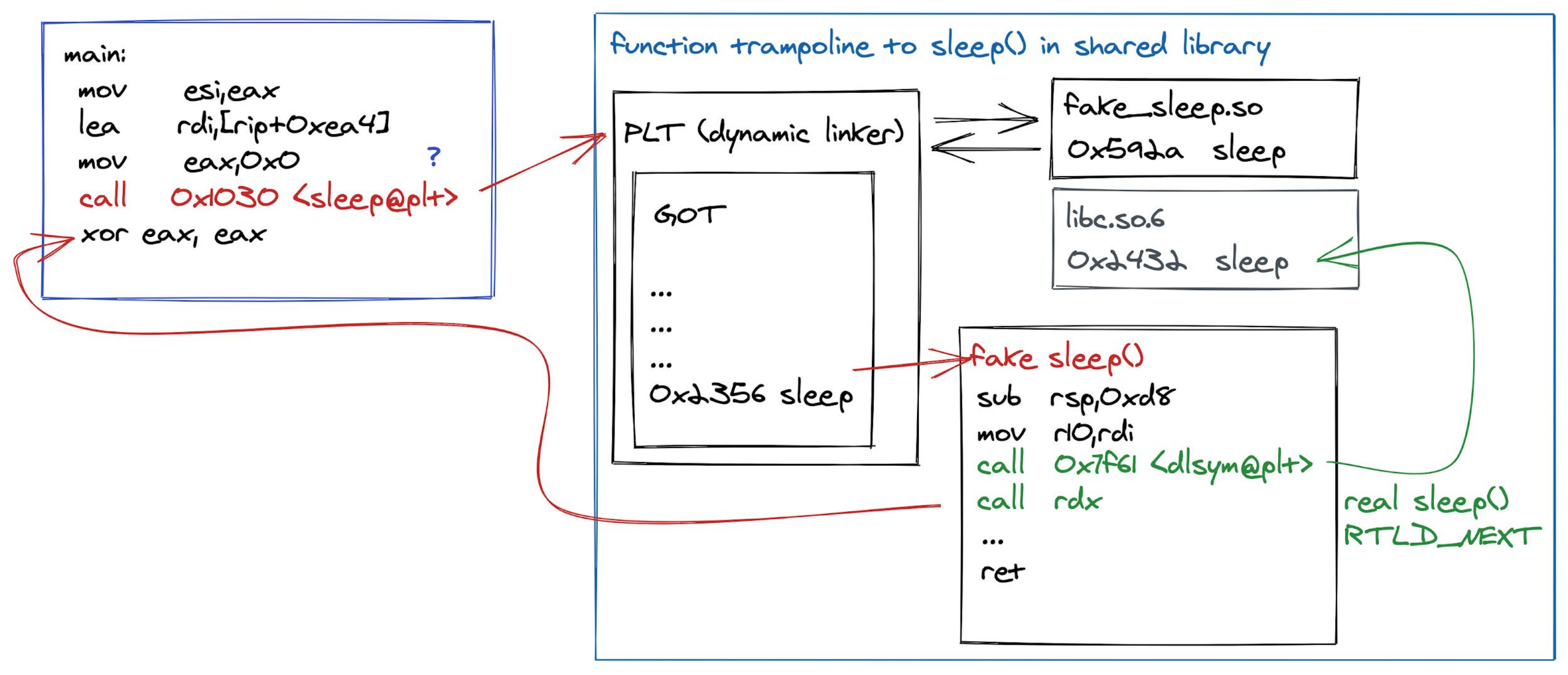
```
gef➤  disas sleep
Dump of assembler code for function sleep:
   0×43115 <+0>:   push   rbp
   0×43116 <+1>:   mov    rbp,rsp
   0×43119 <+4>:   sub    rsp,0×20
   0×4311d <+8>:   mov    DWORD PTR [rbp-0×14],edi
   0×43120 <+11>:  lea    rdi,[rip+0×ed9]
   0×43127 <+18>:  call   0×7f121ec43030 <puts@plt>
   0×4312c <+23>:  mov    DWORD PTR [rbp-0×14],0×1
   0×43133 <+30>:  lea    rsi,[rip+0×eda]
   0×4313a <+37>:  mov    rdi,0×ffffffffffffffff
   0×43141 <+44>:  call   0×7f121ec43040 <dlsym@plt>
   0×43146 <+49>:  mov    QWORD PTR [rbp-0×8],rax
   0×4314a <+53>:  mov    eax,DWORD PTR [rbp-0×14]
   0×4314d <+56>:  mov    rdx,QWORD PTR [rbp-0×8]
   0×43151 <+60>:  mov    edi,eax
   0×43153 <+62>:  call   rdx
   0×43155 <+64>:  leave
   0×43156 <+65>:  ret
End of assembler dump.
```

break on the instruction that calls the RDX register

continue execution until the breakpoint is hit

inspect the address that is in RDX

LD_PRELOAD-ed sleep()



recap - LD_PRELOAD under the hood

- the dynamic linker resolves function locations at runtime, storing results in the got.
- libraries specified with LD_PRELOAD get preference.
- debuggers are not as scary as they seem to be :)

chapter 0×2

part 0×1

FRIDA

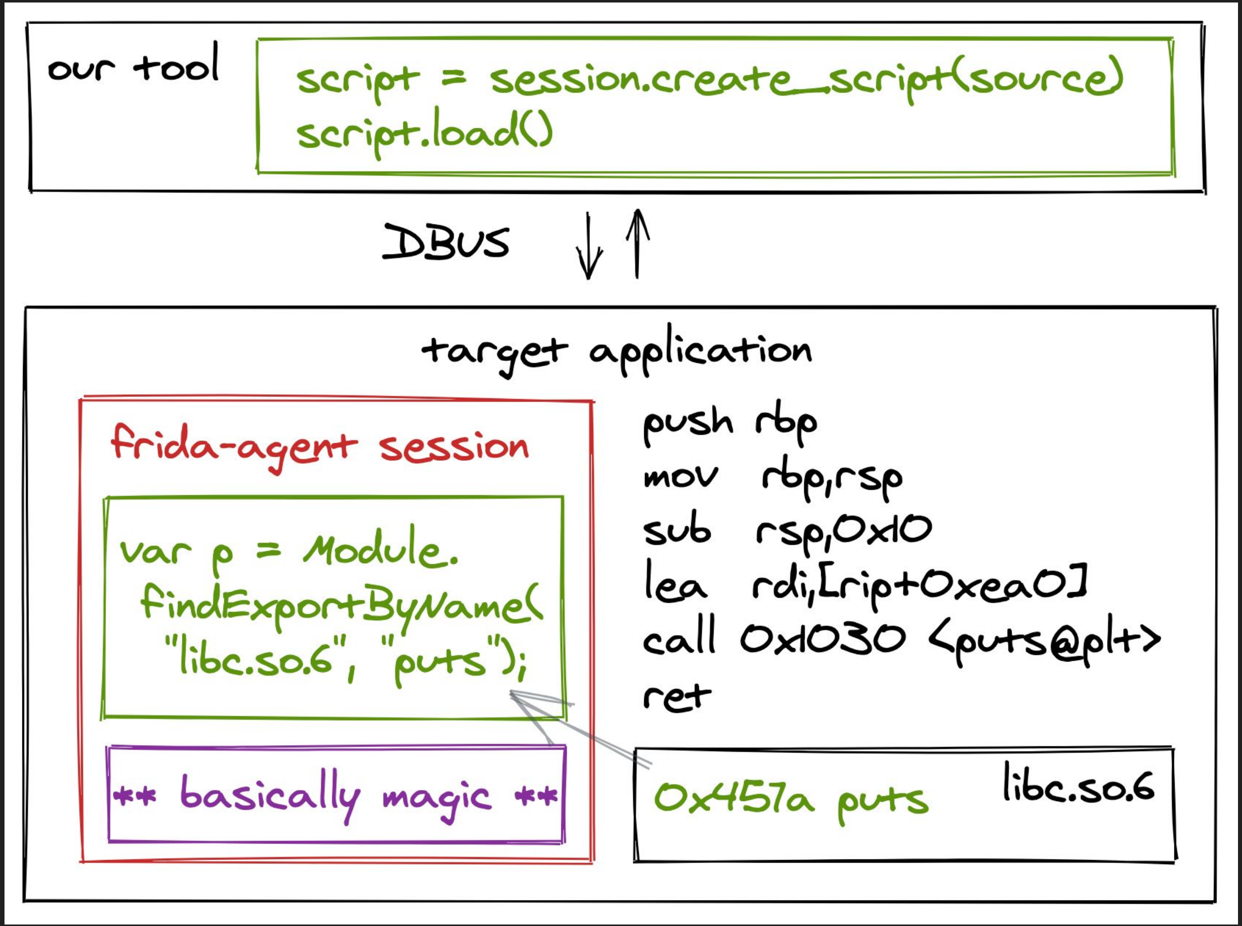
multiple modes of operation

- injected
  - on the same computer using bindings
  - remote device via frida-server

- embedded
  - running local or remote
  - completely autonomous

components

- core (injector and all of the glue)
- language bindings (C, Python, Node, .NET, etc.)
- runtime bridges for ObjC & Java (focussed on mobile platforms)
- cli tools; frida, frida-ps, frida-trace, etc.


our tool
script = session.create_script(source)
script.load()
DBUS
target application
frida-agent session
var p = Module.
findExportByName(
"libc.so.6", "puts");
** basically magic **
push rbp
mov rbp,rsp
sub rsp,0x10
lea rdi,[rip+0xea0]
call 0x1030 <puts@plt>
ret
0x457a puts
libc.so.6

the difference between spawning and attaching to a target process

- spawning with Frida will launch and pause the target application, great for early instrumentation.
- attaching will inject Frida to a running process (using *PTRACE*), launching a new thread to use for instrumentation.

spawning an application with frida

```
~/code$ frida ./pew
     ____
    / _  |   Frida 12.9.2 - A world-class dynamic instrumentation toolkit
   | (_| |
    > _  |   Commands:
   /_/ |_|       help      -> Displays the help system
   . . . .       object?   -> Display information about 'object'
   . . . .       exit/quit -> Exit
   . . . .
   . . . .   More info at https://www.frida.re/docs/home/
Spawned `./pew`. Use %resume to let the main thread start executing!
[Local::pew]->
```

attaching to an application with frida

```
~/code$ frida pew
     ____
    / _  |   Frida 12.9.2 - A world-class dynamic instrumentation toolkit
   | (_| |
    > _  |   Commands:
   /_/ |_|       help      -> Displays the help system
   . . . .       object?   -> Display information about 'object'
   . . . .       exit/quit -> Exit
   . . . .
   . . . .   More info at https://www.frida.re/docs/home/

[Local::pew]->
```

examples of launching the Frida REPL

```
- frida ./pew          # spawn's the app
- frida pew            # attaches to the app
- frida -p 23
- frida -p $(pidof pew)
```

instrumentation logic is written in JavaScript.

frida exposes its own API on top of the JavaScript standard library.

https://www.frida.re/docs/javascript-api/

the frida REPL

```
frida-boot:~/code$ frida pew
     ____
    / _  |   Frida 12.9.2 - A world-class dynamic instrumentation toolkit
   | (_| |
    > _  |   Commands:
   /_/ |_|       help      -> Displays the help system
   . . . .       object?   -> Display information about 'object'
   . . . .       exit/quit -> Exit
   . . . .
   . . . .   More info at https://www.frida.re/docs/home/

[Local::pew]->
[Local::pew]-> Process.enumerate
                                _enumerateMallocRanges
                                _enumerateModules
                                _enumerateRanges
                                _enumerateThreads
                                enumerateMallocRanges
                                enumerateMallocRangesSync
                                enumerateModules
```

external scripts with auto reload

```
~/code$ cat index.js
console.log(Frida.version);

~/code$ frida pew -l index.js
12.9.3
```

use the REPL for quick prototyping

use a script for long term development

chapter 0×2

part 0×2

```
Interceptor.attach(target, callbacks);
```

figuring out the target to attach to

offsets || symbols

resolving sleep() statically

```
~/code$ nm pew | grep sleep
     U sleep@@GLIBC_2.2.5
```

resolving sleep() statically

```
~/code$ ldd pew
	linux-vdso.so.1 (0x00007ffc9b5f4000)
	libc.so.6 => /lib/x86_64-linux-gnu/libc.so.6 (0x00007f552ca13000)
	/lib64/ld-linux-x86-64.so.2 (0x00007f552cbe1000)
```

resolving sleep() statically

```
nm -D /lib/x86_64-linux-gnu/libc.so.6 | grep sleep
 000000000010a3c0 T __clock_nanosleep
 000000000010a3c0 W clock_nanosleep
 00000000000cae80 T __nanosleep
 00000000000cae80 W nanosleep
 00000000000f35d0 T __nanosleep_nocancel
 00000000000cad90 W sleep
 0000000000084d70 T thrd_sleep
 00000000000f5870 T usleep
```

sleep @ 0×cad90

confirming the offset of sleep() in libc

- run a new debugging session of pew
- break on main and run with r
- check info proc map or vmmap for libc
- take that mapped offset and add 0×cad90 in the info symbol command

```
gef➤  info proc map
process 33
Mapped address spaces:

        Start Addr           End Addr       Size     Offset objfile
[ ... ]
    0x564cc8854000     0x564cc8855000     0x1000        0x0 /root/code/pew
    0x564cc8855000     0x564cc8856000     0x1000     0x1000 /root/code/pew
    0x564cc8856000     0x564cc8857000     0x1000     0x2000 /root/code/pew
    0x564cc8857000     0x564cc8858000     0x1000     0x2000 /root/code/pew
    0x7f06f680b000     0x7f06f6830000    0x25000        0x0 /lib/x86_64-linux-gnu/libc-2.30.so
    0x7f06f6830000     0x7f06f697a000   0x14a000    0x25000 /lib/x86_64-linux-gnu/libc-2.30.so
    0x7f06f697a000     0x7f06f69c4000    0x4a000   0x16f000 /lib/x86_64-linux-gnu/libc-2.30.so
    0x7f06f69c4000     0x7f06f69c7000     0x3000   0x1b8000 /lib/x86_64-linux-gnu/libc-2.30.so


gef➤  info symbol 0x7f06f680b000 + 0xcad90
sleep in section .text of /lib/x86_64-linux-gnu/libc.so.6
```

options to resolve sleep() with frida

(time to learn some Frida API’s)

- calculate the offset and add() it to a Module.getBaseAddress() address
- use Module.getExportByName()
- use DebugSymbol.getFunctionByName()

sleep() with frida and an offset

```
[Local::pew]-> Process.enumerateModulesSync();
[
    {
        "base": "0x7fc2edb78000",
        "name": "libc-2.30.so",
        "path": "/lib/x86_64-linux-gnu/libc-2.30.so",
        "size": 1830912
    },
    {
        "base": "0x7fc2edd41000",
        "name": "ld-2.30.so",
        "path": "/lib/x86_64-linux-gnu/ld-2.30.so",
        "size": 172032
    },

    [...]
]
```

sleep() with frida and an offset

```
[Local::pew]-> Process.getModuleByName("libc-2.30.so");
{
    "base": "0x7fc2edb78000",
    "name": "libc-2.30.so",
    "path": "/lib/x86_64-linux-gnu/libc-2.30.so",
    "size": 1830912
}
```

sleep() with frida and an offset

```
[Local::pew]-> Process.getModuleByName("libc-2.30.so").base;
"0x7fc2edb78000"

[Local::pew]-> Module.getBaseAddress("libc-2.30.so");
"0x7fc2edb78000"
```

sleep() with frida and an offset

```
Module.getBaseAddress("libc-2.30.so").add("0×cad90");
"0×7fc2edc42d90"
```

sleep() with frida and an export

```
[Local::pew]-> Process.getModuleByName("libc-2.30.so").enumerateExports();
[
    {
        "address": "0x7fc2edc71ef0",
        "name": "vwarn",
        "type": "function"
    },
    {
        "address": "0x7fc2edc6a370",
        "name": "fts64_close",
        "type": "function"
    },

    [...]
]
```

sleep() with frida and an export

```
[Local::pew]-> Module.getExportByName(null, "sleep");
"0x7fc2edc42d90"
```

sleep() with frida and a debug symbol

```
[Local::pew]-> DebugSymbol.getFunctionByName("sleep");
"0x7fc2edc42d90"
```

we have the target, what about the callbacks?

```
Interceptor.attach(target, callbacks);
```

```
Interceptor.attach(sleepPtr, {
  onEnter: function(args) {},
  onLeave: function(retval) {}
});
```

```javascript
var sleep = Module.getExportByName(null, "sleep");

Interceptor.attach(sleep, {

    onEnter: function(args) {
        console.log("[*] Sleep from Frida!");
    },

    onLeave: function(retval) {
        console.log("[*] Done sleeping from Frida!");
    }
});
```

attach to sleep() in pew

```
~/code$ cp ../software/interceptor-attach.js.1 interceptor-attach.js

~/code$ frida pew -l interceptor-attach.js
```

what did attach do to sleep?

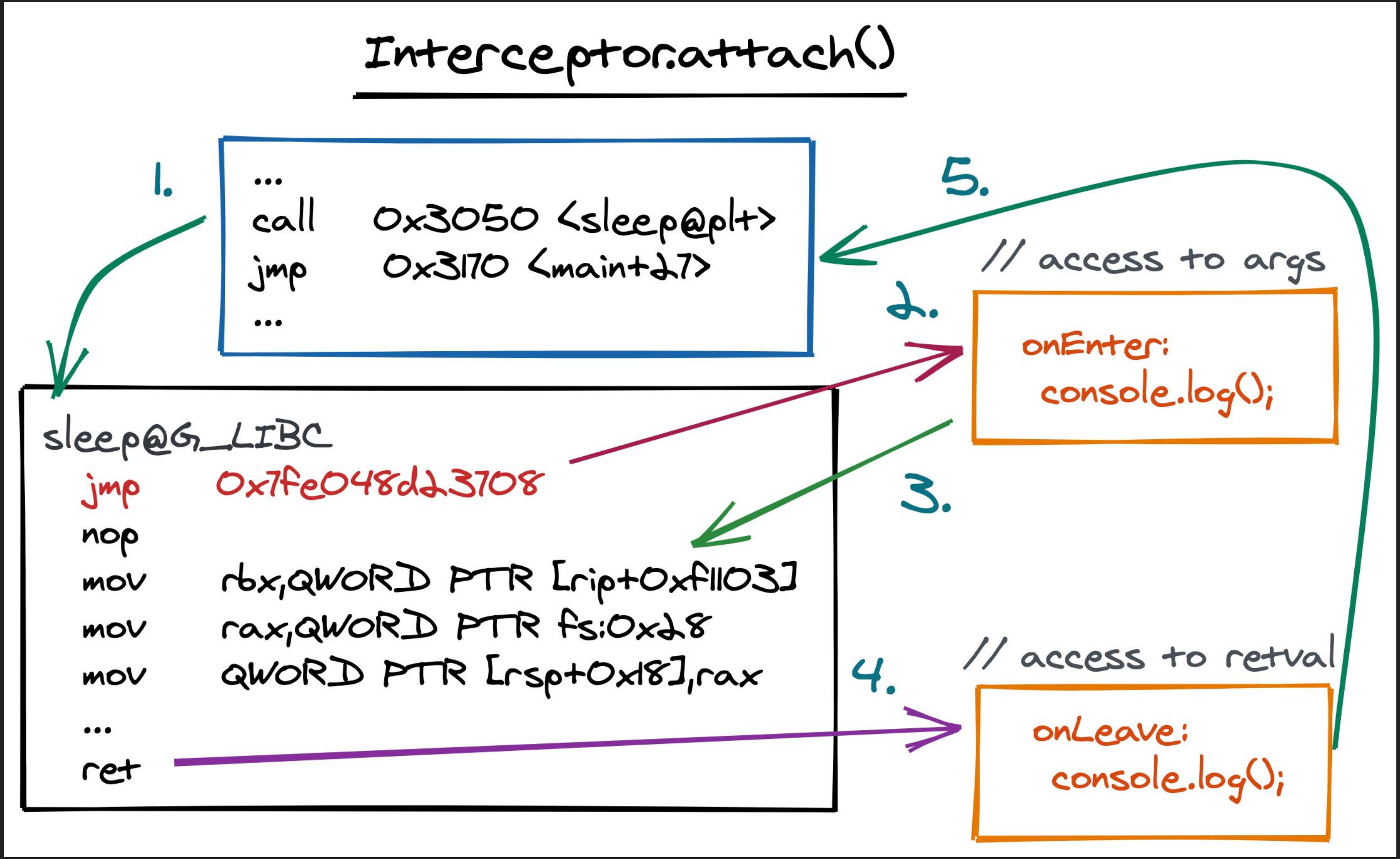
- attach gdb to the running instance of pew while the instrumentation is running with `gdb -q -p $(pidof pew)`
- disassemble the sleep function and have a look at the start with `disas sleep`

```
# with Interceptor.attach()

gef➤  disas sleep
Dump of assembler code for function sleep:
   0x00007fc2edc42d90 <+0>:     jmp    0x7fc2ed197708
   0x00007fc2edc42d95 <+5>:     nop

# without Interceptor.attach()

gef➤  disas sleep
Dump of assembler code for function sleep:
   0x00007fc2edc42d90 <+0>:     push   rbp
   0x00007fc2edc42d91 <+1>:     push   rbx
```



Interceptor.attach()
1.
...
call 0x3050 <sleep@plt>
jmp 0x3170 <main+27>
...
5.
// access to args
2.
onEnter:
console.log();
sleep@GLIBC
jmp 0x7fe048d23708
nop
mov rbx,QWORD PTR [rip+0xf1103]
mov rax,QWORD PTR fs:0x28
mov QWORD PTR [rsp+0x18],rax
...
ret
3.
4.
// access to retval
onLeave:
console.log();

chapter 0×2

part 0×3

overriding arguments

interceptor arguments

```
onEnter: function(args);
```

interceptor arguments

- does **not** know how many arguments there are, by design
- args[0] is the first argument
- args are of type NativePointer

```
args = [
    NativePointer("0x01"),        # args[0]
    NativePointer("0x0fe4795"), # args[1]
     ...
];
```

*len(args) + 1 of the real function is possible, but is *not* an argument*

interceptor arguments

```
onEnter: function(args) {
    console.log("[*] Argument for sleep() => " +
                                   parseInt(args[0]));

    console.log("[*] Sleep from Frida!");
}
```

```
~/code$ cp
../software/interceptor-attach.js.2
interceptor-attach.js

~/code$ frida pew -l
interceptor-attach.js
```

now modify the argument to sleep()

```
args[0] = ptr(“0×01”);

# or

args[0] = new NativePointer(“0×01”);
```

integers are easy, what about strings?

- allocate a new character array with Memory.allocUtf8String and save the pointer
- assign the relevant arg to the value of the new pointer
- profit?

override the argument to printf(), you know enough to do this yourself. if not...

```
~/code$ cp ../software/interceptor-attach.js.3 interceptor-attach.js

~/code$ frida pew -l interceptor-attach.js
```

you have register access here too…

```
var printf = Module.getExportByName(null, "printf");

Interceptor.attach(printf, {
    onEnter: function(args) {
        console.log(JSON.stringify(this.context, null, 4));
    }
});
```

overriding return values

chapter - 0×2 - part 0×3

interceptor return values

```
onLeave: function(retval);
```

let’s find our target, rand_range

which api will you use to get it’s address?

```
[Local::pew]-> DebugSymbol.getFunctionByName("rand_range");
"0x55a5ef21d185"
```

```
var rand_range = DebugSymbol
                    .getFunctionByName("rand_range");

Interceptor.attach(rand_range, {
    onLeave: function(retval) {

        console.log(retval);
    }
});
```

```
~/code$ cp
../software/interceptor-attach.js.4
interceptor-attach.js

~/code$ frida pew -l
interceptor-attach.js
```

to replace a return value, we call replace() on the return value

```
retval.replace(ptr("0×01"));
```

your turn...

databinding between onEnter and onLeave

```
onEnter: function(a) {
  this.value = ptr("0x01");
},

# this is in scope

onLeave: function(r) {
  r.replace(this.value);
}
```

```
~/code$ cp
../software/interceptor-attach.js.5
interceptor-attach.js

~/code$ frida pew -l
interceptor-attach.js
```

chapter 0×2

part 0×4

reusing existing code

we are done with pew. enter crypt.

try not to peek at the source code, but get and compile crypt with:

```
~/code$ cp ../software/crypt.c .
~/code$ gcc crypt.c -o crypt
```

run crypt to get a feel for how it works

```
~/code$ ./crypt
Pin: 1234
Pin:
```

imagine you don’t have the source code for crypt (which will most often be the case), so let’s analyse it.

https://cloud.binary.ninja/

takeaways from analysing crypt

- success condition will print Pwnd!!
- test_pin should return **true** (0x1) to be successful
- test_pin tests a value against 0xd64

static analysis aside, let's do *dynamic* analysis of test_pin!

use interceptor.attach() on test_pin

what are the arguments and return values?

```
~/code$ cp ../software/crypt.js.1
crypt.js

~/code$ frida crypt -l crypt.js
```

```
[Local::crypt]->
test_pin(0x7fff33742ac2)
  => ret: 0x0
test_pin(0x7fff33742ac2)
  => ret: 0x0
test_pin(0x7fff33742ac2)
  => ret: 0x0
```

hexdump the address the first argument (args[0]) points to

```
onEnter: function(args) {
    console.log(hexdump(args[0]));
}
```

```
[Local::crypt]→ test_pin(0x7fff33742ac2)

               0  1  2  3  4  5  6  7  8  9  A  B  C  D  E  F  0123456789ABCDEF
7fff33742ac2  31 32 33 34 0a 00 00 00 00 00 00 00 00 00 10 a2  1234............
7fff33742ad2  54 e1 e4 55 00 00 0b 4e 25 a7 96 7f 00 00 00 00  T..U...N%.......
```

```
# we can print the string too

onEnter: function(args) {
    console.log("test_pin(" +
        args[0].readCString().trim() +
    ")");
}
```

so what will be the easy win here?

swap the return value to 0×1!

give it a try now.

```
var testPin = DebugSymbol.getFunctionByName("test_pin");

Interceptor.attach(testPin, {

    onLeave: function(retval) {
        console.log(" => ret: " + retval);

        retval.replace(ptr("0x1")); // <--
    }
});
```

```
~/code$ cp ../software/crypt.js.2
crypt.js

~/code$ frida crypt -l crypt.js
```

```
Pin: 1
Pwnd!!
```

so that’s cool ‘n all, but what’s the real pin?

what if **we** could call test_pin() ourselves? we know the argument and the return type…

```
new NativeFunction(address, returnType,
                                        argTypes[, abi]);
```

```
var testPinPtr = DebugSymbol.getFunctionByName("test_pin");

var testPin = new NativeFunction(
                    testPinPtr, "int", ["pointer"]);


// Try a PIN of 1111

var pin = Memory.allocUtf8String("1111");
var r = testPin(pin);

console.log(r);
```

```
~/code$ cp ../software/crypt.js.3
crypt.js

~/code$ frida crypt -l crypt.js
```

so let's loop that and brute the pin?

```
for (var i = 0; i < 9999; i++) {

    var pin = Memory.allocUtf8String(i.toString());
    var r = testPin(pin);

    if (r == 1) {
        console.log("Pin is: " + i.toString());
        break;
    }
}
```

```
~/code$ cp ../software/crypt.js.4 crypt.js

~/code$ frida crypt -l crypt.js
```

```
[ ... ]

Trying: 3422
Trying: 3423
Trying: 3424
Trying: 3425
Trying: 3426
Trying: 3427
Trying: 3428
Pin is: 3428
```

Pin: 3428

Pwnd !!

O_o

o_O

chapter 0×3

part 0×1

https://codeshare.frida.re/

- use python bindings to attach/spawn to targets
- inject frida scripts
- accept input

```python
import frida
import sys

session = frida.attach("crypt")
script = session.create_script("""
  console.log("ver: " + Frida.version);
""")
script.load()
```

```
~/code$ cp ../software/tool.py.1 tool.py

~/code$ python3 tool.py
```

replace the script with our pin brute forcer now

[...]

```
script = session.create_script("""
  var testPinPtr =
      DebugSymbol.getFunctionByName("test_pin");

 [ ... ]
""")
```

```
~/code$ cp ../software/tool.py.2 tool.py

~/code$ python3 tool.py
```

two languages in the same file is not bad, but it’s not great either so let’s refactor again

```python
import frida
import sys

# read the agent source
with open("index.js", "r") as f:
    agent = f.read()

session = frida.attach("crypt")
script = session.create_script(agent)
script.load()
```

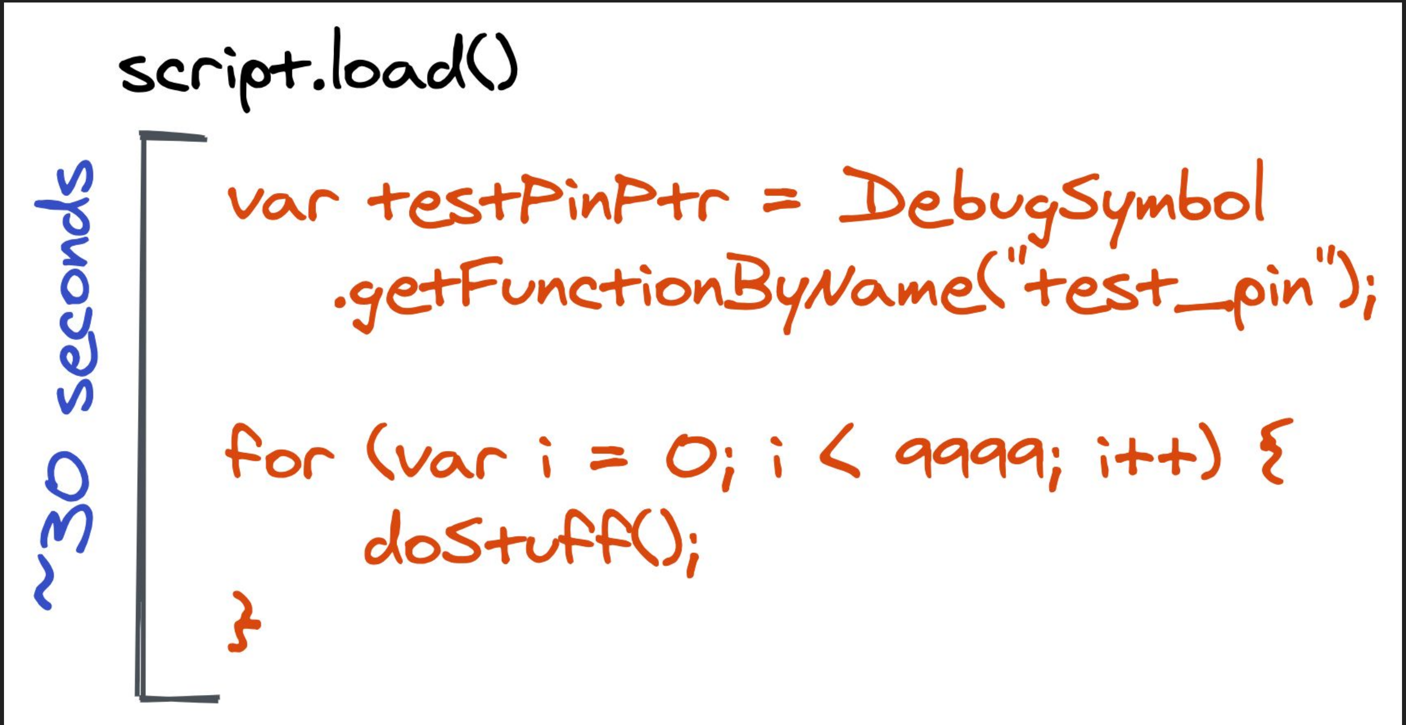
```
~/code$ cp ../software/tool.py.3 tool.py
~/code$ cp ../software/index.js.1 index.js

~/code$ python3 tool.py
```

chapter 0×3

part 0×2

the script loading lifecycle



- so far we abused the startup to let our script finish
- longer running scripts (like those using the Interceptor) will need a blocking function so we don't just exit
- in python we can do this with `sys.stdin.read()` to wait for input

```python
import sys

[ … ]

session = frida.attach("crypt")
script = session.create_script(agent)
script.load()

# block so that the program does not quit.
sys.stdin.read()
```

send() and recv()

send() example

```
// javascript
var answer = 42;
send(answer);


# python
def incoming(message, data):
  print(message)

script.on("message", incoming)
```

- update your agent script to send() a message when the brute forcer starts and when it is finished

- update the python tool to handle incoming messages

```
~/code$ cp ../software/tool.py.4 tool.py
~/code$ cp ../software/index.js.2 index.js

~/code$ python3 tool.py
```

recv() example

```javascript
// javascript
recv(function(m) {
  console.log("message: " + m);
});
```

```python
# python
script.on("message", incoming)
script.load()
script.post("test")
```

update your agent to receive a message from the python environment and print it

```
~/code$ cp ../software/tool.py.5 tool.py
~/code$ cp ../software/index.js.3 index.js

~/code$ python3 tool.py
```

frida RPC interface

(the bindings to agent glue)

- call functions defined in the JavaScript agent, from python
- pass along arguments from python, and get return values from JavaScript
- don’t have to use send() / recv()
- does not block script.load()

- functions in the agent should be exported in the global rpc.exports object in the agent
- exports are accessed from the script.exports property in python
- the function testPin() defined in the agent is called test_pin() in python

javascript exports definition

```
rpc.exports = {
    brute: function() {
        console.log("Brute function");
    }
}
```

accessing exports in python

```
script.exports.brute()
```

let’s refactor once more, this time implementing the brute force logic in an agent with a rpc export

```
~/code$ cp ../software/tool.py.6 tool.py
~/code$ cp ../software/index.js.4
index.js

~/code$ python3 tool.py
```

one more refactor where we implement the pin check loop in python and simplify or agent

```python
# python

for x in range(0, 9999):
      res = test_pin(str(x))

      [ … ]
```

```
~/code$ cp ../software/tool.py.7 tool.py
~/code$ cp ../software/index.js.5 index.js

~/code$ python3 tool.py
```

from python, you just called a javascript method that called a c method and returned some results back...

(•_•)

(•_•)>⌐■-■

(⌐■_■)

chapter 0×3

part 0×3

typescript && frida == <3

crash course for us mere mortals

- typescript is a superset of javascript
- valid javascript is also valid typescript
- frida-compile can take typescript and transpile to any target (important for duktape/v8 language support)

frida-compile exposes the entire NPM ecosystem to use inside of agents

what do you need?

- vscode
- node
- oleavr/frida-agent-example repository

what does it look like?

```
11
12  Interceptor.at
```

attach
detachAll

function Interceptor.attach(target: NativePointerValue, callbacksOrProbe: ScriptInvocationListenerCallbacks | NativeInvocationListenerCallbacks | InstructionProbeCallback, data?: NativePointerValue): InvocationListener

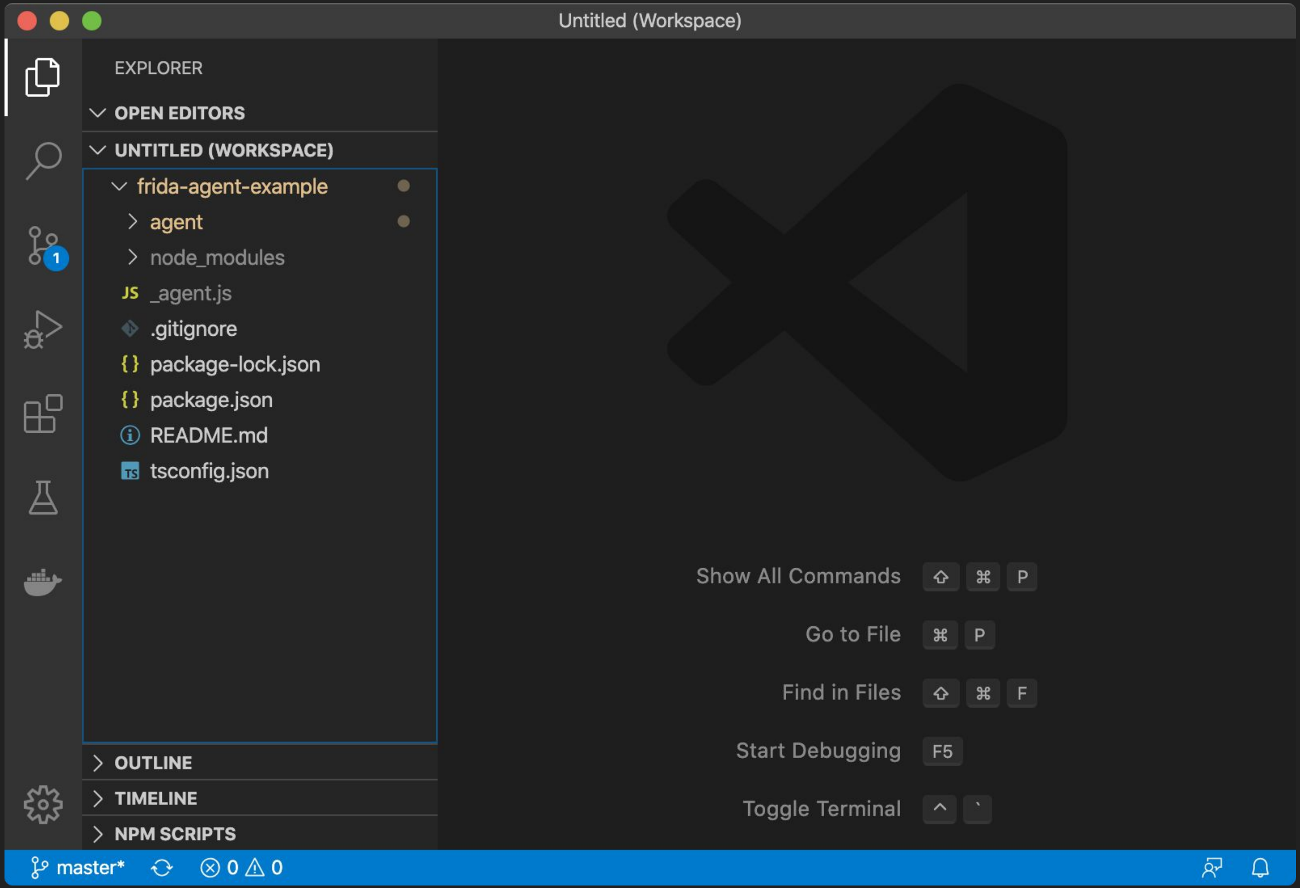
Intercepts calls to function/instruction at `target`. It is important to specify a `InstructionProbeCallback` if

- a-mazing inline documentation
- autocompletion
- benefits of strictly typed TS

setup for this workshop

- already have node & the repo cloned and all dependencies installed
- copy the repo to your code/ folder
- add the frida-agent-example folder to vscode
- play with the autocompletion

```
~/code$ cp -R ~/frida-agent-example/ .
```



chapter - 0x3 - part 0x3

npm run watch vs npm run build

- build will perform a single shot build of the agent
- watch will monitoring for changes and automatically rebuild
- both result in a new _agent.js file

implement testPin in the example index.ts file or copy the example from the software folder

```
~/code/frida-agent-example$ cp
  ~/software/index.ts.1 agent/index.ts
```

finally, update the tool.py to read the generated _agent.js file

```
with open("frida-agent-example/_agent.js", "r") as f:
```

a few moving parts but now you’re ready

- run ./crypt
- run npm run watch
- run python3 tool.py

- edit index.ts and watch the recompile

what about starting up a web server in the target process and try and guess the pin using http requests?

```
~/code/frida-agent-example$ cp
  ~/software/index.ts.2 agent/index.ts

~/code$ cp ../software/tool.py.8 tool.py
```

```
~$ curl -v localhost:1337/3428
```

(ﾟДﾟ)

chapter 0×3
part 0×4

tools part of the frida-tools pip package

- frida
- frida-discover
- frida-kill
- frida-ls-devices
- frida-ps
- frida-trace

frida-trace, a tool for quick function call tracing

- generate interceptor-like hooks
- wildcard symbol resolution
- man page reference for function args
- dumps hooks in __handlers__ folder

try it

```
$ frida-trace crypt -i "ato*"
```

chapter 0×3

part 0×5

you've made it this far, let's cover operating modes quickly

- frida-server & frida-gadget opens a socket that clients to
- frida-server usually runs standalone
- frida-gadget run embedded / preloaded
  - LD_PRELOAD
  - patching the gadget to load
  - can be configured

using frida-server

the docker container has frida-server in the $PATH already. run it with
`frida-server -l 0.0.0.0:1337`

next, `frida-ps -H localhost:1337`

using the frida-ps output, you can now tell frida which target to attach to

```
$ frida -H localhost:1337 crypt
$ frida -H localhost:1337 -p 24
```

in this mode, frida-server does the heavy lifting (injection etc.), client tools just communicate with it over the socket

using frida-gadget

- load with LD_PRELOAD
- load with patchelf

apps launched with the Gadget are paused until a client connects. this can be changed with a gadget config.

frida-gadget using LD_PRELOAD

```
~$ LD_PRELOAD=./frida-gadget.so code/crypt

[Frida INFO] Listening on 127.0.0.1 TCP port 27042
```

```
~$ frida-ps -R
PID  Name
--   ------
78   Gadget

# or run frida-ps -H localhost
```

run the frida REPL connecting to the remote gadget

```
# failed invocation

~$ frida -q -R crypt -e "console.log(Process.id);"
Failed to spawn: unable to find process with name 'crypt'

# successful invocation

~$ frida -q -R Gadget -e "console.log(Process.id);"
12
```

notice how when the client connected, the Pin prompt displayed. this is because the application resumed when the client connected

frida-gadget by patching (patchelf)

```
~/code$ patchelf --add-needed
 ../frida-gadget.so crypt

~/code$ ./crypt
[Frida INFO] Listening on 127.0.0.1 TCP
port 27042
```

```
~/code$ ldd crypt
        linux-vdso.so.1 (0x00007ffdc7962000)
        ../frida-gadget.so (0x00007fceeca4b000)
        libc.so.6 => /lib/x86_64-linux-gnu/libc.so.6 (0x00007fceec884000)
        libdl.so.2 => /lib/x86_64-linux-gnu/libdl.so.2 (0x00007fceec87f000)

         [ ... ]
```

configuring the gadget

- a small json file next to the gadget
- same name with the .config extension

```json
{
  "interaction": {
    "type"    : "listen",
    "address": "127.0.0.1",
    "port"    : 27042,
    "on_load": "wait"
  }
}
```

add a gadget configuration, changing the default wait behaviour to resume.

```
~$ cp software/frida-gadget.config.1
     frida-gadget.config
```

```json
{
  "interaction": {
    "type": "script",
    "path": "/root/code/agent.js"
  }
}
```

```json
{
  "interaction": {
    "type": "script-directory",
    "path": "/usr/local/frida/scripts"
  }
}
```

add a gadget configuration, embedding an agent to print the crypt pin.

```
~$ cp software/frida-gadget.config.2
     frida-gadget.config

~$ cp software/embedded-agent.js
     code/embedded-agent.js
```

thank you!

https://t.me/fridadotre

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bonus chapter

```
new CModule()
```

compile C source code, in memory, from your JavaScript (using TinyCC)

bonus chapter

```
const cm = new CModule(`
#inlude <stdio.h>

void init() {
  printf(“hello from CModule\n”);
}
`);
```

bonus chapter

limited available headers, by design

- glib.h
- stdio.h
- stdlib.h
- etc…

https://github.com/frida/frida-gum/tree/master/bindings/gumjs/runtime/cmodule

```
const cm = new CModule(`
int value() {
  return 42;
}
`);

const v = new NativeFunction(cm.value,
‘int’, []); // no args for our func

v(); // 42
```

bonus chapter

```
const p = Memory.alloc(4);
const cm = new CModule(`
#include <glib.h>
#include <stdio.h>

extern volatile gpointer p;

int value() {
  printf(“%p”, p);
}
`, { p }); // ← pass a symbol
```

bonus chapter

frida REPL can load .c files
(with the same magical auto-reload goodies you are used to)

```
$ frida crypt -l index.js -C test.c
```

bonus chapter

```
~/code$ cp ../software/tool.py.9 tool.py
~/code$ cp ../software/index.js.6
index.js
```

test_pin, from python, calling JavaScript, calling a CModule, calling the real C implementation

.fini