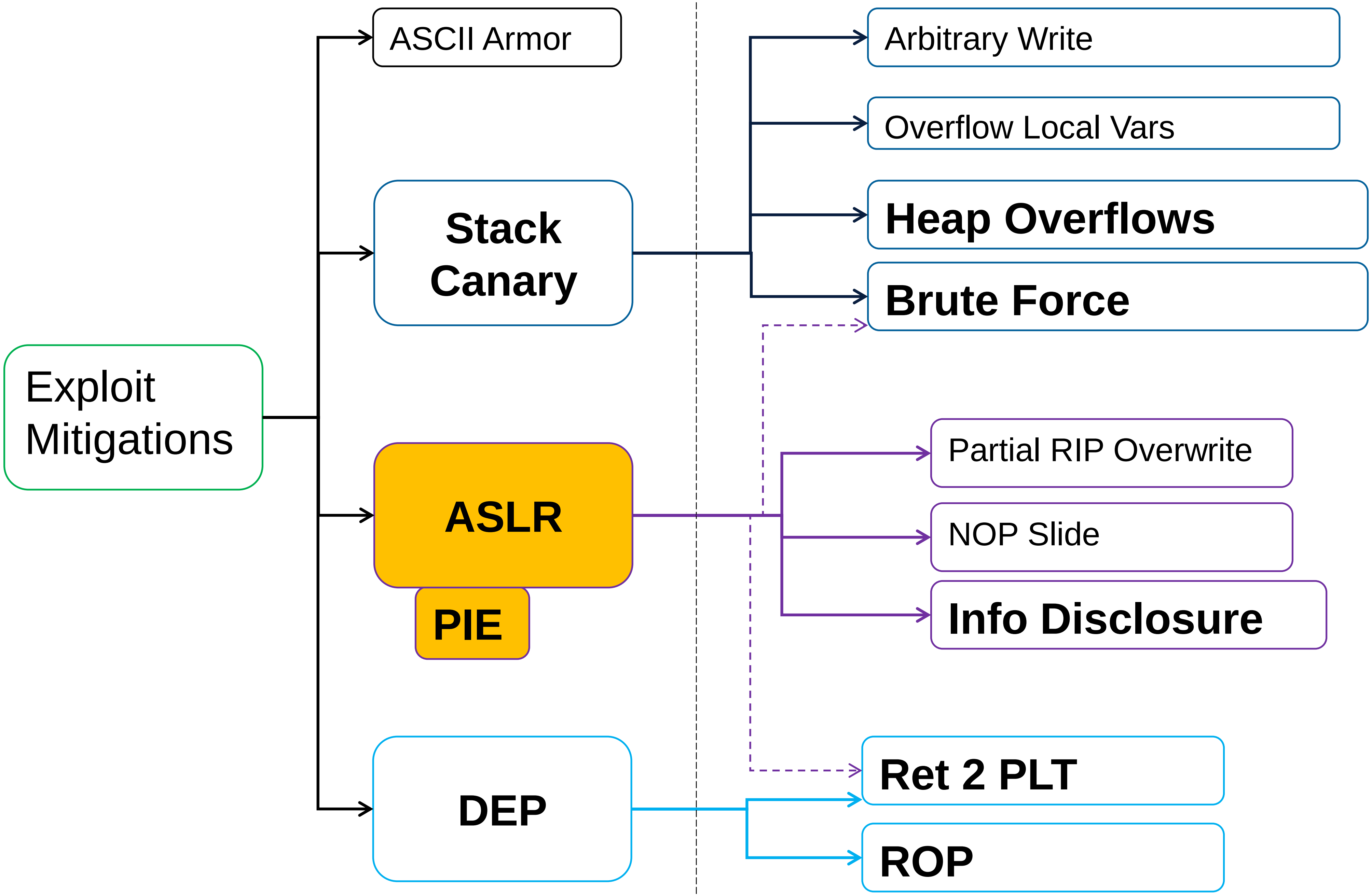
Exploit Mitigation - PIE



Exploit Mitigations
ASCII Armor
Stack Canary
ASLR
PIE
DEP
Arbitrary Write
Overflow Local Vars
Heap Overflows
Brute Force
Partial RIP Overwrite
NOP Slide
Info Disclosure
Ret 2 PLT
ROP

Recap! Exploit Mitigation Exploits

All three exploit mitigations can be defeated by black magic

Easily

Is there a solution?

Exploit Mitigation - PIE

The solution

The solution to all problems… PIE

Exploit Mitigation++

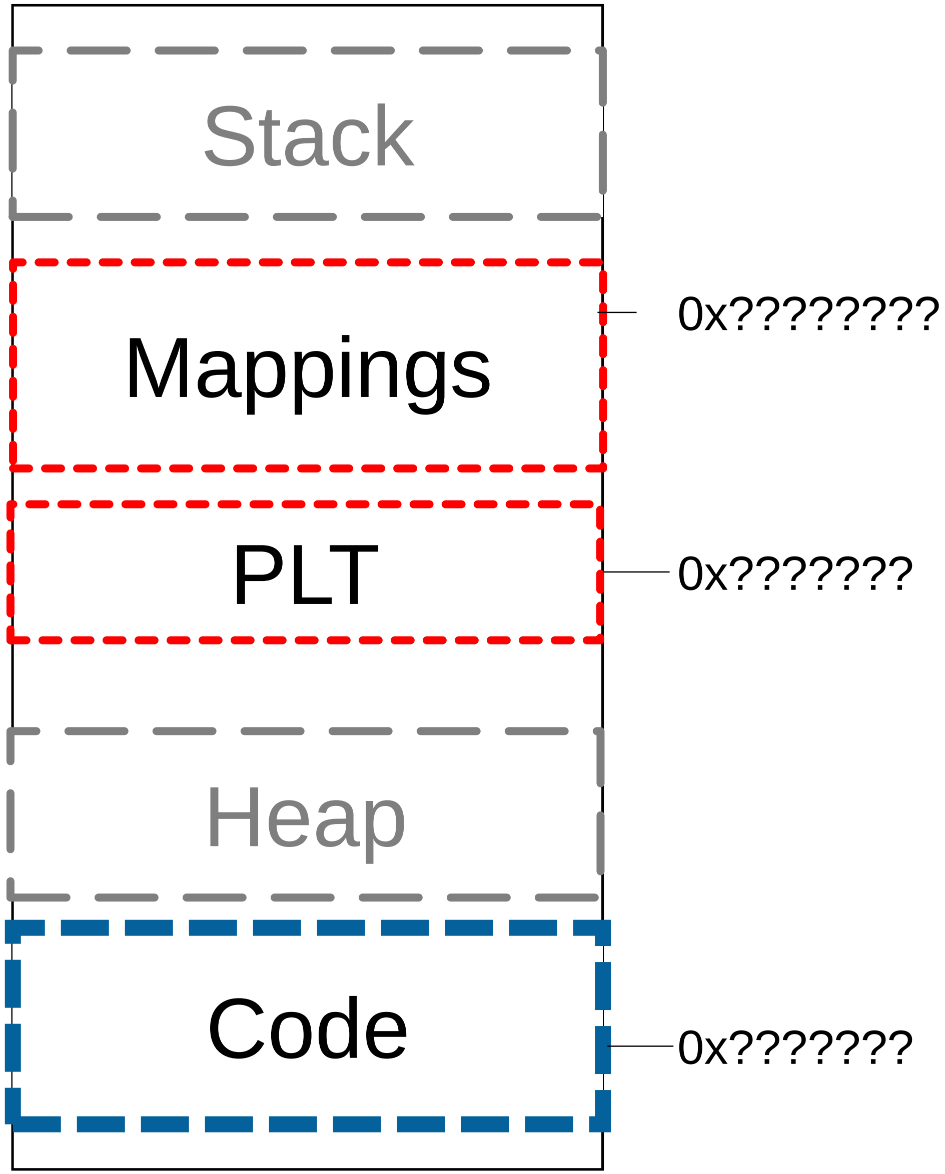
Fix:

- Compile as PIE
- PIE: Position Independent Executable
- Will randomize Code and PLT, too

Note:

- Shared libraries are PIC
  - (Position Independent Code)
- Because they don’t know where they are being loaded
- Always randomized, even without PIE

Exploiting: ASLR for code: PIE



PIE Executable

```
$ cat test.c
#include <stdio.h>

void func() {
        printf("\n");
}
void main(void) {
        printf("%p\n", &func);
}
$ gcc -fpic -pie test.c
$ ./a.out
0x557d9dee57c5
$ ./a.out
0x5581df9d67c5
```

PIE Executable

```
Type           Offset             VirtAddr           PhysAddr
                 FileSiz            MemSiz              Flags  Align
  PHDR           0x0000000000000040 0x0000000000000040 0x0000000000000040
                 0x00000000000001f8 0x00000000000001f8  R E    8
  INTERP         0x0000000000000238 0x0000000000000238 0x0000000000000238
                 0x000000000000001c 0x000000000000001c  R      1
      [Requesting program interpreter: /lib64/ld-linux-x86-64.so.2]
  LOAD           0x0000000000000000 0x0000000000000000 0x0000000000000000
                 0x00000000000009dc 0x00000000000009dc  R E    200000
[…]
 Segment Sections...
   00
   01     .interp
   02     .interp .note.ABI-tag .note.gnu.build-id .gnu.hash .dynsym .dynstr .gn
u.version .gnu.version_r .rela.dyn .rela.plt .init .plt .text .fini .rodata
```

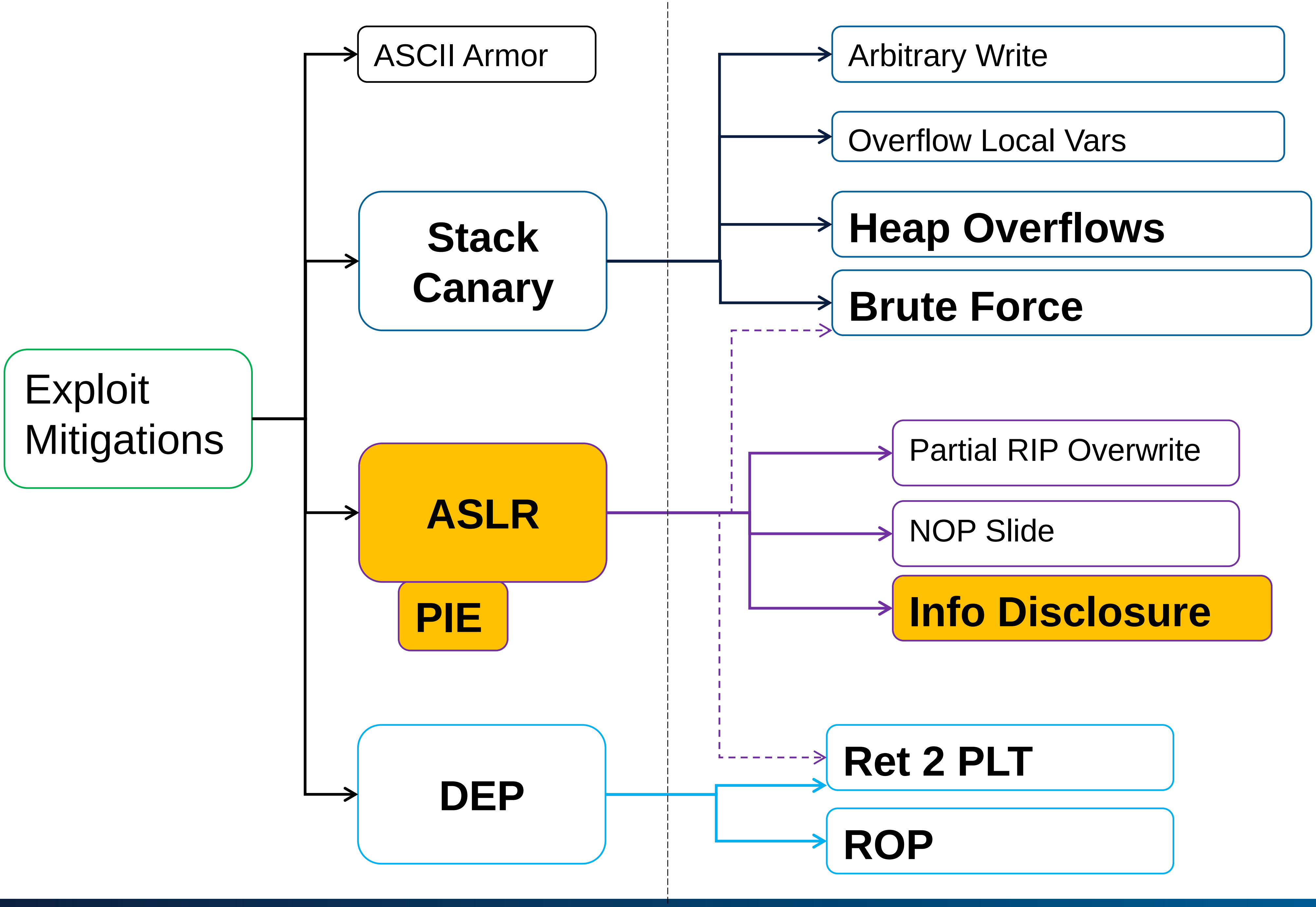
Exploiting: ASLR for code: PIE

PIE randomizes Code segment base address

PIE randomizes GOT/PLT base address too

No more static locations!

Defeat Exploit Mitigation: PIE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[the cake is a lie]

ASLR vs Information Leak

ASLR assumes attacker can’t get information

What if they can?

Meet: Memory Leak

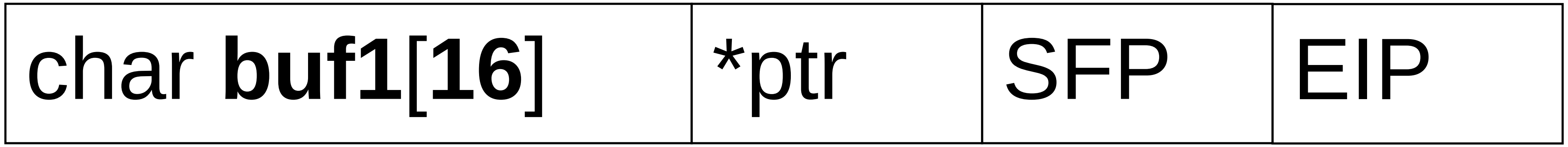
Memory Leak / Information Disclosure

Memory Leak

Memory leak or information disclosure:

- Return more data to the attacker than the intended object size
- The data usually includes meta-data, like:
  - Stack pointers
  - Return addresses
  - Heap-management data
  - Etc.

ASLR vs Memory Leak



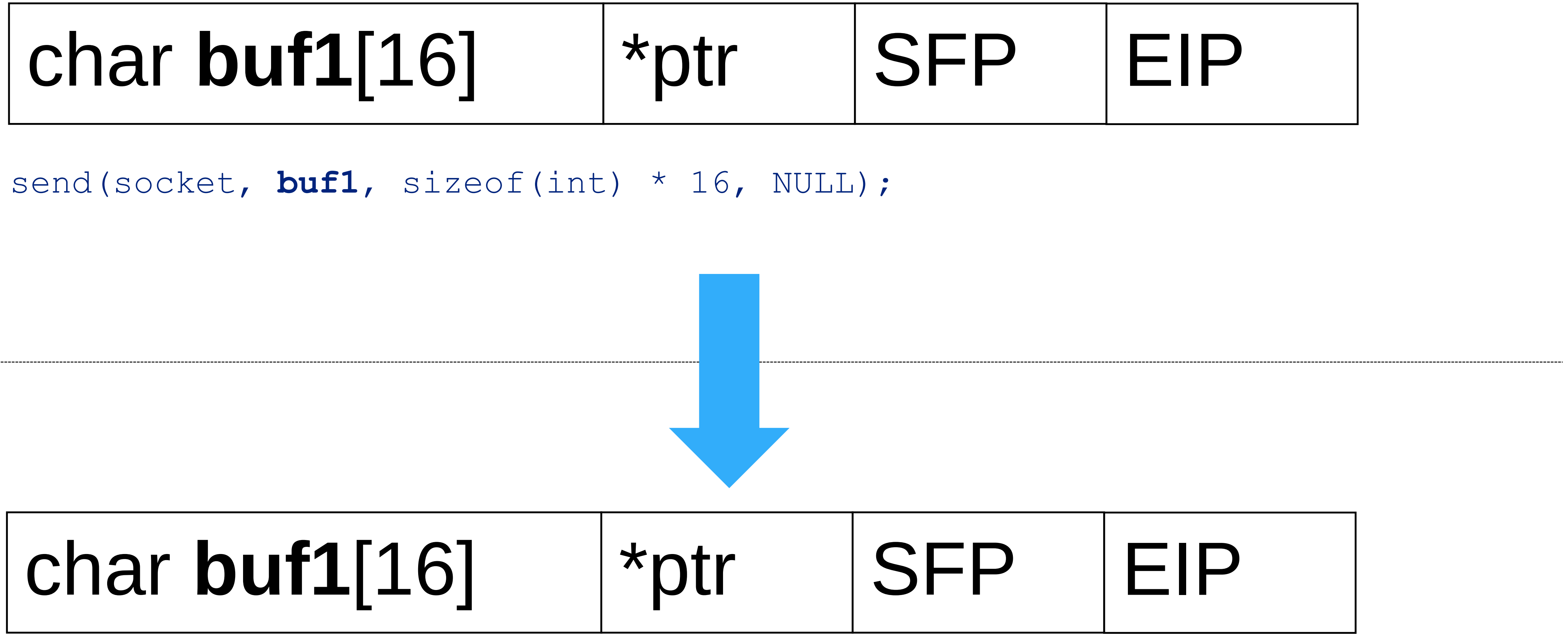
char **buf1[16**]	*ptr	SFP	EIP

Server:

```
send(socket, buf1, sizeof(int) * 16, NULL);
```

- Oups, attacker got 64 bytes back
  - Pointer to stack, code, heap
  - Can deduce base address

ASLR vs Memory Leak

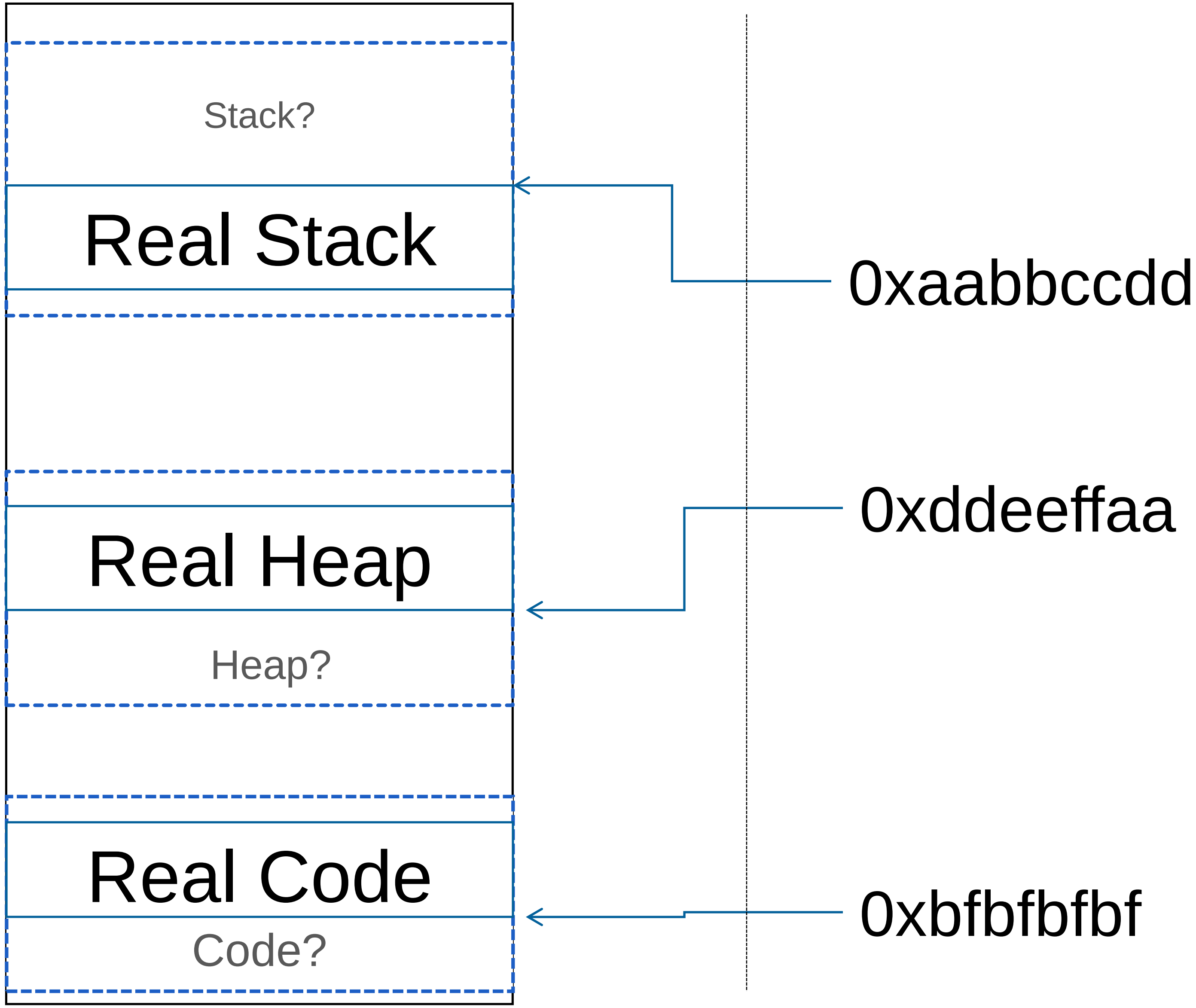


char **buf1**[16]	*ptr	SFP	EIP

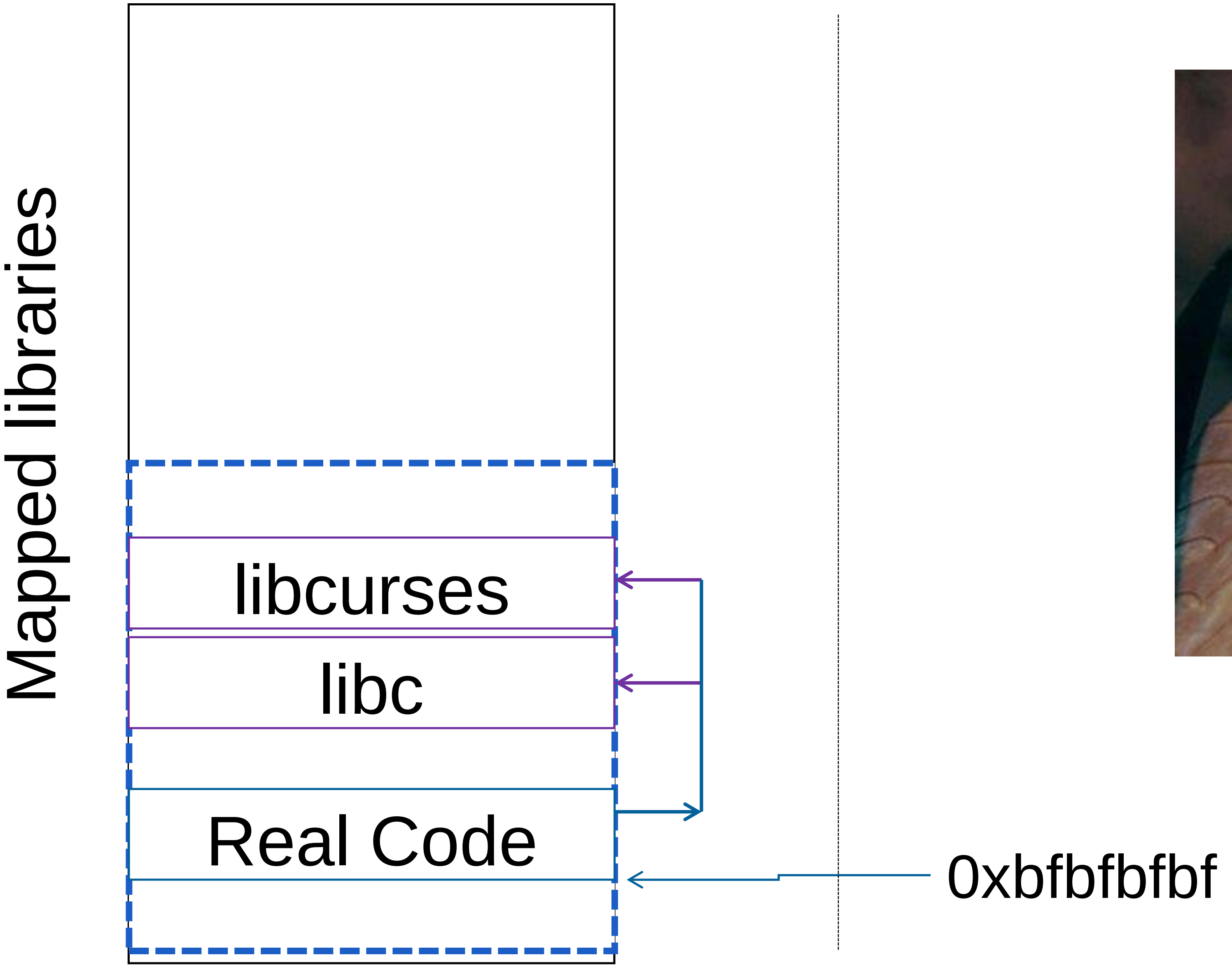
```
send(socket, buf1, sizeof(int) * 16, NULL);
```

char **buf1**[16]	*ptr	SFP	EIP

Exploiting: ASLR for code: PIE



Exploiting: ASLR for code: PIE



Exploiting: ASLR for code: PIE

Attacker:

- Information disclosure / memory leak
- Gains a pointer (Address of memory location)
- From pointer: Deduct base address of segment
- From base address: Can deduct all other addresses

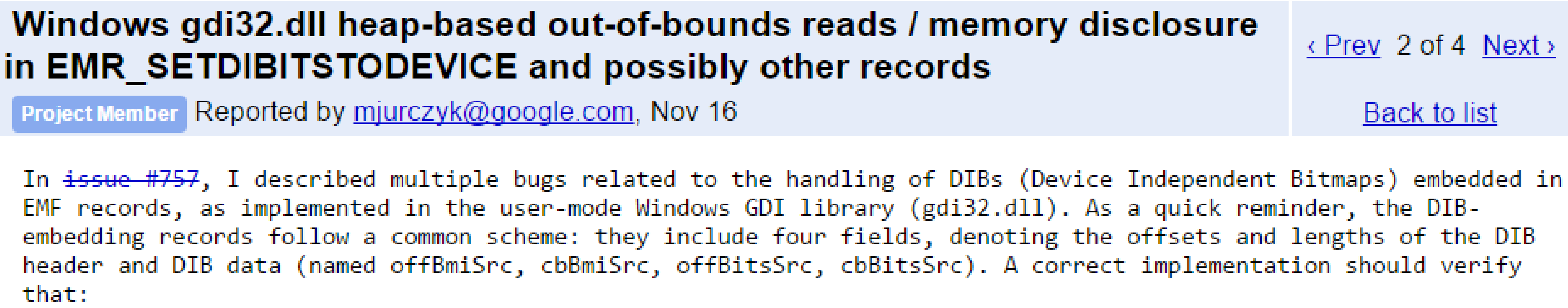
~~A note on code -> libraries:~~

- ~~Distance between code segment and mapped libraries is usually constant~~
- ~~Got SIP? Can use LIBC gadgets…~~

Exploiting: ASLR for code: PIE

Example: Windows memory disclosure (unpatched, 21.2.17, CVE-2017-0038)

```
As a consequence, the 16x16/24bpp bitmap is now described by just 4 bytes, which
is good for only a single pixel. The remaining 255 pixels are drawn based on
junk heap data, which may include sensitive information, such as private user
data or information about the virtual address space.
```



Windows gdi32.dll heap-based out-of-bounds reads / memory disclosure in EMR_SETDIBITSTODEVICE and possibly other records

Project Member Reported by mjurczyk@google.com, Nov 16

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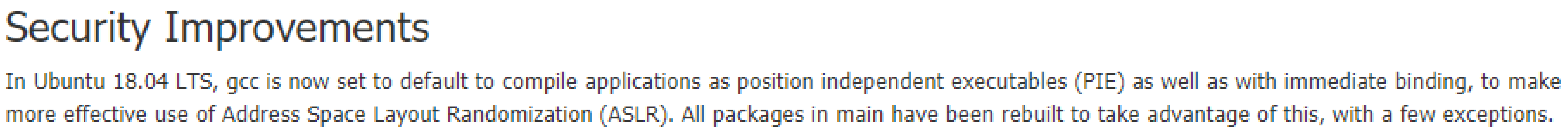
Back to list

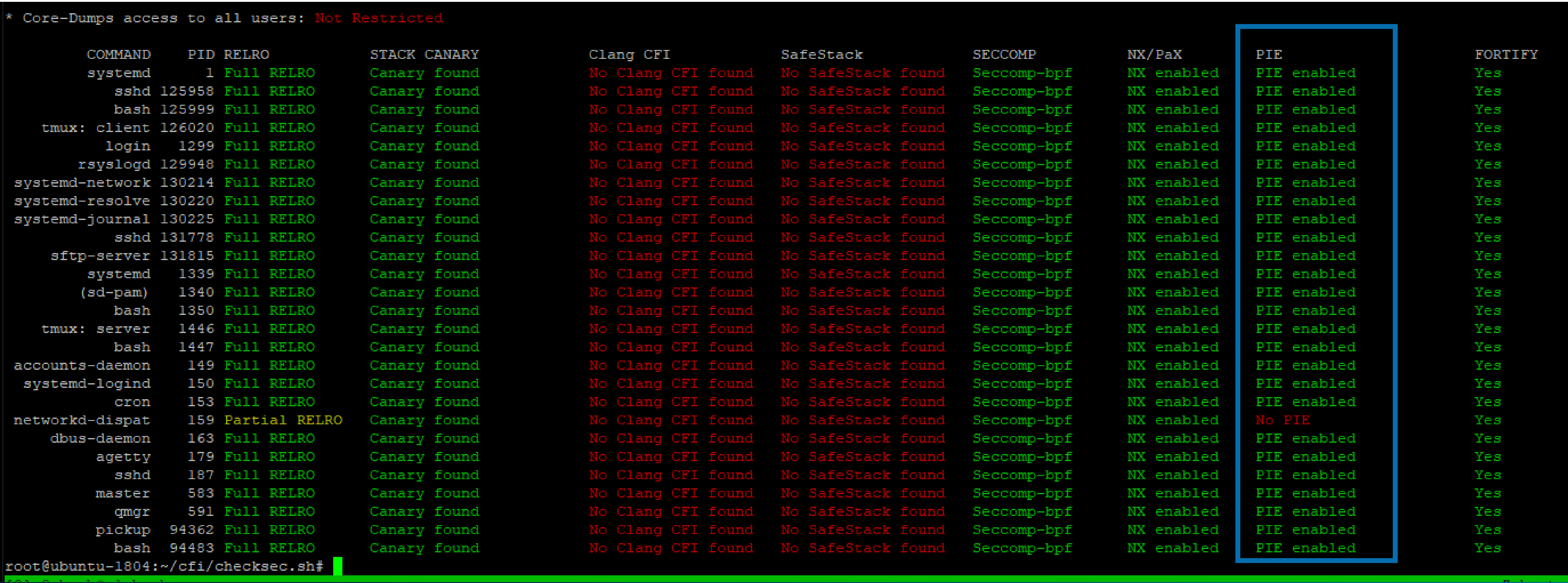
In ~~issue #757~~, I described multiple bugs related to the handling of DIBs (Device Independent Bitmaps) embedded in EMF records, as implemented in the user-mode Windows GDI library (gdi32.dll). As a quick reminder, the DIB-embedding records follow a common scheme: they include four fields, denoting the offsets and lengths of the DIB header and DIB data (named offBmiSrc, cbBmiSrc, offBitsSrc, cbBitsSrc). A correct implementation should verify that:

PIE in Ubuntu



Security Improvements

In Ubuntu 18.04 LTS, gcc is now set to default to compile applications as position independent executables (PIE) as well as with immediate binding, to make more effective use of Address Space Layout Randomization (ASLR). All packages in main have been rebuilt to take advantage of this, with a few exceptions.



```
* Core-Dumps access to all users: Not Restricted

         COMMAND    PID RELRO             STACK CANARY            Clang CFI            SafeStack            SECCOMP          NX/PaX        PIE                    FORTIFY
         systemd      1 Full RELRO        Canary found            No Clang CFI found   No SafeStack found   Seccomp-bpf      NX enabled    PIE enabled            Yes
            sshd 125958 Full RELRO        Canary found            No Clang CFI found   No SafeStack found   Seccomp-bpf      NX enabled    PIE enabled            Yes
            bash 125999 Full RELRO        Canary found            No Clang CFI found   No SafeStack found   Seccomp-bpf      NX enabled    PIE enabled            Yes
    tmux: client 126020 Full RELRO        Canary found            No Clang CFI found   No SafeStack found   Seccomp-bpf      NX enabled    PIE enabled            Yes
           login   1299 Full RELRO        Canary found            No Clang CFI found   No SafeStack found   Seccomp-bpf      NX enabled    PIE enabled            Yes
        rsyslogd 129948 Full RELRO        Canary found            No Clang CFI found   No SafeStack found   Seccomp-bpf      NX enabled    PIE enabled            Yes
 systemd-network 130214 Full RELRO        Canary found            No Clang CFI found   No SafeStack found   Seccomp-bpf      NX enabled    PIE enabled            Yes
 systemd-resolve 130220 Full RELRO        Canary found            No Clang CFI found   No SafeStack found   Seccomp-bpf      NX enabled    PIE enabled            Yes
 systemd-journal 130225 Full RELRO        Canary found            No Clang CFI found   No SafeStack found   Seccomp-bpf      NX enabled    PIE enabled            Yes
            sshd 131778 Full RELRO        Canary found            No Clang CFI found   No SafeStack found   Seccomp-bpf      NX enabled    PIE enabled            Yes
     sftp-server 131815 Full RELRO        Canary found            No Clang CFI found   No SafeStack found   Seccomp-bpf      NX enabled    PIE enabled            Yes
         systemd   1339 Full RELRO        Canary found            No Clang CFI found   No SafeStack found   Seccomp-bpf      NX enabled    PIE enabled            Yes
        (sd-pam)   1340 Full RELRO        Canary found            No Clang CFI found   No SafeStack found   Seccomp-bpf      NX enabled    PIE enabled            Yes
            bash   1350 Full RELRO        Canary found            No Clang CFI found   No SafeStack found   Seccomp-bpf      NX enabled    PIE enabled            Yes
    tmux: server   1446 Full RELRO        Canary found            No Clang CFI found   No SafeStack found   Seccomp-bpf      NX enabled    PIE enabled            Yes
            bash   1447 Full RELRO        Canary found            No Clang CFI found   No SafeStack found   Seccomp-bpf      NX enabled    PIE enabled            Yes
 accounts-daemon    149 Full RELRO        Canary found            No Clang CFI found   No SafeStack found   Seccomp-bpf      NX enabled    PIE enabled            Yes
  systemd-logind    150 Full RELRO        Canary found            No Clang CFI found   No SafeStack found   Seccomp-bpf      NX enabled    PIE enabled            Yes
            cron    153 Full RELRO        Canary found            No Clang CFI found   No SafeStack found   Seccomp-bpf      NX enabled    PIE enabled            Yes
 networkd-dispat    159 Partial RELRO     Canary found            No Clang CFI found   No SafeStack found   Seccomp-bpf      NX enabled    No PIE                 Yes
     dbus-daemon    163 Full RELRO        Canary found            No Clang CFI found   No SafeStack found   Seccomp-bpf      NX enabled    PIE enabled            Yes
          agetty    179 Full RELRO        Canary found            No Clang CFI found   No SafeStack found   Seccomp-bpf      NX enabled    PIE enabled            Yes
            sshd    187 Full RELRO        Canary found            No Clang CFI found   No SafeStack found   Seccomp-bpf      NX enabled    PIE enabled            Yes
          master    583 Full RELRO        Canary found            No Clang CFI found   No SafeStack found   Seccomp-bpf      NX enabled    PIE enabled            Yes
            qmgr    591 Full RELRO        Canary found            No Clang CFI found   No SafeStack found   Seccomp-bpf      NX enabled    PIE enabled            Yes
          pickup  94362 Full RELRO        Canary found            No Clang CFI found   No SafeStack found   Seccomp-bpf      NX enabled    PIE enabled            Yes
            bash  94483 Full RELRO        Canary found            No Clang CFI found   No SafeStack found   Seccomp-bpf      NX enabled    PIE enabled            Yes
root@ubuntu-1804:~/cfi/checksec.sh#
```

GIT THE PRINCESS!
HOW TO SAVE THE PRINCESS USING 8 PROGRAMMING LANGUAGES
BY toggl Goon Squad
YOU HAVE JAVASCRIPT
YOU SPEND HOURS PICKING LIBRARIES, SETTING UP NODE & BUILDING A FRAMEWORK FOR THE CASTLE.
BY THE TIME YOU'RE FINISHED WITH THE FRAMEWORK, THE FORT HAS BEEN ABANDONED AND THE PRINCESS HAS MOVED TO ANOTHER CASTLE
YOU HAVE C
YOU HAVE A LIBRARY FOR A CASTLE & A LIBRARY FOR THE PRINCESS - CHARGE!
YOU RESCUE THE PRINCESS HER DOG, HER ENTIRE WARDROBE & EVERYTHING SHE HAS EVER EATEN...
FUCK - DID I FORGET A NULL-TERMINATOR ?
C

Exploit Mitigation Conclusion

Defeat Exploit Mitigations: TL;DR

Enable ALL the mitigations (DEP, ASLR w/PIE, Stack Protector)

- Defeat ALL the mitigations:
  - ROP shellcode as stager to defeat DEP
  - Information leak to defeat ASLR
  - Non stack-based-stack-overflow vulnerability

Recap

Information disclosure can eliminate ASLR protection

Which enables ROP to eliminate DEP

References

References:

- ROP CFI RAP XNR CPI WTF? Navigating the Exploit Mitigation Jungle
  - https://bsidesljubljana.si/wp-content/uploads/2017/02/ropcfirapxnrcpiwtf-rodler-bsidesljubljana2017.pdf