Binary Exploitation

PART 1

@sleepunderflow

Categories

- Stack Overflow
- Format String Vulnerability
- Heap Overflow
- Memory Corruption (use after free, double free)
- Type Confusion

Stack Overflow

- Uses out of bounds read/write
- Local variables located on the stack
    - Checks
    - Pointers
    - Other stuff
- Return Pointer and Base (Stack) pointer located on the stack
- Stack pointed to by RSP
- Mitigated by Stack Canaries and NX bit

Format String Vulnerability

- Present if user supplied string is used as a format string for printf, sprint etc.
- Can be used as arbitrary read and arbitrary write (leak canaries?)
- Controlled using format characters:
  - %s – string
  - %p – pointer
  - %7$099x – 7th argument taken from the stack printed as hex and extended to 99 characters
  - %n – write the number of characters written so far to a given location
- Often both the buffer and data come from the stack – self feeding addresses

Heap Overflow

- Use out of bounds write to modify pointers in other heap segments
- Can lead to heap allocation to/from controlled location and other issues

Type Confusion

- Unions!!!

```
union variable {
    char string[10];
    int number;
    void* pointer;
} dataType;
```

Memory Corruptions

- A lot of options
- Most common type in the wild
- Can be difficult to exploit
- Heap magic
  - Heap sprays
  - Holes
  - Buckets

Mitigations

- Address Space Layout Randomization (ASLR)
- Position Independent Code
- Dynamic Linking
- NX bit + Data Execution Prevention (DEP)
- Stack Canaries
- Shadow Stack
- Fortify Source
- Sandboxing
- Good programming practices and code review

Address Space Layout Randomization (ASLR)

- Most of the sections in the binary are placed on a random location in a memory
- Some sections might be static (GOT, PLT)
- Only part of the address changes
- Order of sections is (usually) preserved
- Can be leaked via /proc/self/maps
- Preserved between threads
- Controlled through /proc/sys/kernel/randomize_va_space

Position Independent Executable

- Program compiled to only use relative jumps/calls
- Doesn’t use static, hardcoded addresses
- Every section can be located anywhere in the memory
- Sections are in the same position in relation to each other or are pointed to by variables/registers

Static vs Dynamic Linking

- Static:
  - All the libraries included in the binary
  - Addresses known in advance as part of the executable
  - No runtime resolving
  - Huge size
  - Lots of unnecessary code
- Dynamic:
  - External functions loaded from external libraries
  - Addresses resolved in the runtime
  - Smaller size
  - Only few functions exposed via direct addresses
  - Entire library still loaded into the memory

NX bit + Data Execution Prevention

- Disables on a CPU level ability to execute code from a given page in memory (rw-p)
- Disables execution from a stack and heap (no shellcode)
- Can be modified using mprotect syscall
- Usually only Read+Execute or Read+Write access to a page
- Page based for a CPU, not necessarily for a system (if there are two sections on a same page, one RW and one RX they both become RWX)

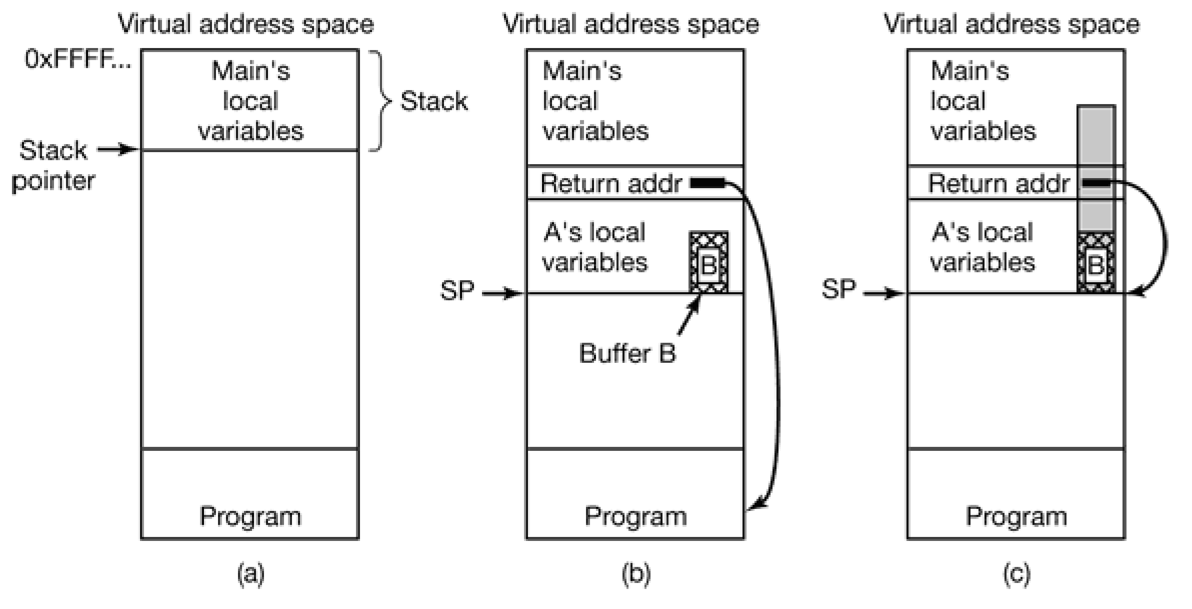
Stack Canaries (Protectors)

- Random number protecting return pointer
- Placed on a stack at the start of the function
- Checked just before returning
- Might be low entropy (predictable)
- Doesn’t protect other variables on the stack
- Can be bypassed if memory leak is present or arbitrary write

Shadow Stack

- Return pointer is duplicated and placed on two stacks
- On return they are both compared
- If different then crash

Stack Overflow



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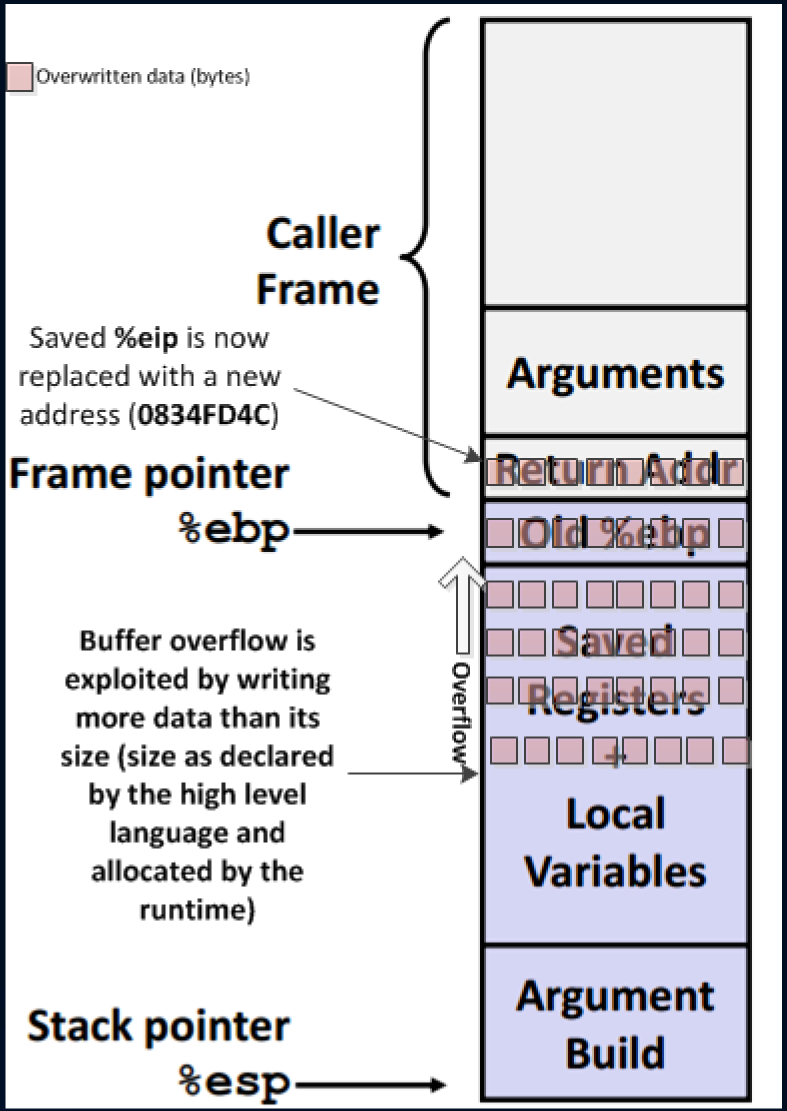

Saved **%eip** is now replaced with a new address (**0834FD4C**)

Buffer overflow is exploited by writing more data than its size (size as declared by the high level language and allocated by the runtime)

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```
void function(int a, char* b) {
        int test;
        long long ago; // in a galaxy far far away
        float var;
        char text[10];
}
```

	char* b (64 bit)
	int a (32 bit)
	PADDING (32 bit)
	Return Pointer (64 bit) --
RBP->	Saved Base Pointer (64 bit) --
	PADDING (32 bit)
	int test (32 bit)
	long long ago (64 bit) --
	PADDING (32 bit)
	float var (32 bit)
	PADDING (48 bit)
RSP->	Char text[10] (80 bit) ---

Common overflow scenarios

- gets
- strcpy (NULL!!!)
- while (char != null)
- Different sizes for buffer and passed to read/fgets/…

Exploitation techniques

- Check if NX bit is present
- Ret2Reg -> call RAX + shellcode
- Leaked stack address + shellcode
- NOP-sled can be helpful

Format String Vulnerability

- Check what’s available on the stack
  - %1$016llx -> %2$016llx -> …
- Chain them
  - %1$016llx:%2$016llx -> …
- Try to locate at which point you start processing your own string
- Change of the string length changes the offsets!
- Interesting targets to leak:
  - Return pointer
  - Stack pointer
  - Variables
  - Code segments (RWX?)
  - Canary

Essential Tools

- strings -tx /bin/bash | grep /bin/sh
- readelf -s /bin/bash | grep main
- objdump -d /bin/bash | grep -A 3 –B 3 "callq.*rax“
- ldd /bin/bash
- readelf -a /bin/bash
- radare2
- gdb + GEF
  - vmmap
  - checksec

Challenge

```
curl https://bit.ly/2HE1Ti4 | sh
```