Hacker&co.

or

how I learned to demystify cyber attacks and love the security

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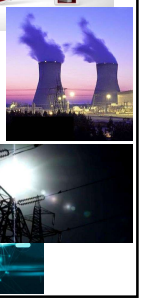
Security? No, thank you!

cyber-crime more and more organized
- new paradigm: malware-as-a-service
- malware built with development tools, e.g. TOX malware

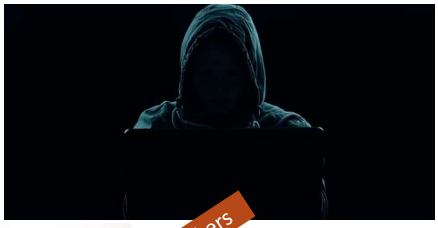
virus / worm / trojan horse / ransomware
- e.g. Wanna Cry income about 130M$
- Mirai: DDoS based on IoT

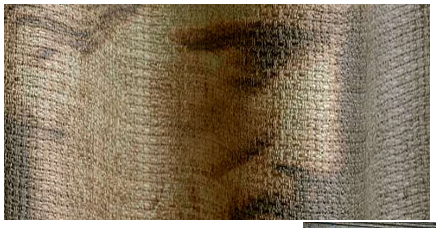
infrastructures at risk
- USA dams reported as vulnerable
- Stuxnet: spin dryers for Uranium enrichment
- Black Energy: 230k Ukrainians without electricity
  - APT (Advanced Persistent Threat)
- cars too much connected
  …and too much vulnerable (BlueBorn)
- cloud and fog?



BlueBorne

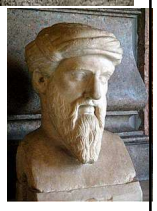
Hackers&co.: media strategy





crackers

- hackers are surrounded of an aura of mystery
  - a similar strategy used in the past
- newspaper focus on the consequences of attacks, ethical aspects, cyberwar, politics, etc.
- this talk aims a (partially) answering the question…



…but what are these people doing?

A silly program…

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#include <stdio.h>

void func(int a, int b, int c){
      int response = 0;
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      gets(buffer);
      if(response == 42)
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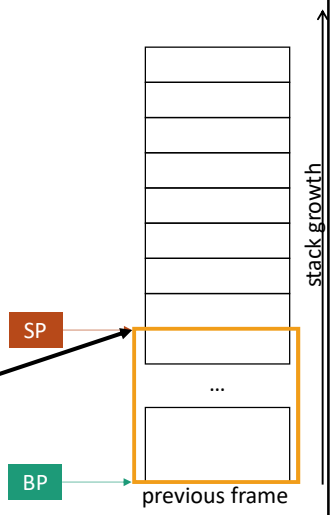

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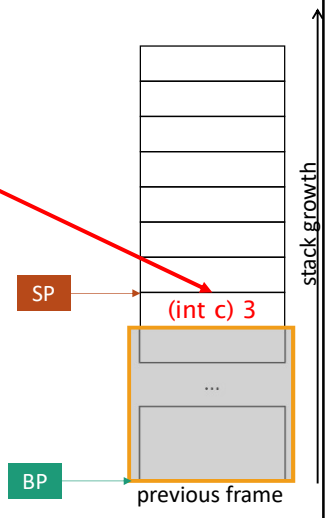

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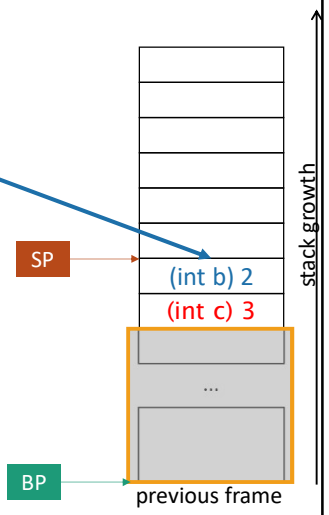

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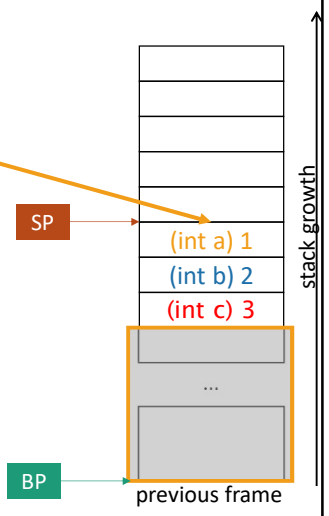

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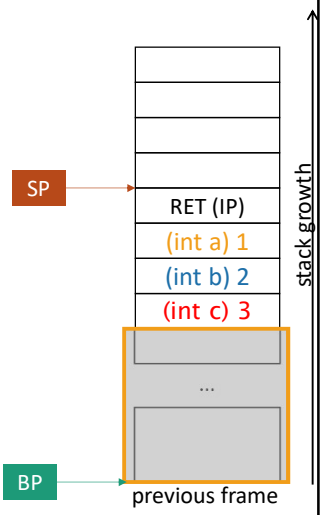

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0x56556252 <+36>:    call   0x56556030 <printf@plt>
0x56556257 <+41>:    add    esp,0x10
0x5655625a <+44>:    sub    esp,0x4
0x5655625d <+47>:    push   0x3
0x5655625f <+49>:    push   0x2
0x56556261 <+51>:    push   0x1
0x56556263 <+53>:    call   0x565561b9 <func>
0x56556268 <+58>:    add    esp,0x10
0x5655626b <+61>:    sub    esp,0xc
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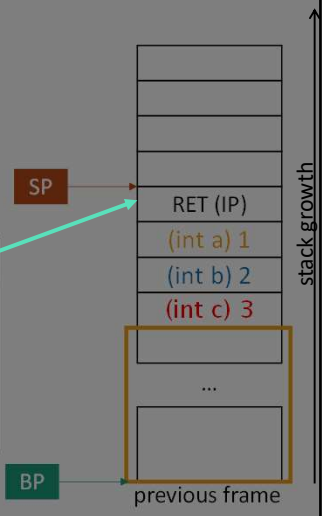

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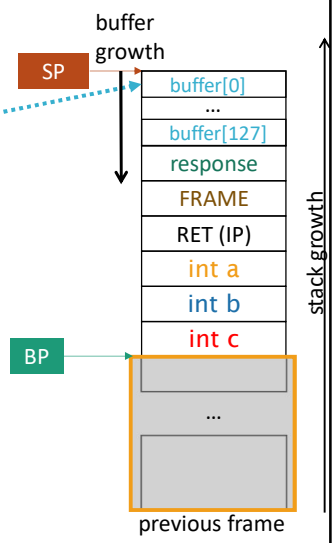

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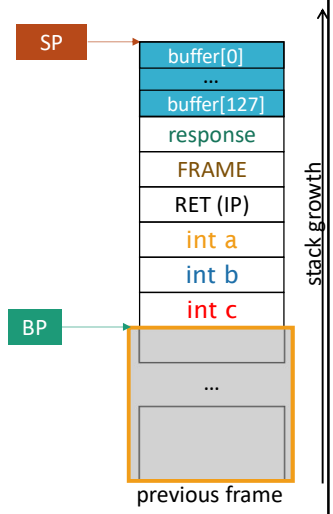
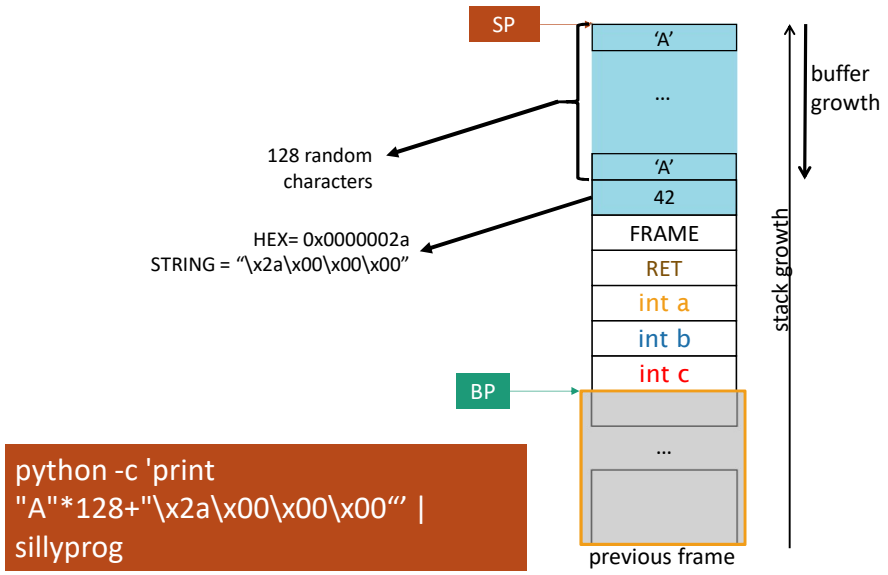
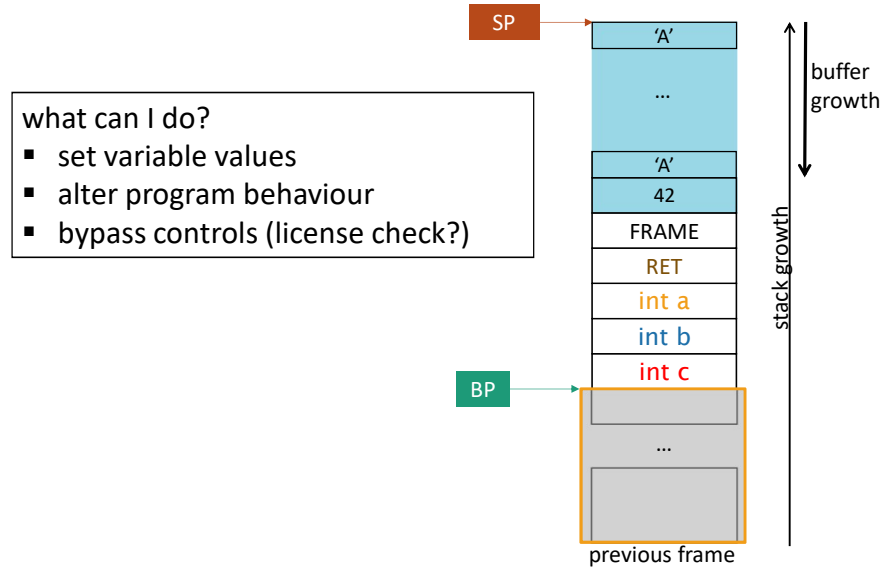


A simple buffer overflow




```
python -c 'print "A"*128+"\x2a\x00\x00\x00"' | sillyprog
```

A simple buffer overflow

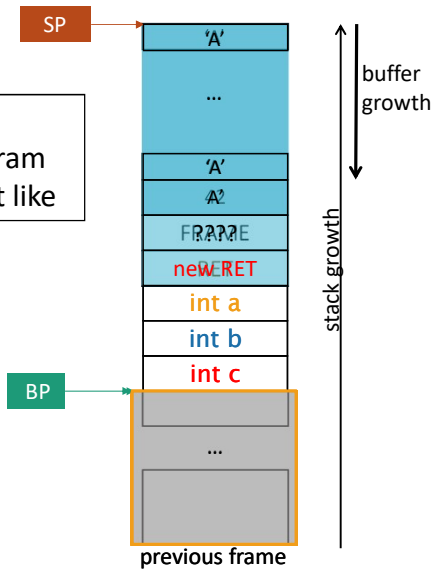


what can I do?

- set variable values
- alter program behaviour
- bypass controls (license check?)

Can I do something better?

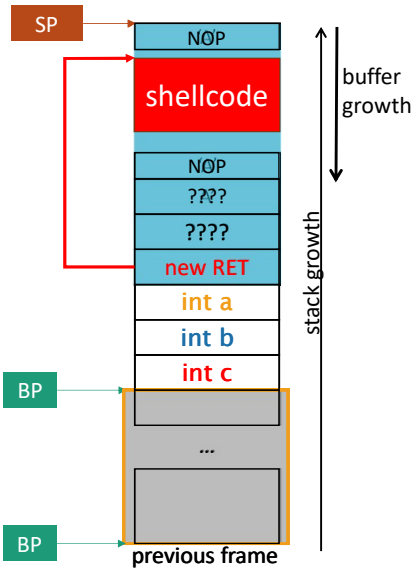
what can I do?
- jump to anywhere in the program
- skip pieces of code that I don't like



Can I do something even better?

open a shell on a remote host and (if possible) set root privileges!

different levels of politeness



Shellcode

small piece of code used as the payload in the exploitation of a software vulnerability.

Reverse Shell

- if calls the attacker, who acts as a server

several available on the web

- http://shell-storm.org/shellcode/
- with different sizes (in bytes)
- for different architectures and OSes
- with different purposes
  - create users and add password
  - read /etc/passwd
  - setuid(0) → become root, setreuid() → real user
  - flush iptables DB

Shellcode

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Reverse Shell

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several available on the web

```
"\x31\xc0\xb0\x19\x50\xcd\x80\x50 "
"\x50\x31\xc0\xb0\x7e\x50\xcd\x80" //setreuid(geteuid(),getuid());
"\xeb\x0d\x5f\x31\xc0\x50\x89\xe2 "
"\x52\x57\x54\xb0\x3b\xcd\x80\xe8"
"\xee\xff\xff\xff/bin/sh" // exec(/bin/sh)
```

- read /etc/passwd
- setuid(0) → become root, setreuid() → real user
- flush iptables DB

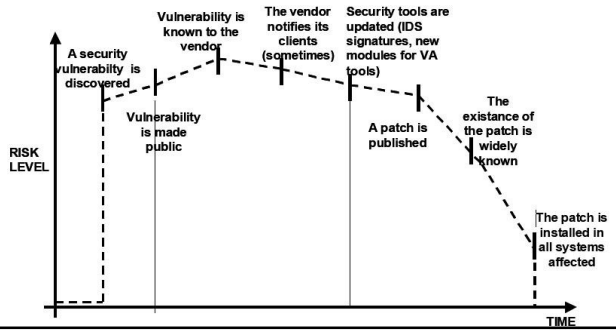
Exploitation

once you find a vulnerability in the code…

- …automate the process
- = write a script that provides the proper payload!

the vulnerability can be used everywhere by everyone

- e.g., with the Metasploit framework
- script kiddies



Data Execution Prevention (DEP)

why execute code from data segments?

- only makes code segments as executable
- not Writable and Executable at the same time
  - aka NX, XN, XD, W^X
  - 2004, Linux Kernel 2.6.8, Windows XP SP2
  - 2006, Mac OSX 10.5

running code on write-only segments →segmentation fault

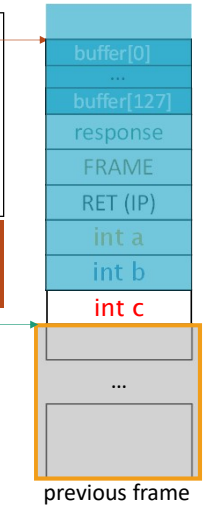
- data segments (RW)
  - Stack, Heap, .bss, .ro, .data
- code segments (RX)
  - .text, .plt

check all with: `objectdump -h program_name`

Stack canaries

canaries = random values
- added in the stack after each call
- checked at function exit by the OS
- same for all functions
- different at each execution

to overwrite the return address you 'kill the canary'



Address Space Layout Randomization

randomize the memory location where
- system executables are loaded
- attackers cannot use fixed addresses obtained by debugging the application offline
  - e.g., the stack address
  - exploits built without ASLR do not work
    - guessing is needed / brute force
  - detect crashes associated with ASLR
- or use more leaks to perform buffer overflow attacks
  - if you know the base address with different ways
    - you can reuse the same offsets

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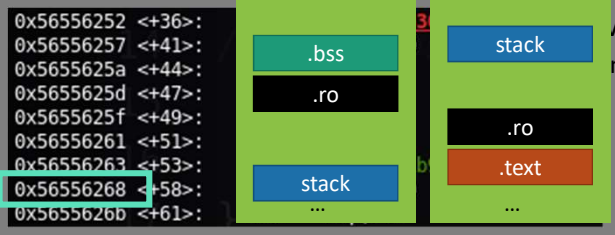
  - exploit
    - gu
  - detect



verflow attacks
nt ways

Return Oriented Programming (ROP)

there's plenty of code in a program

- not needed to write the shellcode
  - just borrow pieces from the target program
- however, not that easy!

jumping on a different part of the program means loosing the control

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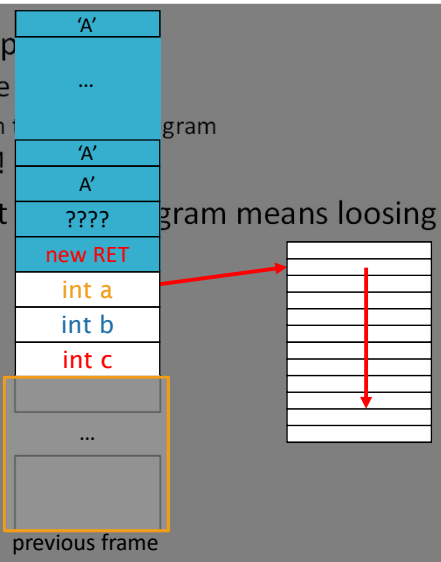

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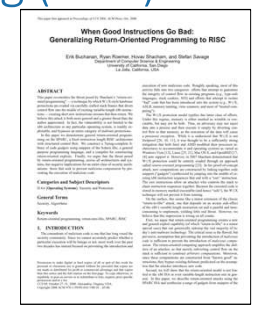

When Good Instructions Go Bad:
Generalizing Return-Oriented Programming to RISC

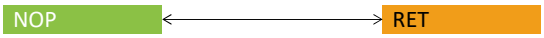
look for gadgets in the program (e.g. with `ropgadget`)
- sequence of meaningful instructions followed by a RET

`xor eax, eax` `ret`	zero EAX	`pop eax` `ret`	remove one word from the stack

`add eax, ebx`
`ret`
	sum	`pop ebx`
		`pop eax`
		`ret`
			remove two words from the stack

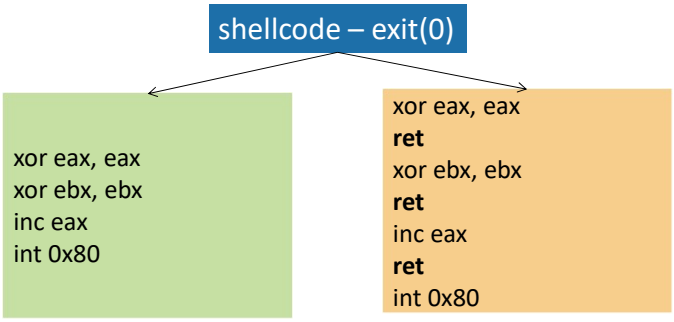
ROP: an example

gadgets found in the program form a new instruction set



ROPing: write shellcode by chaining gadgets

- not guaranteed it is possible



inspired by Markus Gaasedelen Dep&ROP course

ROP: an example

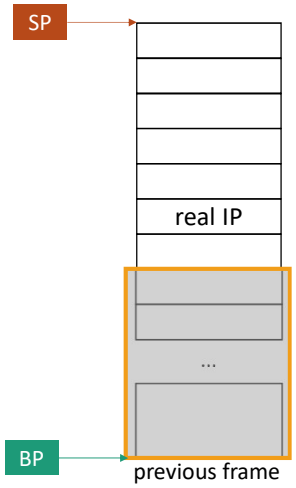
gadgets

addr1: xor eax, eax
ret

addr2: xor ebx, ebx
ret

addr3: inc eax
ret

addr4: int 0x80



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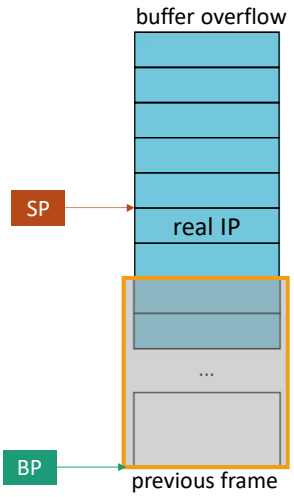

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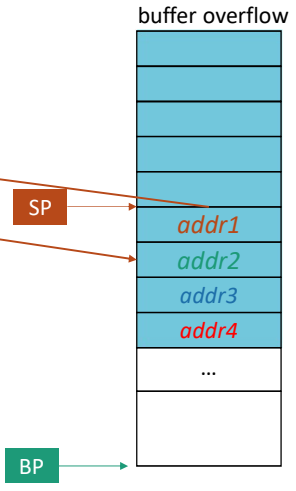

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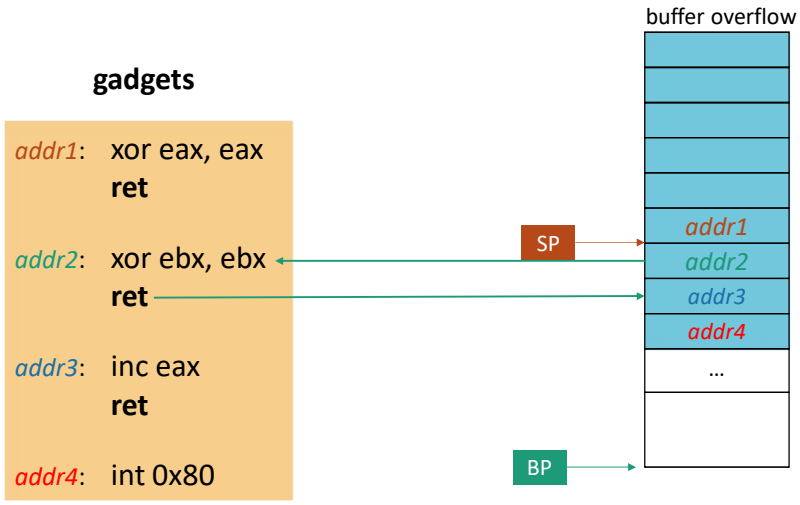

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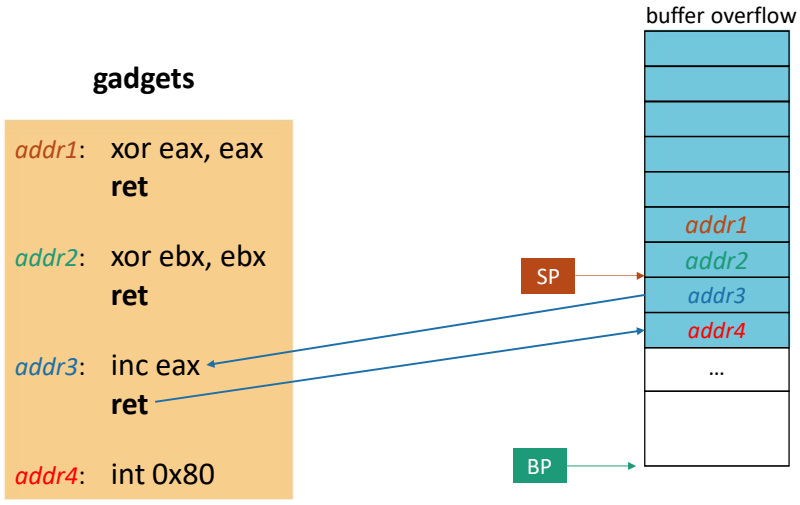

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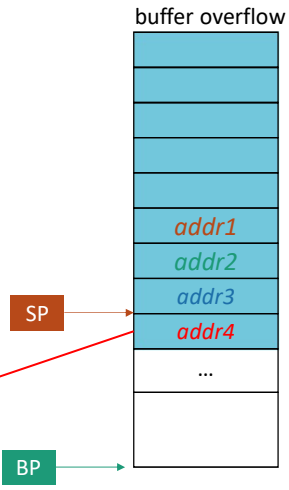


Ret2libc


The Geometry of Innocent Flesh on the Bone:
Return-into-libc without Function Calls (on the x86)

what is the best mine of code-to-borrow?

- the C standard library!
  - e.g., system(), open(), read(), write()

if libc is available in the program…

- return to libc functions instead of using gadgets
- just find the addresses of the functions you want to ROP
  - in general, ret2libc a lot easier than making a ROP chain

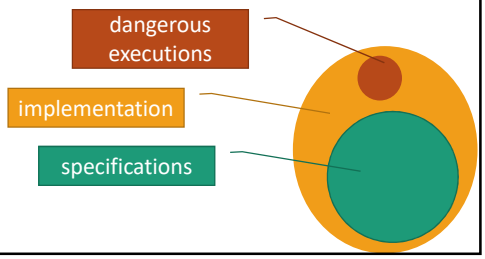
ret2libc techniques does not use the *call* instruction

- the stack must be properly prepared to have the same data the *call* would have put
  - leave room for the return address
    - in order to properly place the input parameters to the function to call

The security approach?

thinking about security consequences is not in the usual mind set of designers

- engineers solve problems
  - …from specifications
- attackers can change the designers' perspective
  - imagine new ways to abuse the specifications
- reactions and corrections, in any case, will arrive late
- design test beds are not necessarily the best way to test the implementations
  - fuzzy testing is limited (random errors?)
- best practice can reduce the attack surface



Software protection

we cannot rely on OS protections to avoid software to be compromised

- with proper effort, new attack strategies, etc.
  - …and by using human errors (and explicitly added backdoors)
- …software will be attacked

software protections are code transformation and infrastructure components that aim at reducing the risks

- …making them economically disadvantageous
- reduce code understandability (obfuscation)
- detect and/or react to modifications (anti-tampering techniques, local and remote)
- diversify software copies
- dynamically modify code at run-time
  - with or without HW

Software attestation

family of anti-tampering techniques

binary integrity: check that loaded binaries (or in memory during execution) are the original ones

- limited, several attacks possible without altering binaries
- easy attacks in literature
  - e.g., modify the execution environment: system calls, TLB

trusted computing approaches are not the solution

- not usable in complex scenarios
  - work for small pieces of software with specific functionalities

execution correctness: check that what is actually executed behaves as expected

- behavioural attestation
  - still an open issue!

Execution correctness

we have investigated the use of invariants…

- predicates built on variables' values
  - true if the software is working as expected
- likely invariants are just 'statistically true'
  - true only in the collected execution traces

literature analysis depicted invariants monitoring as a very promising technique

- …but we proved that they are (almost) useless
  - the inference "violation of invariants if and only if the software is not behaving as expected" is in general false

therefore we will concentrate on different types of integrity evidences…

- symbolic analysis? Other abstract interpretations?