Revamping Security Patching with Virtual Patches

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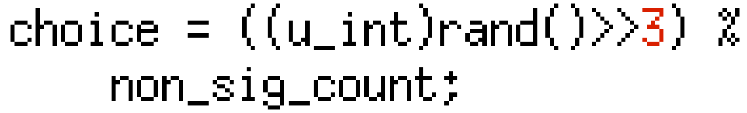
Problem

- Conventional security patching is ineffective
  - Users don't patch their systems in time
- Why don't people patch?
  - Patches are unreliable
  - Patches are disruptive
  - Patches are irreversible
- We need to rethink the way we create and apply security patches

A simple observation

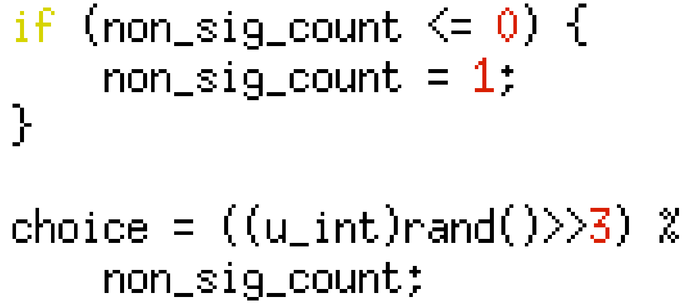
- Many existing security patches have two parts:
  1. a check
  2. a fix
- Many bug fixes can be written this way

Bind 8.2.2 division by 0 bug



```
choice = ((u_int)rand()>>3) %
      non_sig_count;
```

Bind 8.2.2 vendor patch



```
if (non_sig_count <= 0) {
      non_sig_count = 1;
}

choice = ((u_int)rand()>>3) %
      non_sig_count;
```

What is a “virtual patch”?

- Programmer inserted code that has two clearly denoted parts:
  1. a check and
  2. a fix
- Sandbox the check, but not the fix

Bind 8.2.2 division by 0 bug

```
choice = ((u_int)rand()>>3) %
     non_sig_count;
```

Bind 8.2.2 virtual patch

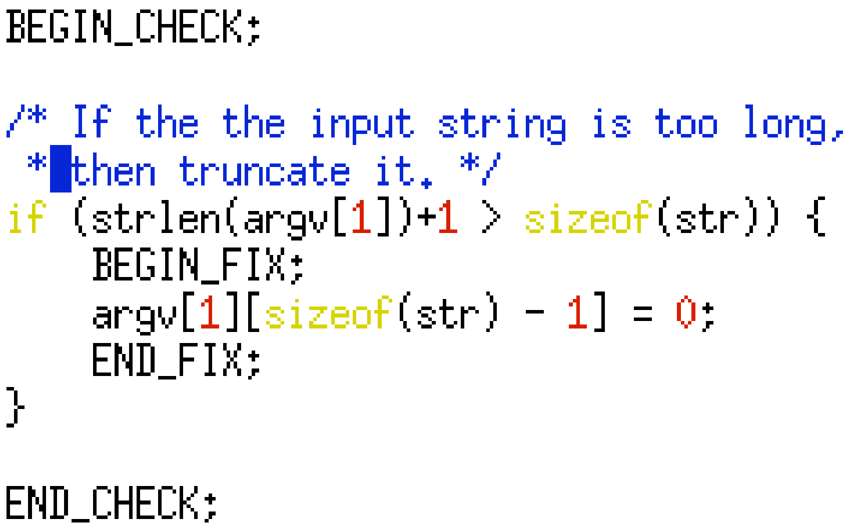
```
BEGIN_CHECK;
if (non_sig_count <= 0) {
    BEGIN_FIX;
    non_sig_count = 1;
    END_FIX;
}
END_CHECK;

choice = ((u_int)rand()>>3) %
    non_sig_count;
```

Virtual patches are reliable

- Guarantee: the patch will not side-effect your application until the fix is applied
  - Sandbox the check using Software Fault Isolation (Wahbe *et al.* '93)
  - Internally represent each check and fix as a nested C function
  - Much SFI overhead can be optimized out
    - Total overhead = ~50 cycles for patches we have tested

Sandboxing example



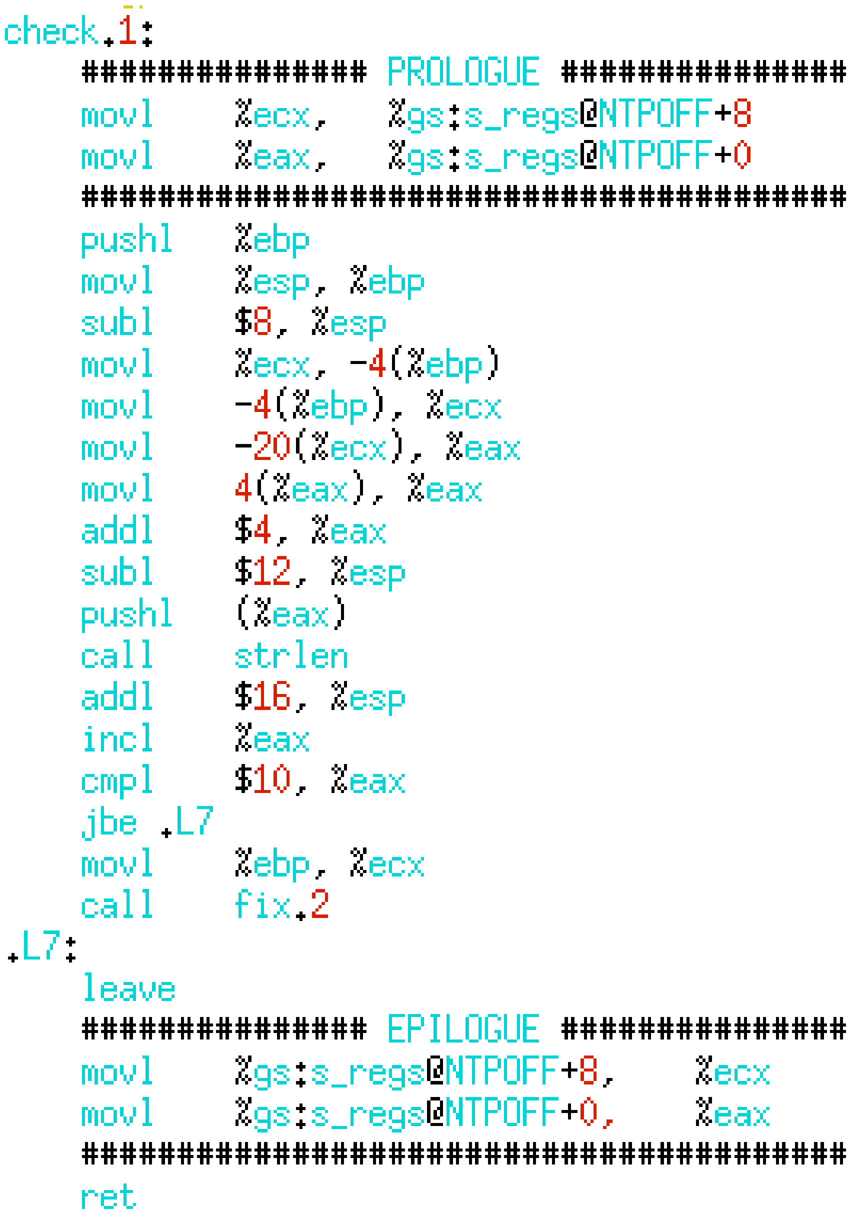
```
BEGIN_CHECK;

/* If the the input string is too long,
 * then truncate it. */
if (strlen(argv[1])+1 > sizeof(str)) {
    BEGIN_FIX;
    argv[1][sizeof(str) - 1] = 0;
    END_FIX;
}

END_CHECK;
```

Most writes are to the stack and can be statically optimized out.

Most jumps are direct and can be statically verified.



```
check.1:
    ############### PROLOGUE ###############
    movl    %ecx,   %gs:s_regs@NTPOFF+8
    movl    %eax,   %gs:s_regs@NTPOFF+0
    ########################################
    pushl   %ebp
    movl    %esp, %ebp
    subl    $8, %esp
    movl    %ecx, -4(%ebp)
    movl    -4(%ebp), %ecx
    movl    -20(%ecx), %eax
    movl    4(%eax), %eax
    addl    $4, %eax
    subl    $12, %esp
    pushl   (%eax)
    call    strlen
    addl    $16, %esp
    incl    %eax
    cmpl    $10, %eax
    jbe .L7
    movl    %ebp, %ecx
    call    fix.2
.L7:
    leave
    ############### EPILOGUE ###############
    movl    %gs:s_regs@NTPOFF+8,    %ecx
    movl    %gs:s_regs@NTPOFF+0,    %eax
    ########################################
    ret
```

Virtual patches are non-disruptive

- Put virtual patch code in dynamic library
- Use ptrace(2) to:
  - Dynamically load the virtual patch DLL
  - Modify process to invoke virtual patch code at programmer inserted location
- ==> Virtual patches are reversible

Is it practical?

- Problem: programmer has to explicitly denote the check and the fix
  - Departs from established patching practices
- Question: is it possible to automatically derive the check and fix?
  - Assume you have access to the conventional security patch
- Conjecture: there exists a virtual patch for any conventional security patch

Limitations

- Patch programmer may screw up the check
  - False negatives - benign
  - False positives - dangerous
- Patch programmer may screw up the fix
  - Program may crash or worse…