Static Analysis of a Linux Distribution

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How to find programming mistakes efficiently?

0. users (preferably volunteers)

1. Automatic Bug Reporting Tool

2. code review, automated tests

3. static analysis!
Static Analysis

- is a good alternative to testing,
- can detect bugs fully automatically,
- can detect bugs before the code even runs!
Agenda

1. Terminology

2. Static Analysis of a Linux Distribution
Linux Distribution

- operating system (OS)
- based on the Linux kernel
- a lot of other programs running in user space
- usually open source
Upstream vs. Downstream

- **upstream** SW projects – usually independent
- **downstream** distribution of upstream SW projects
  - Fedora and RHEL use the RPM package manager
  - Files on the file system owned by packages:
    - Dependencies form an oriented graph over packages.
    - We can query package database.
    - We can verify installed packages.
Fedora vs. RHEL

- **Fedora**
  - new features available early
  - driven by the community (developers, users, ...)

- **RHEL** (Red Hat Enterprise Linux)
  - stability and security of running systems
  - driven by Red Hat (and its customers)
Where do RPM packages come from?

- Developers maintain source RPM packages (SRPMs).
- Binary RPMs can be built from SRPMs using `rpmbuild`:
  ```
  rpmbuild --rebuild git-2.6.3-1.fc24.src.rpm
  ```
- Binary RPMs can be then installed on the system:
  ```
  sudo dnf install git
  ```
Reproducible builds

- Local builds are not reproducible.

- **mock** – chroot-based tool for building RPMs:
  ```bash
  mock -r fedora-rawhide-i386 git-2.6.3-1.fc24.src.rpm
  ```

- **koji** – service for scheduling build tasks
  ```bash
  koji build rawhide git-2.6.3-1.fc24.src.rpm
  ```
Agenda

1. Terminology

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Static Analysis of a Linux Distribution

- approx. 150 Million lines of C/C++ code in RHEL-7
- huge number of (potential?) defects in certain projects
- thousands of packages developed independently of each other
- no control over technologies and programming languages
- no control over upstream coding style
Which static analyzers?

- Not many of them are ready for scanning a Linux distribution.
- Some analyzers are tweaked for a particular project (e.g. sparse for kernel).
- Using a single static analyzer appeared to be insufficient.
- How to combine multiple static analyzers efficiently?
- Currently supported by csmock: GCC, Clang, Cppcheck, Shellcheck, Pylint, Coverity
What is important for developers?

The static analysis tools need to:

- be fully automatic
- provide reasonable signal to noise ratio
- be approximately as fast as compilation of the package
- deliver results in a predictable amount of time \( \Rightarrow \) timeouts!
Research Prototypes

- Researchers are done when their tool works on a few examples of their choice. (phase 0)

- SW companies are interested in tools that can reliably process a significant amount of their code base. (phase 1)

- 99% of work on developing a successful tool is the transition: phase 0 → phase 1

- example – Predator: 
  http://www.fit.vutbr.cz/research/groups/verifit/tools/predator
Priority Assessment Problem

- Developers say:

  "I have 200+ already known bugs in my project waiting for a fix. Why should I care about additional bugs that users are not aware of yet?"

- Not all defects are equally important to be fixed!

- Scoring systems like CWE (Common Weakness Enumeration)

- ... but none of them is universally applicable.
Differential scans

- We know that our packages contain a lot of potential bugs.
- It is easy to create new bugs while trying to fix existing bugs.
- Which bugs were **added/fixed** in an update of something?
- An example using the `csbuild` utility – demo:

```
% csbuild -c "make -j5"
% csbuild -g curl-7_40_0..master -c "make -j5"
% csbuild -g curl-7_40_0..master --git-bisect \
  -c "make clean && make -j5"
```
Upstream vs. Enterprise

Different approaches to (differential) static analysis:

**Upstream**

- Fix as many defects as possible.
- False positive ratio increases over time!

**Enterprise**

- Need to verify code changes in ancient SW.
- 5–10% of defects are usually detected as new in an update.
- 5–10% of them are usually confirmed as real by developers.
Processing the Results of Static Analysis

- Some tools come with a user interface for waiving defects.
- Per-defect waivers do not scale for a Linux distribution.
- Certain developers prefer to use terminal over web browser.
- Utilities processing text line-by-line are not optimal for this:
  
  ```
  grep → csgrep
  sort → cssort
  ...
  ```
  
  https://github.com/kdudka/csdiff
Continuous Integration

- It is expensive to fix bugs detected late in the release schedule.

- It is difficult and risky to fix bugs in already released products.

- We would like to catch bugs at the time they are created.

- An example using the csbuild utility – demo:

```bash
csbuild -c "./buildconf && ./configure && make -j5" \   
   --install libtool --git-bisect \   
   --gen-travis-yml > .travis.yml

git add .travis.yml
git commit -m "notify me about newly introduced defects"
```

```bash
git push
```