Università di Catania

Fuzzing: the art of discovering vulnerabilities in an automated way

Marcello Maugeri

Hardening 7

Agenda

1. Introduction to Fuzz Testing
2. Input-based Taxonomy
3. Knowledge-based Taxonomy
4. Demo
5. Reflections

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Functional Testing VS Non-Functional Testing

User view

- Unit Testing
- Integration Testing
- System Testing
- ...

Attacker view

- Performance Testing
- Compliance Testing
- Security Testing
- ...

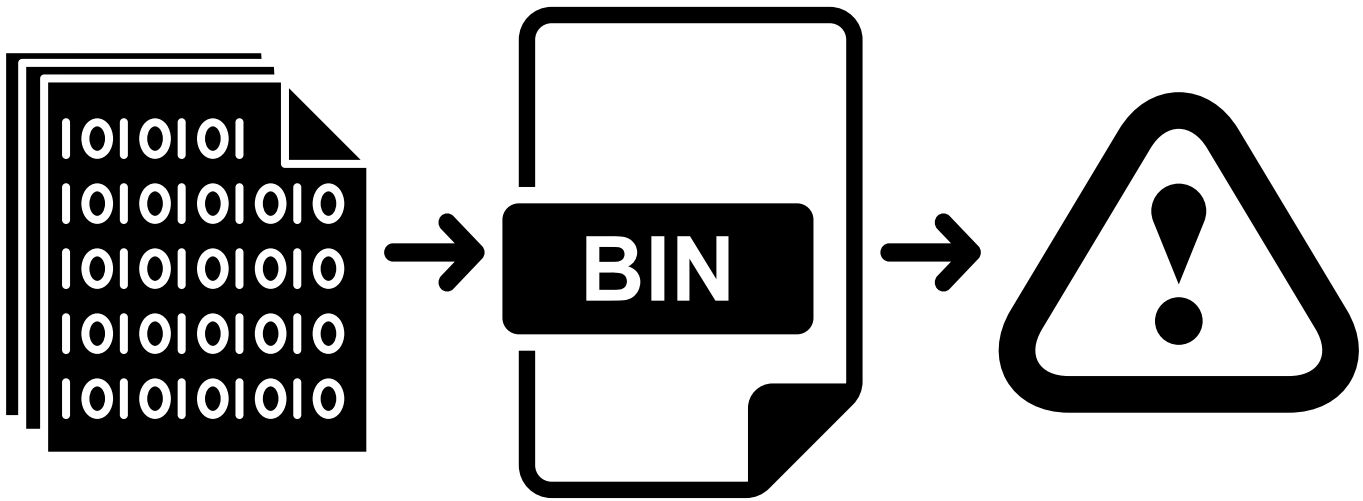
Security Testing

- Static Analysis
- Manual Code Inspection
- Dynamic Analysis

Patrice Godefroid. 2020. Fuzzing: hack, art, and science.

Fuzz testing

Fuzz Testing, or fuzzing, is a software testing technique that involves providing invalid, unexpected, or random test inputs to the software system under test. The system is then monitored for crashes and other undesirable behaviour.[1]



[1] Okun, V. and Fong, E. (2015), Fuzz Testing for Software Assurance

History of Fuzzing

The name was given by Miller et al.[2] to denote the *fuzz* utility.

[2] Barton P. Miller, Lars Fredriksen, and Bryan So. 1990. An empirical study of the reliability of UNIX utilities.

Some taxonomies

- Input-based
  1. Generation-based
  2. Mutation-based
  3. Structure-aware
- Knowledge-based
  1. Black-box fuzzing
  2. White-box fuzzing
  3. Gray-box fuzzing

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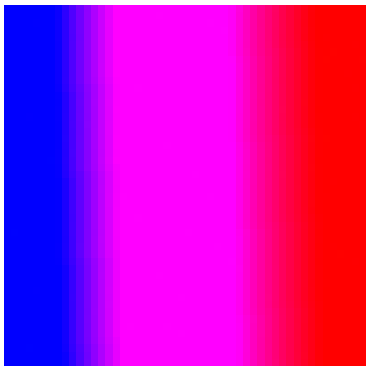
Generation-based



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Mutation-based

http://www.google.com/search?q=fuzzing

Dopo 1 mutazione: ’http://www.google.com/search?q=fuz:ing’
Dopo 5 mutazioni: ’http:/L/www.googlej.com/seaRchq=fuz:ing’
Dopo 10 mutazioni: ’http:/L/www.ggoWglej.com/seaRchqfu:in’
Dopo 15 mutazioni: ’http:/L/wwggoWglej.com/seaR3hqf,u:in’
Dopo 20 mutazioni: ’htt://wwggoVgle”j.som/seaR3hqf,u:in’

Structure-Aware

```
message SQLQueries {
    repeated CreateTable queries = 1;
}

message CreateTable {
    optional TempModifier temp_table = 1;
    required Table table = 2;
    required ColumnDef col_def = 3;
    repeated ColumnDef extra_col_defs = 4;
    repeated TableConstraint table_constraints = 5;
    required bool without_rowid = 6;
}
```

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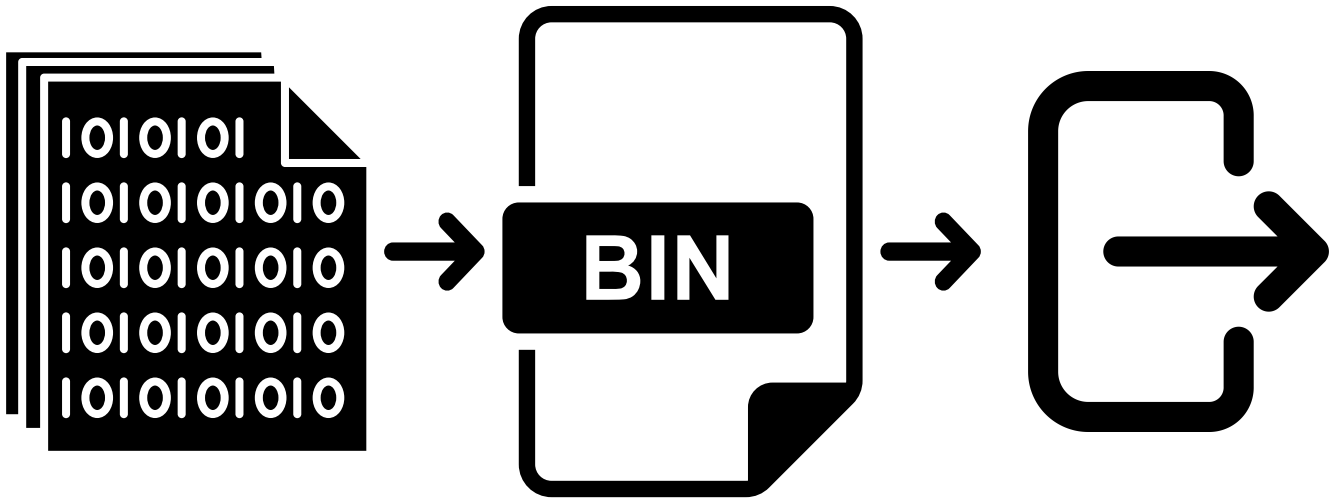
Black-box Fuzzing



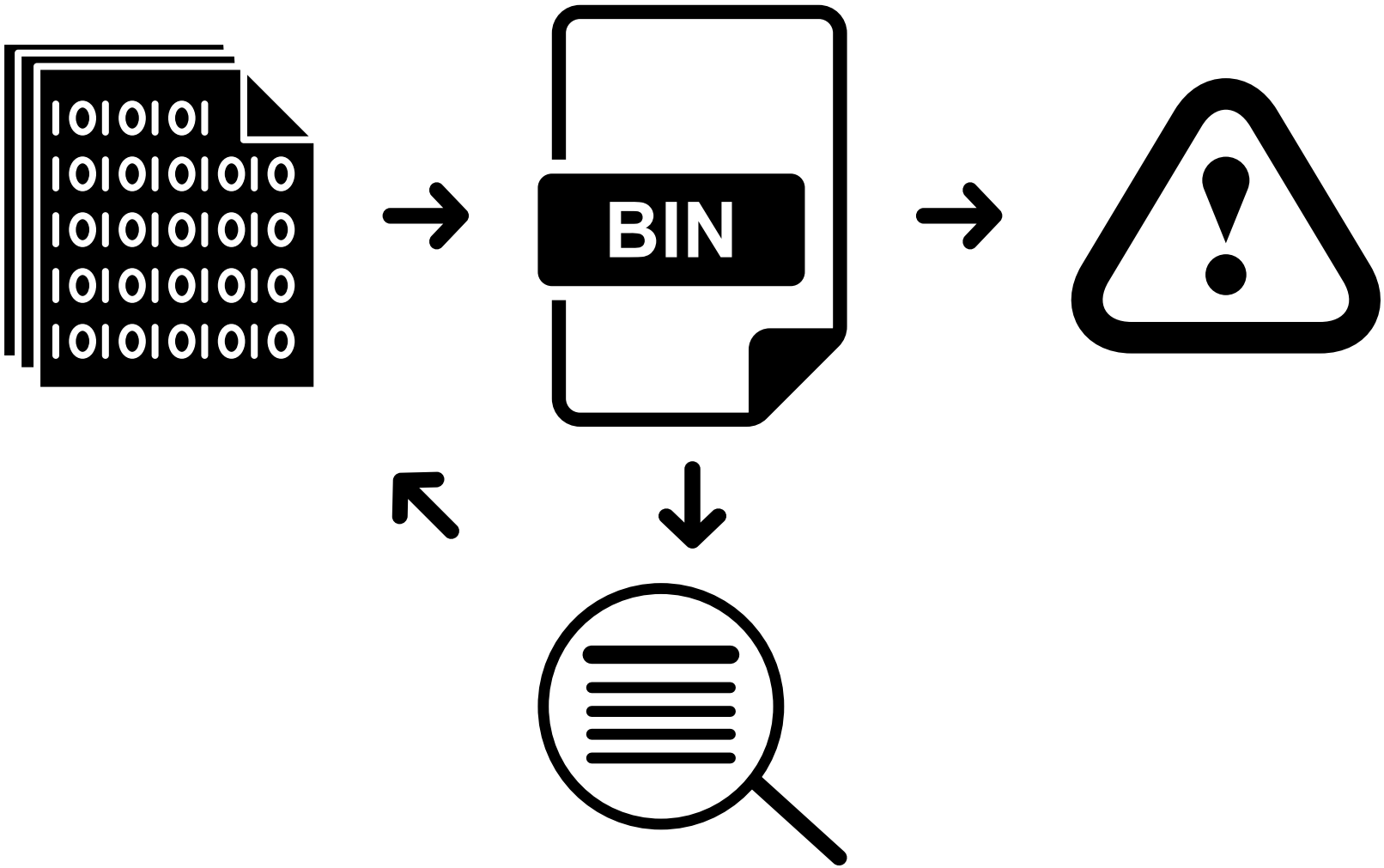
White-box Fuzzing (Symbolic Execution)

Steps: [3]

1. Run the code with some initial well-formed input
2. Collect constraints on input with symbolic execution
3. Generate new constraints (by negating constraints one by one)
4. Solve constraints with a constraint solver
5. Synthesize new inputs

[3] Patrice Godefroid. 2008. Automated Whitebox Fuzz Testing

Gray-box Fuzzing (Coverage-Guided Fuzzing)



AFL++

Steps:

1. Instrument the target
2. Collect input seed
3. Start Fuzzing!

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Demo time

- First example: a simple crashing program
- Second example: CVE-2021-3156 on sudo
- Both examples available on `https://github.com/marcellomaugeri/Hardening-7-Fuzzing`

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What else?


THE #1 FUZZ TESTER EXCUSE FOR LEGITIMATELY SLACKING OFF:
"MY CODE'S FUZZING!"
HEY! GET BACK TO WORK!
FUZZING!
OH. CARRY ON.

Automation Challenges

1. How can we fuzz efficiently more types of software systems?
2. How can the fuzzer identify more types of vulnerabilities?
3. How can we improve the usability of fuzzing tools?

Böhme, Marcel, Cristian Cadar, and Abhik Roychoudhury. 2021. ”Fuzzing: Challenges and Reflections.”

Current Research

- Fork-Awareness
- Blackbox fuzzing of API

Visit *marcellomaugeri.github.io* for all my contacts

Summary

- Fuzzing is an effective technique to discover bugs
- It is automated, but not yet automatic
- Several open challenges to be faced

References

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Thank you for the attention

Q&A