Binary Fuzzing

Jon Crussell

UC Davis

February 21th, 2014

(Semi-)Automated technique that involves sending unexpected input to programs.

(Semi-)Automated technique that involves sending unexpected input to programs.

Two main techniques:

(Semi-)Automated technique that involves sending unexpected input to programs.

Two main techniques:

Mutation based: randomly mutate known (valid) inputs

(Semi-)Automated technique that involves sending unexpected input to programs.

Two main techniques:

- Mutation based: randomly mutate known (valid) inputs
- Generation based: create input from scratch based on specification

(Semi-)Automated technique that involves sending unexpected input to programs.

Two main techniques:

- Mutation based: randomly mutate known (valid) inputs
- Generation based: create input from scratch based on specification

Smart vs. Dumb

(Semi-)Automated technique that involves sending unexpected input to programs.

Two main techniques:

- Mutation based: randomly mutate known (valid) inputs
- Generation based: create input from scratch based on specification

Smart vs. Dumb

• Dumb: Knows nothing about input format

(Semi-)Automated technique that involves sending unexpected input to programs.

Two main techniques:

- Mutation based: randomly mutate known (valid) inputs
- Generation based: create input from scratch based on specification

Smart vs. Dumb

- Dumb: Knows nothing about input format
- Smart: Knows more than nothing about input format

Dumb mutative:

3

Dumb mutative:

• Take known inputs, randomly flip bits

Dumb mutative:

• Take known inputs, randomly flip bits

Smart mutative:

Dumb mutative:

• Take known inputs, randomly flip bits

Smart mutative:

• Take known inputs, randomly flip bits

3

Dumb mutative:

• Take known inputs, randomly flip bits

Smart mutative:

- Take known inputs, randomly flip bits
- Fix checksums

Dumb mutative:

• Take known inputs, randomly flip bits

Smart mutative:

- Take known inputs, randomly flip bits
- Fix checksums

Generative:

Dumb mutative:

• Take known inputs, randomly flip bits

Smart mutative:

- Take known inputs, randomly flip bits
- Fix checksums

Generative:

• All generative fuzzers should be "smart"

3

Dumb mutative:

• Take known inputs, randomly flip bits

Smart mutative:

- Take known inputs, randomly flip bits
- Fix checksums

Generative:

- All generative fuzzers should be "smart"
- Take HTTP specification, generate HTTP requests

• Find security vulnerabilities

- Find security vulnerabilities
- Find memory leaks

- Find security vulnerabilities
- Find memory leaks
- Find uncaught exceptions

- Find security vulnerabilities
- Find memory leaks
- Find uncaught exceptions
- Find differences between program versions

- Find security vulnerabilities
- Find memory leaks
- Find uncaught exceptions
- Find differences between program versions
- Fun, Profit?

• Code coverage

- Code coverage
 - Every program can be expressed as a control flow graph

- Code coverage
 - Every program can be expressed as a control flow graph
 - Effective fuzzers find less commonly used code paths

- Code coverage
 - Every program can be expressed as a control flow graph
 - Effective fuzzers find less commonly used code paths
 - Hard for mutative fuzzers to find paths not already in known inputs

- Code coverage
 - Every program can be expressed as a control flow graph
 - Effective fuzzers find less commonly used code paths
 - Hard for mutative fuzzers to find paths not already in known inputs
- Complexity

- Code coverage
 - Every program can be expressed as a control flow graph
 - Effective fuzzers find less commonly used code paths
 - Hard for mutative fuzzers to find paths not already in known inputs
- Complexity
 - How many files of length N bits?

- Code coverage
 - Every program can be expressed as a control flow graph
 - Effective fuzzers find less commonly used code paths
 - Hard for mutative fuzzers to find paths not already in known inputs
- Complexity
 - How many files of length N bits? 2^N

- Code coverage
 - Every program can be expressed as a control flow graph
 - Effective fuzzers find less commonly used code paths
 - Hard for mutative fuzzers to find paths not already in known inputs
- Complexity
 - How many files of length N bits? 2^N
 - 10 bit input

- Code coverage
 - Every program can be expressed as a control flow graph
 - Effective fuzzers find less commonly used code paths
 - Hard for mutative fuzzers to find paths not already in known inputs
- Complexity
 - How many files of length N bits? 2^N
 - 10 bit input \rightarrow 2¹⁰ = 1024 files

- Code coverage
 - Every program can be expressed as a control flow graph
 - Effective fuzzers find less commonly used code paths
 - Hard for mutative fuzzers to find paths not already in known inputs
- Complexity
 - How many files of length N bits? 2^N
 - 10 bit input \rightarrow 2¹⁰ = 1024 files
 - 1024 bit input

- Code coverage
 - Every program can be expressed as a control flow graph
 - Effective fuzzers find less commonly used code paths
 - Hard for mutative fuzzers to find paths not already in known inputs
- Complexity
 - How many files of length N bits? 2^N
 - 10 bit input $ightarrow 2^{10} = 1024$ files
 - 1024 bit input \rightarrow 2¹⁰²⁴ = 17976931348623159077293051907890247336179769789423065727 34300811577326758055009631327084773224075360211201138798 71393357658789768814416622492847430639474124377767893424 86548527630221960124609411945308295208500576883815068234 24628814739131105408272371633505106845862982399472459384 79716304835356329624224137216 files

Dumb mutative fuzzer

• Runs for *i* iterations

- Runs for *i* iterations
- For each iteration, generates one input file, randomly replacing bytes with random values

- Runs for *i* iterations
- For each iteration, generates one input file, randomly replacing bytes with random values
- \bullet Every j iterations, appends new random bytes

- Runs for *i* iterations
- For each iteration, generates one input file, randomly replacing bytes with random values
- Every j iterations, appends new random bytes
- Target: feh a "mode-based image viewer."