A Quantitative Analysis of Errors in Linux

Elvis Flesborg
@ Helenekilde Badehotel, Tisvildeleje

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About Me

- Elvis Flesborg
- Master thesis at IT University of Copenhagen
- Specialization in scalable computing
- Claus Brabrand as supervisor
- Jean Melo as co-supervisor

Objective

- Quantify errors in Linux

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- In contrast to [42bugs], which is a qualitative analysis

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- Quantify errors in Linux
- In contrast to [42bugs], which is a qualitative analysis
  - Linux has 14,172 different features
    - grep -r "^\ *config " | grep Kconfig | awk -F':' '{print $ 2}' | sort | uniq | wc
  - That is $\underline{2^{14,172}}$ different configurations minus invalid configurations.
  - More than estimated number of atoms in the known universe.

Research Questions

- How many bugs? (percentage)

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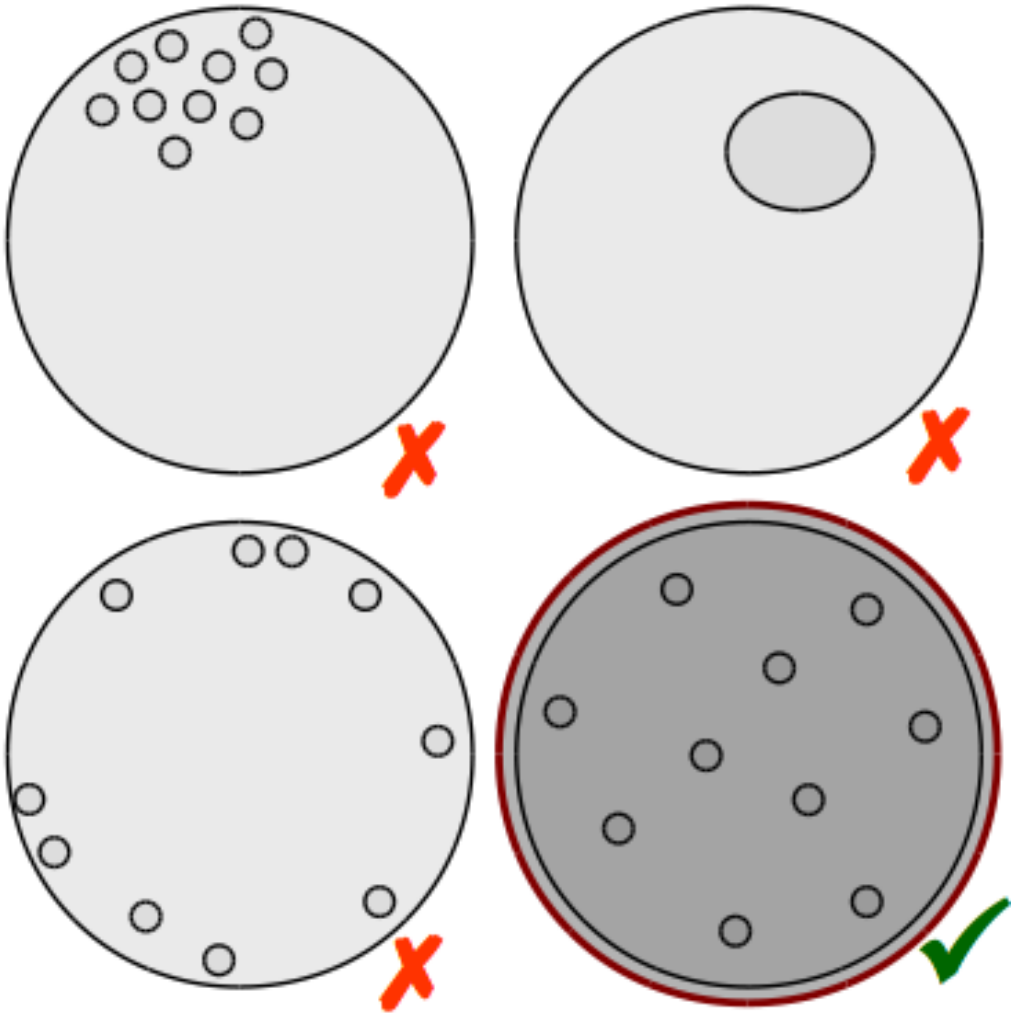
- Which features are error-prone?

Metric

- **A representative sample of configurations**



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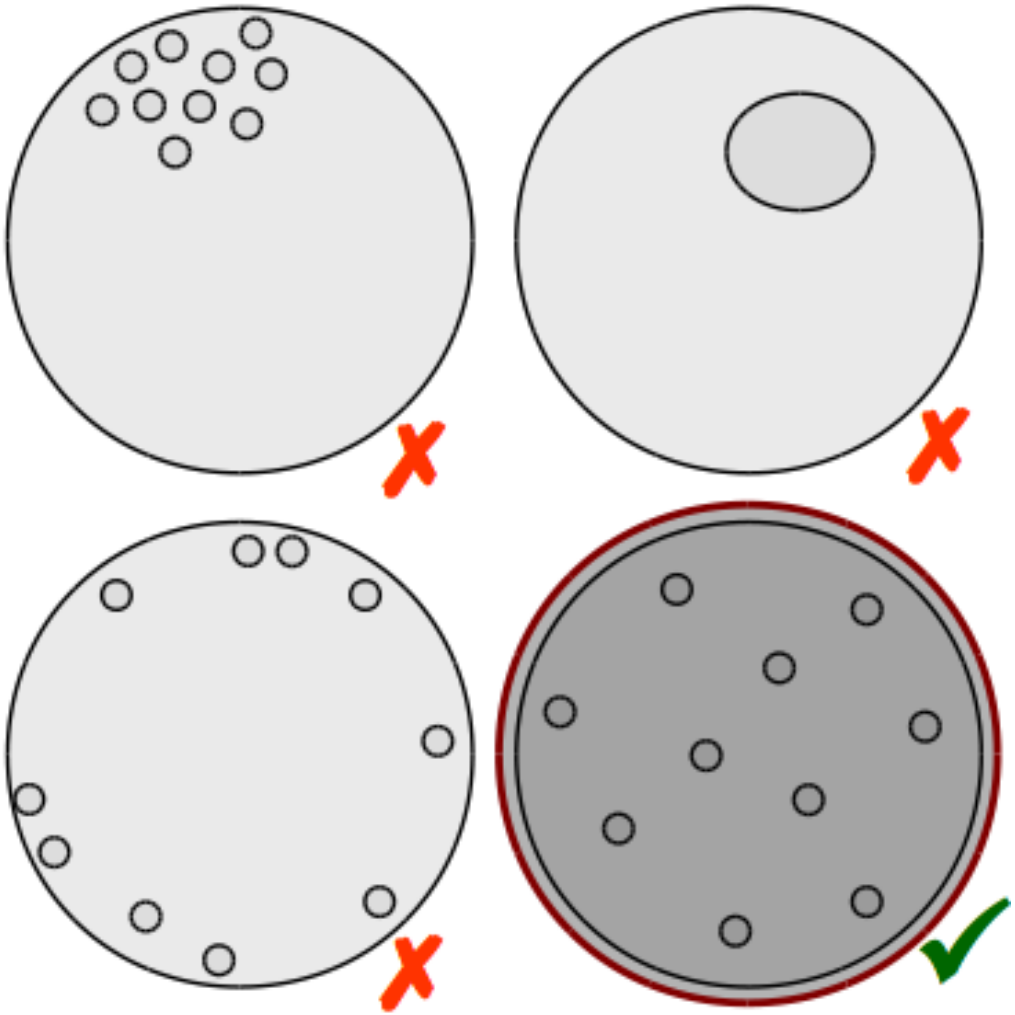

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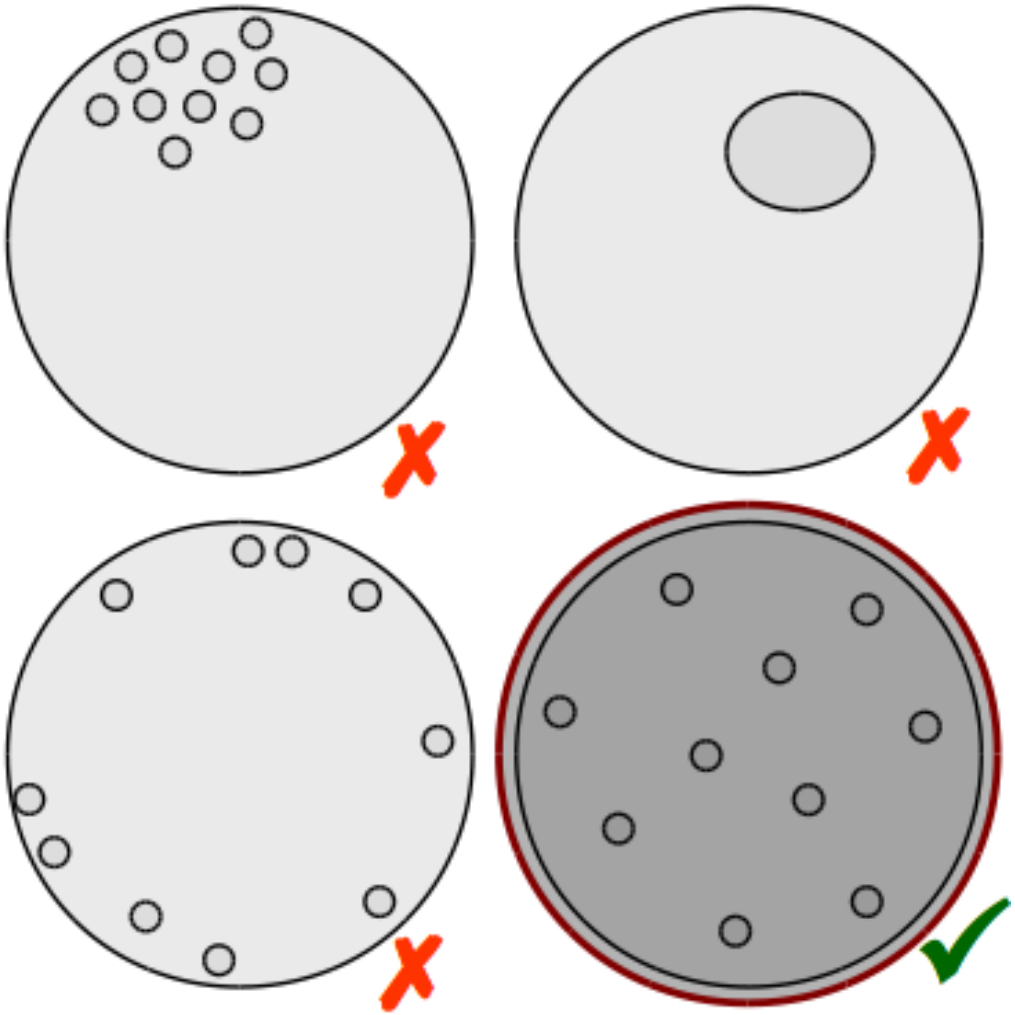

- If it is representative, I can generalize
- Need a method of generating very random configurations from the feature model

Research Questions - Revisited

- How many bugs?
- What are the most common types of bugs?
- Where are most bugs?
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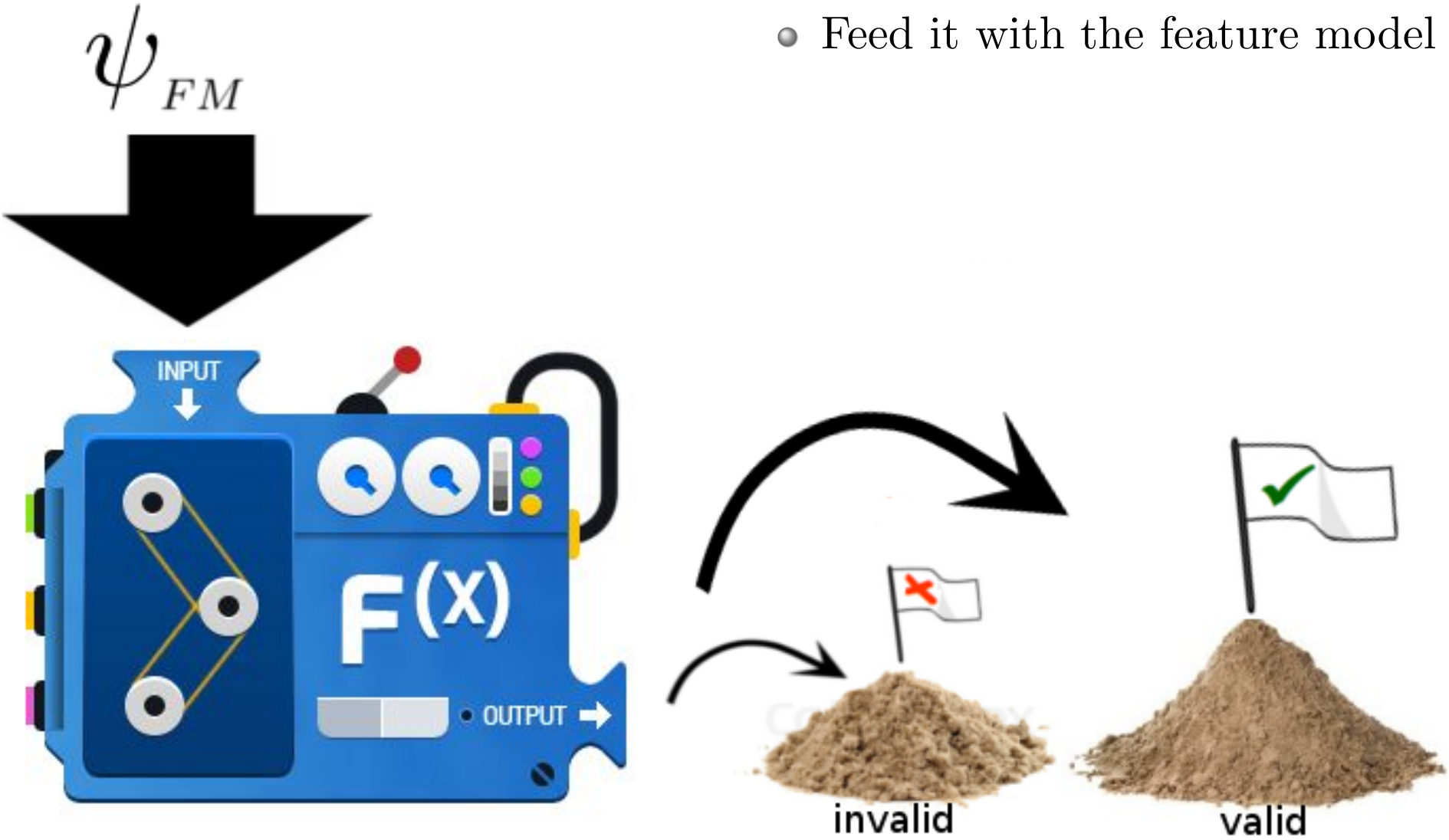
Research Questions - Revisited

- How many bugs?
- What are the most common types of bugs?
- Where are most bugs?
- Which features are error-prone?
- ... Additional questions?
- ... Prioritization?
- ... Take a few minutes to brainstorm about it
- (One-disabled vs. randconfig)

Methodology

- Feed it with the feature model



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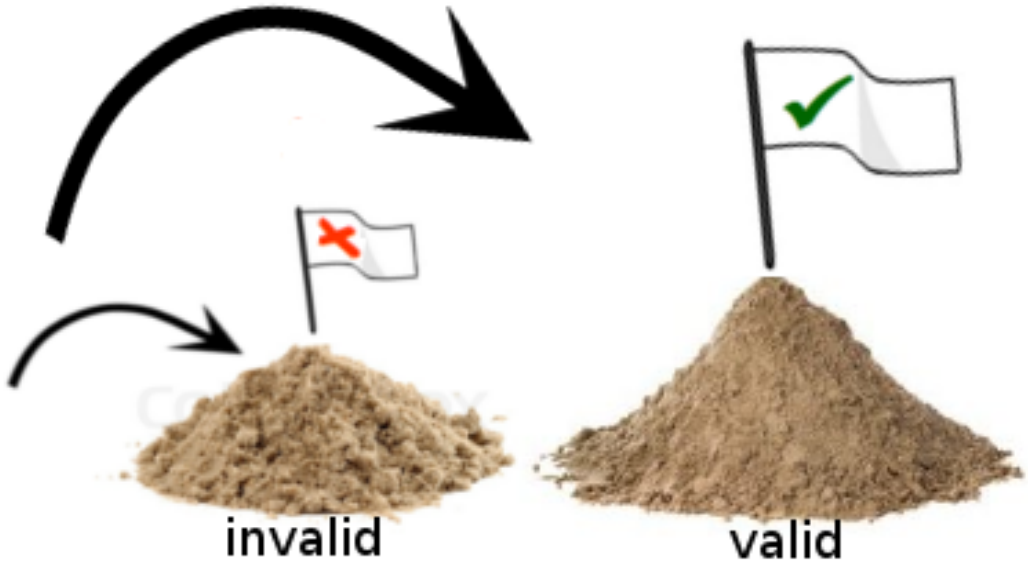
- Feed it with the feature model
- Collect κ_{random}



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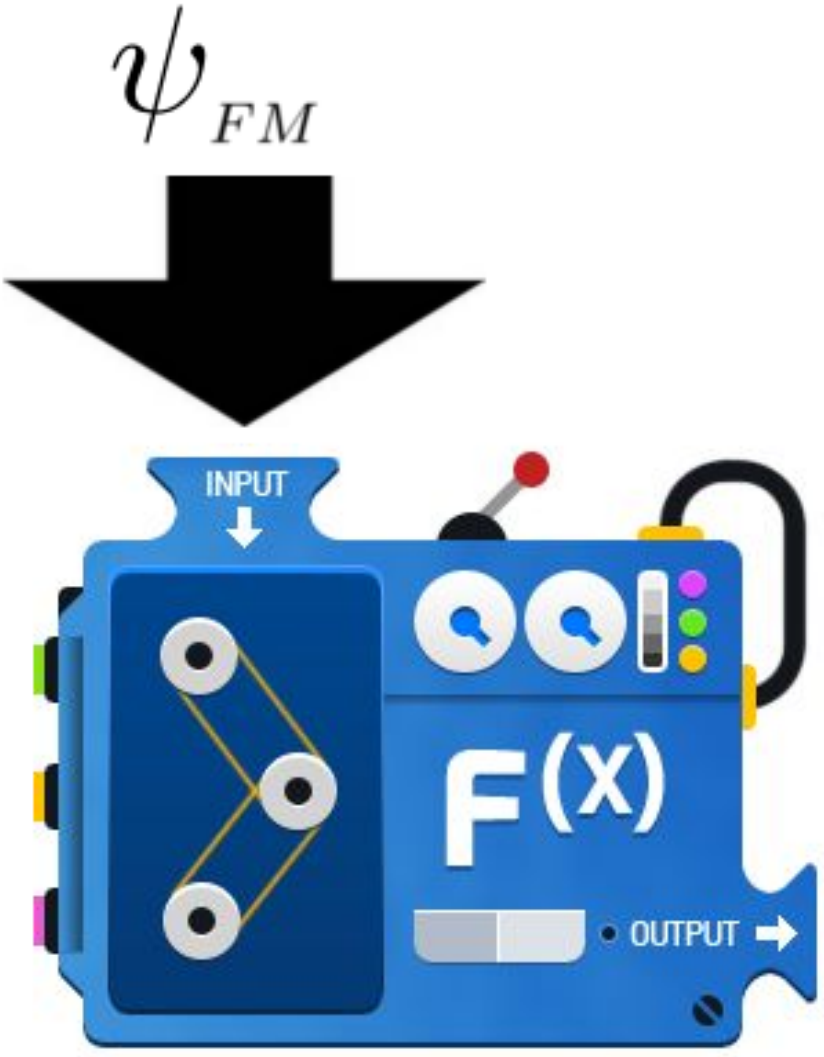
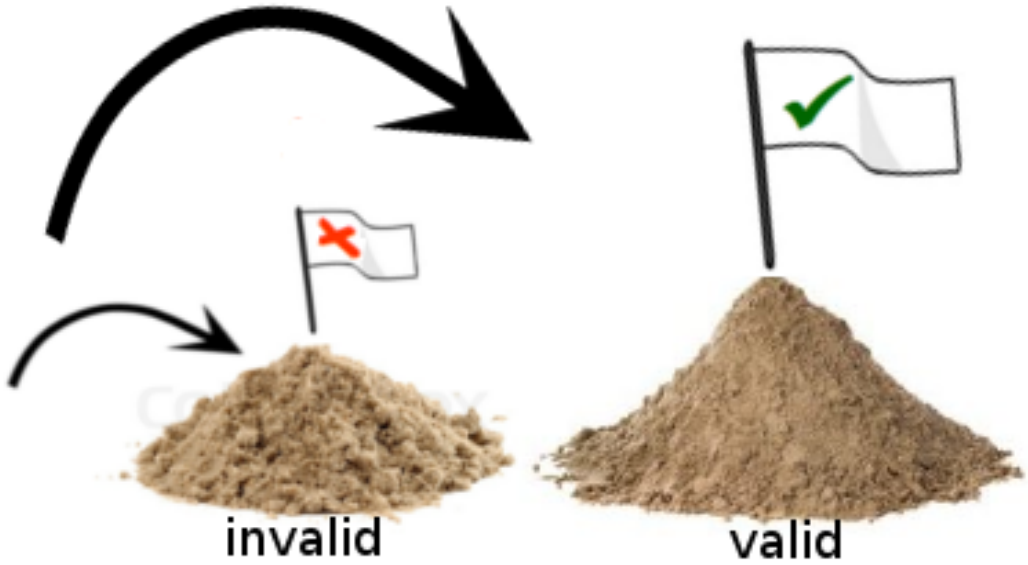


- Feed it with the feature model
- Collect κ_{random}
- Assure $\kappa_{random} \in \mathbb{K}$



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randconfig bias

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config A
    bool

config B
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  - (A) ***25%***
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- This is biased, and not representative.

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- We would prefer a totally equal probability:
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- We would prefer a totally equal probability:
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- And so maybe we could invent something

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- Same idea as *randconfig*

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- Flip a coin for every feature

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- May take much time

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Other ideas? Best solution?

Analysing - Data collection

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- Analyse one random configuration (with **gcc**)
- Save all kinds of information
  - Configuration.
  - Errors / warnings
  - Program versions (Linux / gcc)
  - Make a bug reproducable
- Do it over and over again (with a new random configuration)

Kconfig

- The language of the feature model in Linux (Busybox and others)

Kconfig

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  - Grammar
  - Data types
  - Transformation

Kconfig - Grammar

```
K ->      "config" ID TYPE OPT*
        | "if" ID K "endif"
        | "choice" K+ "endchoice"

TYPE ->   "bool" | "tristate" | "string" | "int"

OPT  ->   "default" STRING
        | "range" INT
        | "depends on" ID
        | "select" ID
```

Kconfig - Data types

```
config A
    bool
config B
    tristate
config C
    int
    range 5 15
config D
    hex
    default "c0000000"
config E
    string
    default "FOO"
```

y (ENABLED), n (DISABLED)

y, n, module

integers

hexadecimals

string

Kconfig - Transformation

```
config A
    bool

if A
    config B
        bool

    config C
        bool
endif
```

Transformation

```
config A
    bool

config B
    bool
    depends on A

config C
    bool
    depends on A
```

Threats to validity

- Sample not being representative
- Not getting enough bugs

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- Sample not being representative
- Not getting enough bugs
- Can you think of more?

Bye

Thank you for your time.