CodeTickler: Automated Software Testing as a Service

Cristian Zamfir, Vitaly Chipounov, George Candea

ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE


UNDOCKING
IN PROGRESS
[NCC-1701]
DOCKING PROCEDURE
ENGAGED FOR ALL CONNECTS. REGISTRY 1895 - 34.
STARFLEET PROTOCOL ENGAGEMENT 567.05
LOCKING MECHANISM PENDING APPROVAL FOR
CONTINUED CODIFICATIONS IS IN PROCESS.
ENERGY PROCESS CATALYST.
CONNECTION MONITOR
DOWNLOADING
DOWNLOADING
Wouldn’t it be nice to have reliable software?

Vision

- Machines should
  - *find corner cases*
  - *do tricky security testing*
  - *generate test suites*
- Developers (a.k.a. sentient beings) should
  - *build cool new software*
  - *tell machines how software should behave*

Outline

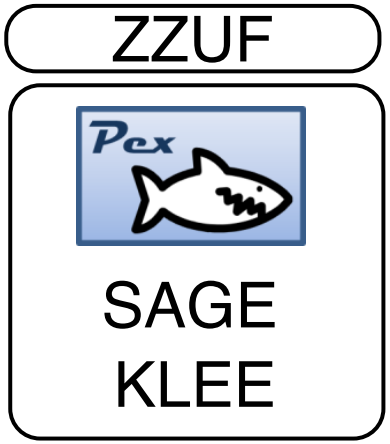
- Status quo
- Our approach
- The road ahead

Outline

- Status quo
- Our approach
- The road ahead

Status Quo

- Automate the **running** of tests
  - *do not automate test generation*
- Automatically **finding** bugs
  - *static analysis*
    - false positives
  - *random fuzzing*
    - inefficient at finding corner cases
  - *white-box fuzzing*
    - hard to use, requires models of the environment



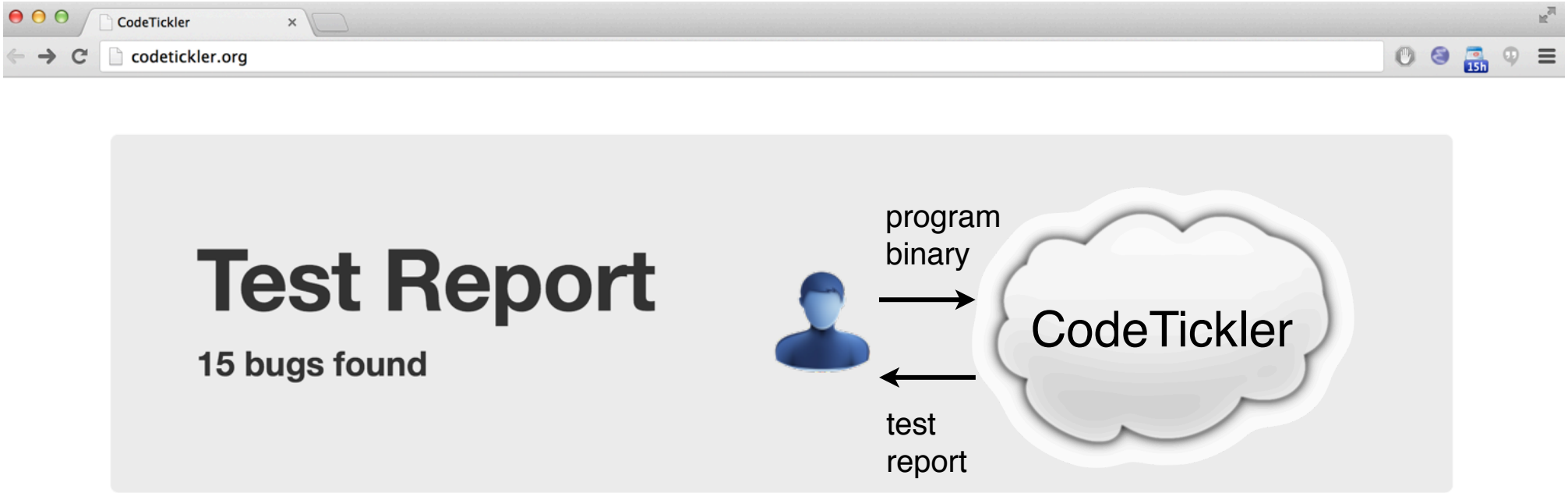
Software bugs cost US economy $59B/year *

50% of development budgets go to testing *

* US National Institute of Standards and Technology

Outline

- Status quo
- Our approach
- The road ahead



SQLite DB

Library

Details »

Memcached

Application

Details »

Realtek RTL8029

Network device driver

Details »

Technology

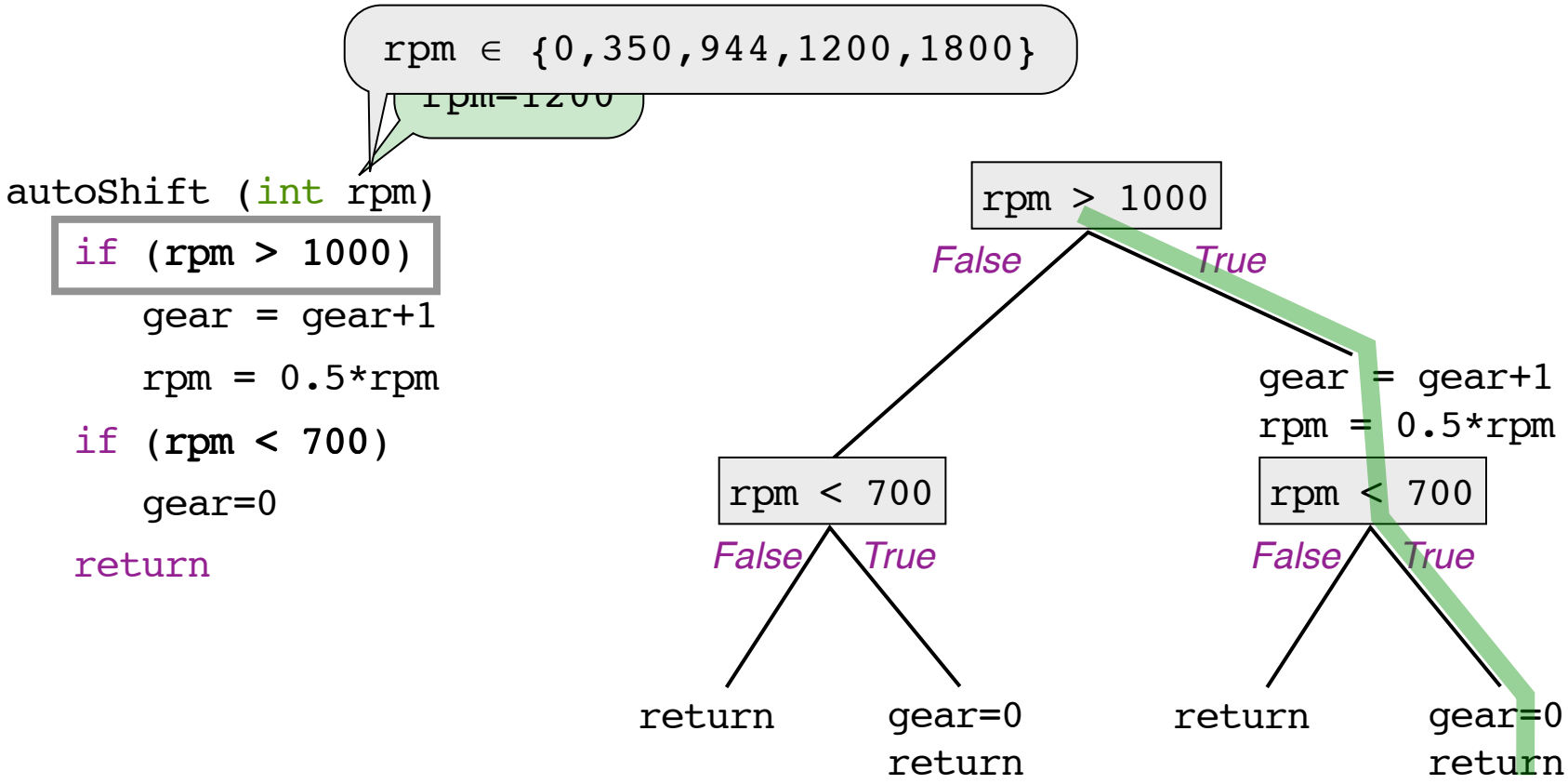
No false positives  → Higher quality testing

Tests lots of types of binaries

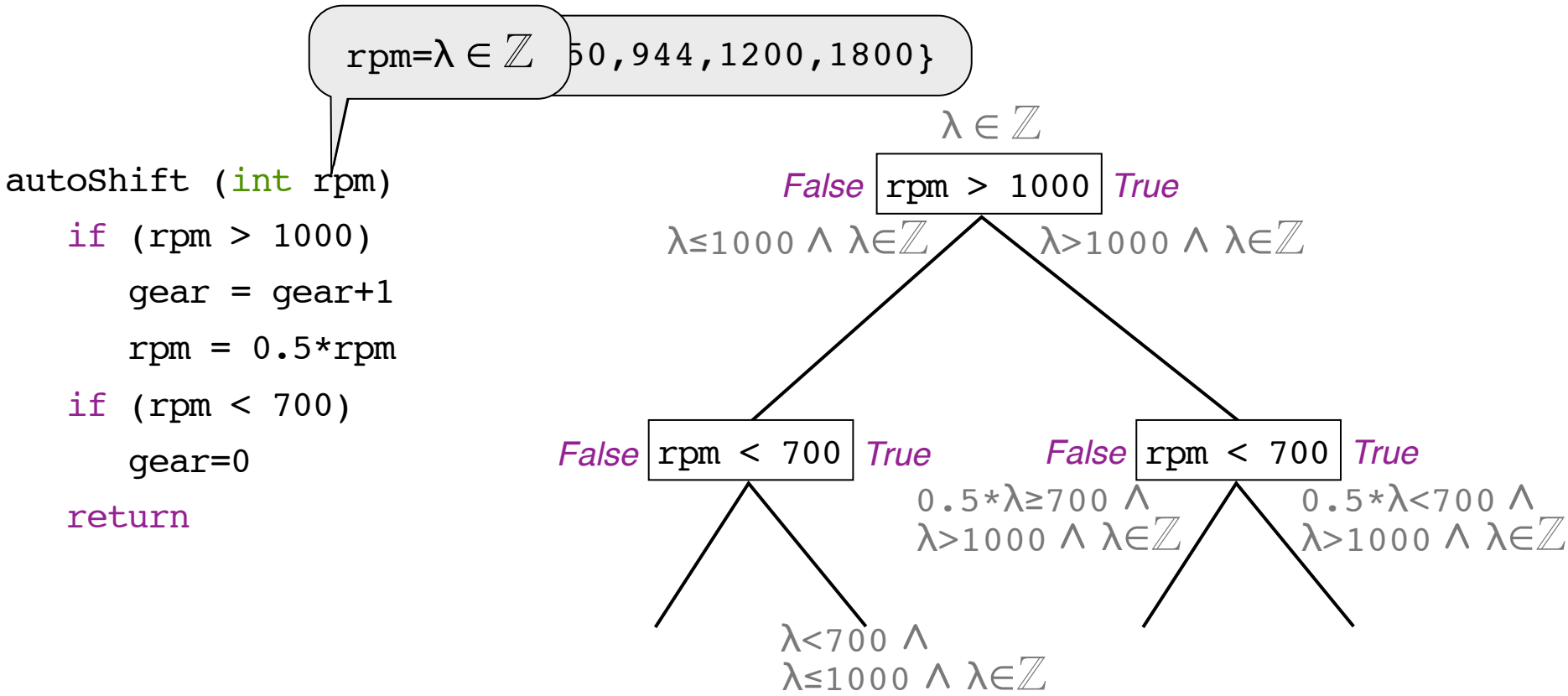
 → Source code not required

Scales
in the cloud

→ No upfront costs

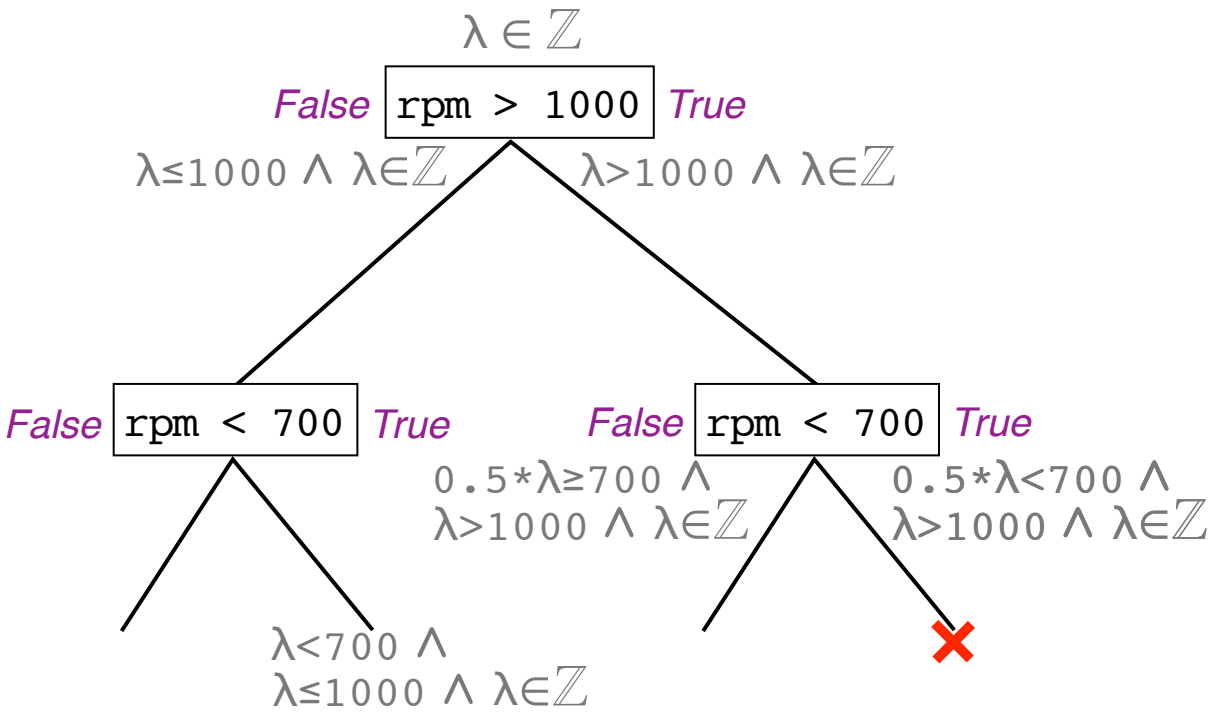

rpm ∈ {0,350,944,1200,1800}
autoShift (int rpm)
if (rpm > 1000)
gear = gear+1
rpm = 0.5*rpm
if (rpm < 700)
gear=0
return
rpm > 1000
False
True
rpm < 700
gear = gear+1
rpm = 0.5*rpm
rpm < 700
False
True
False
True
return
gear=0
return
return
gear=0
return

Symbolic Execution

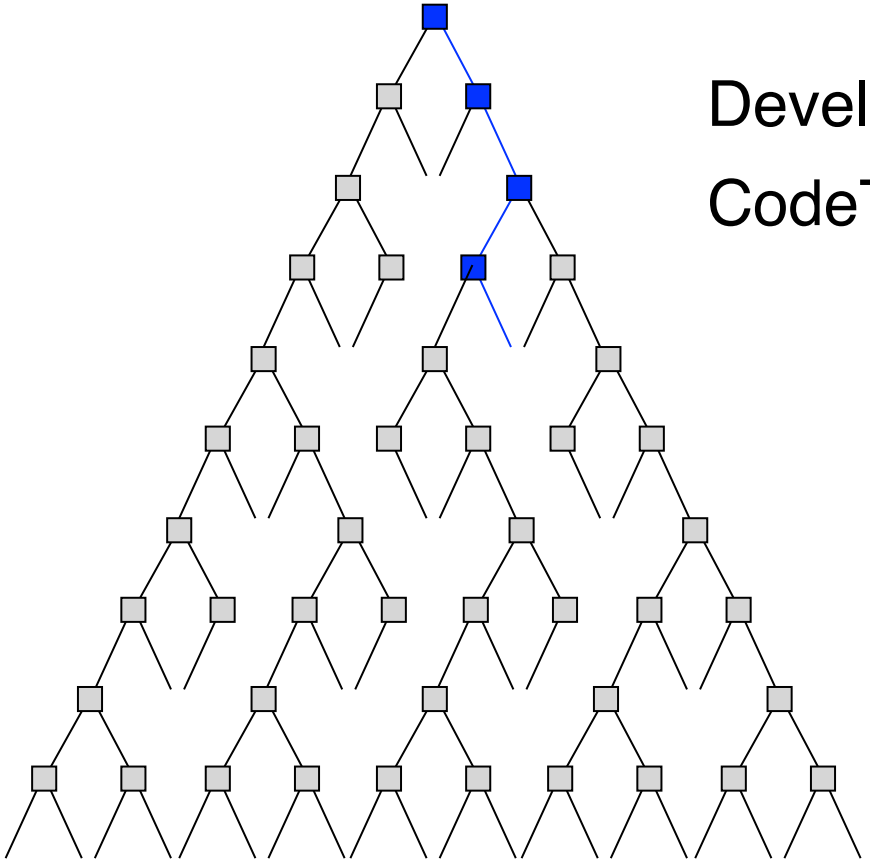


Finding Bugs Automatically

```
autoShift (int rpm)
    if (rpm > 1000)
        gear = gear+1
        rpm = 0.5*rpm
    if (rpm < 700)
        gear=0
    return
```



Constraint solver



Developer: one test

CodeTickler: many tests

Generated tests contain:

- *program inputs*
- *system events*
- *thread schedules*
- *faults*

in vitro

in vivo

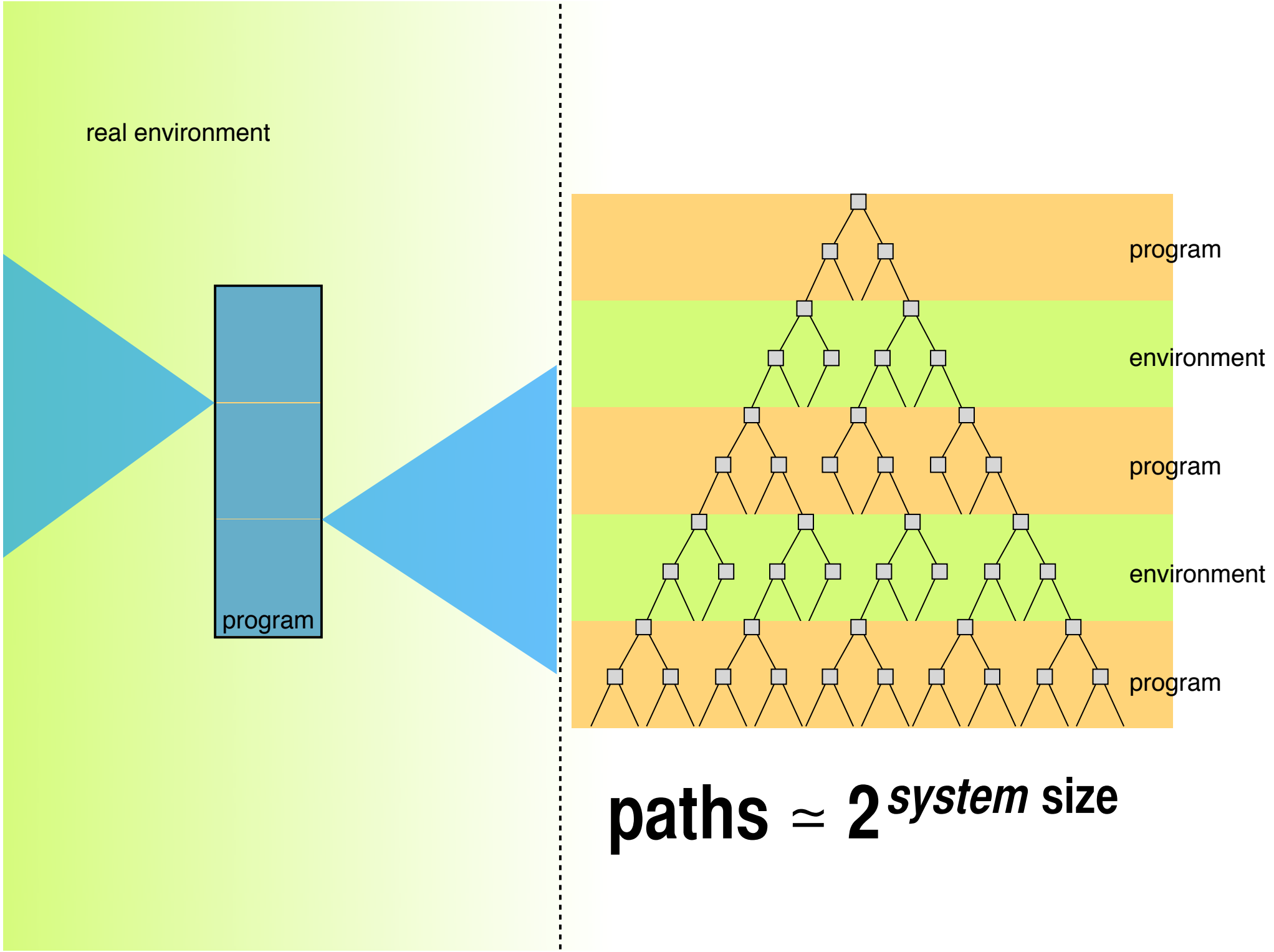
mockup environment

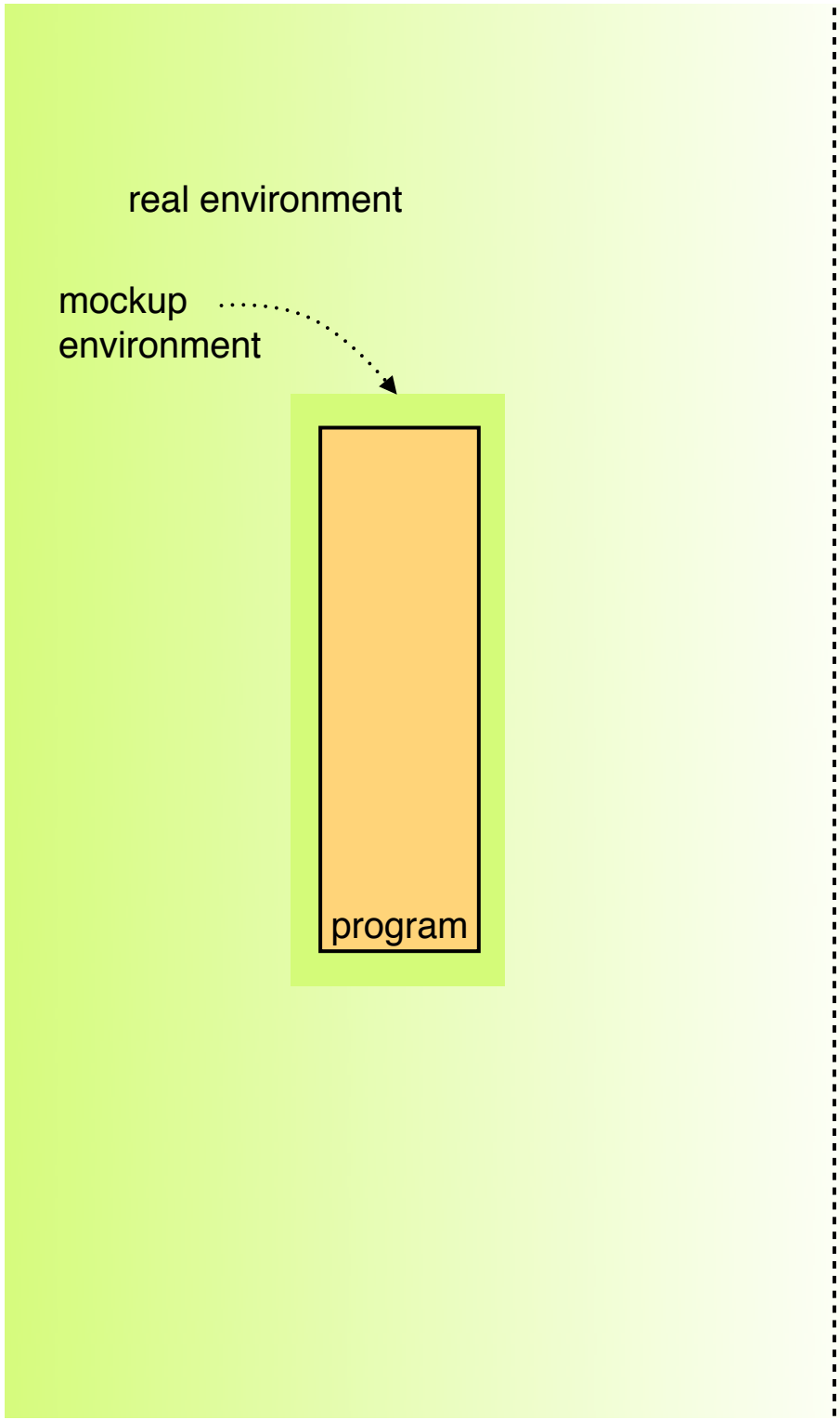
program

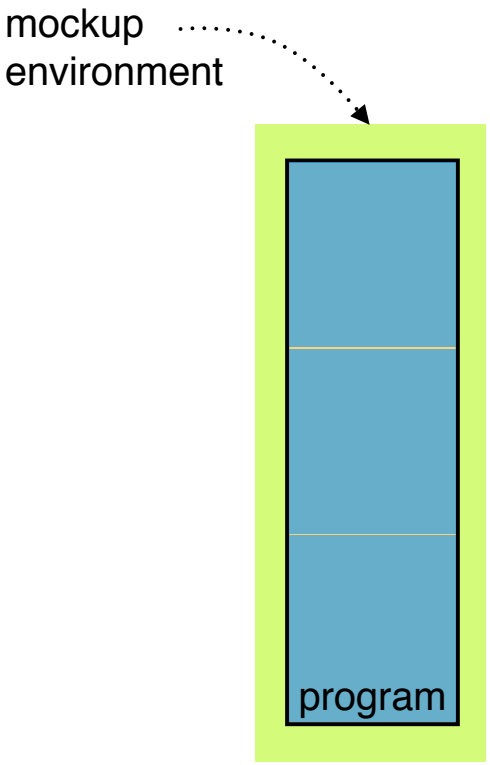
real environment

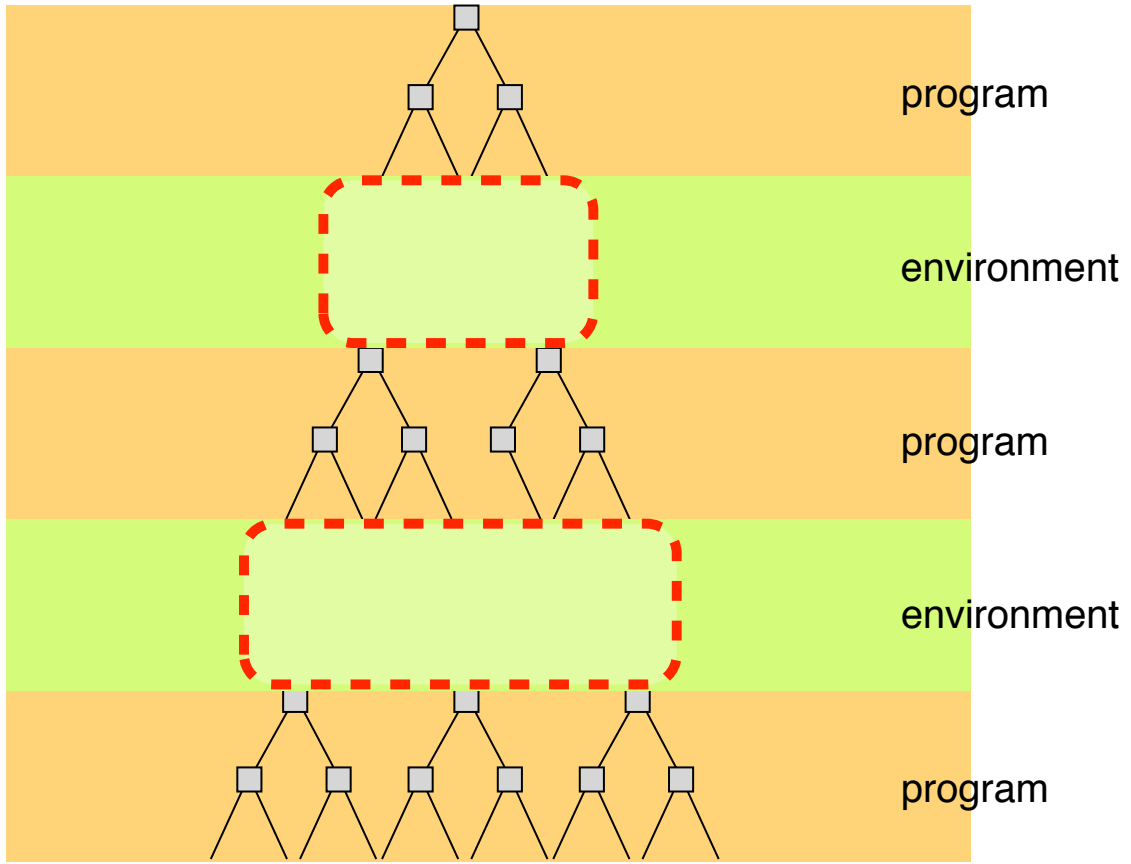
(libraries, operating sytem, drivers, etc.)

program

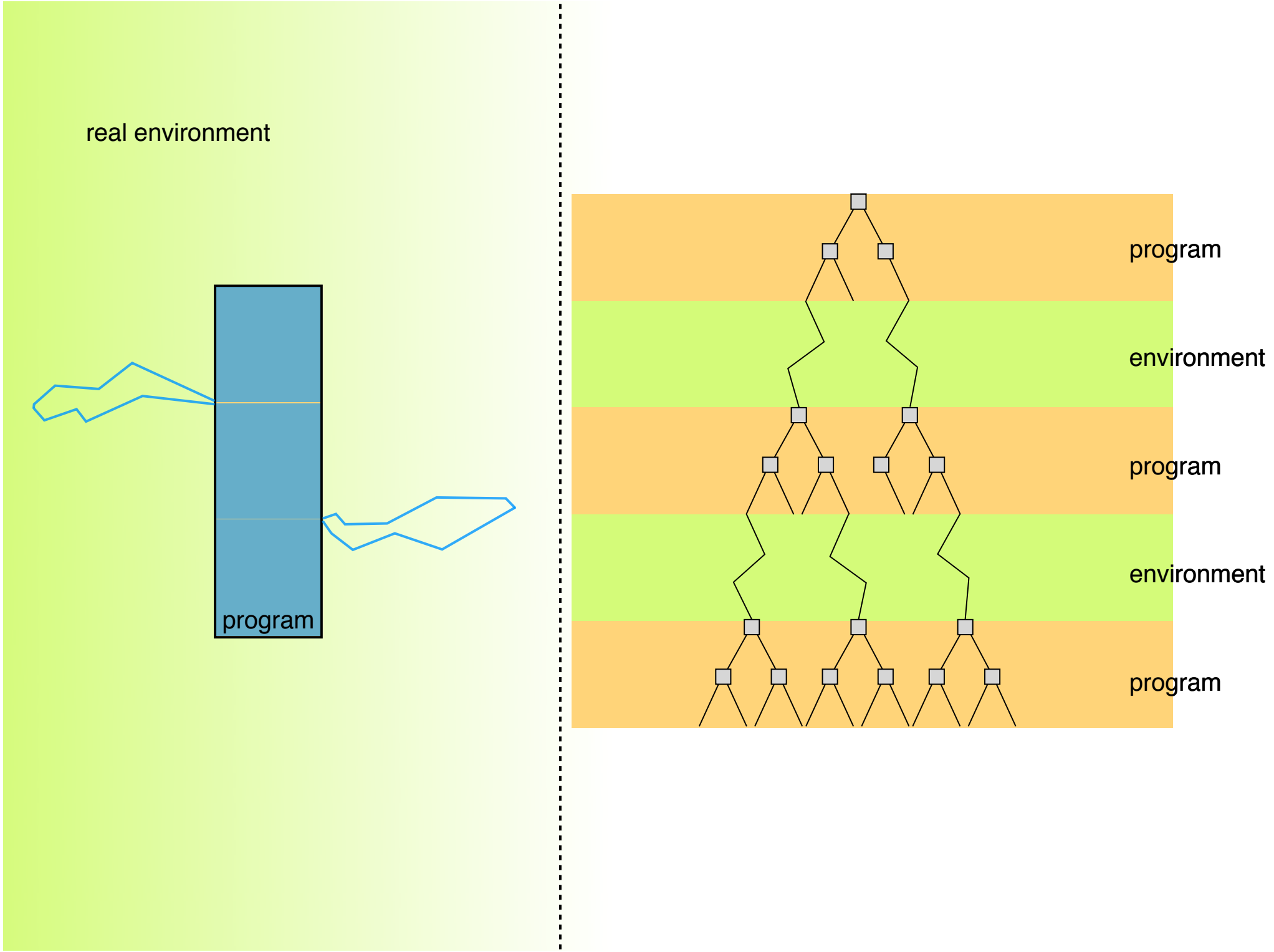

real environment
program
program
environment
program
environment
program
paths ≃ 2 system size


real environment
mockup
environment
program

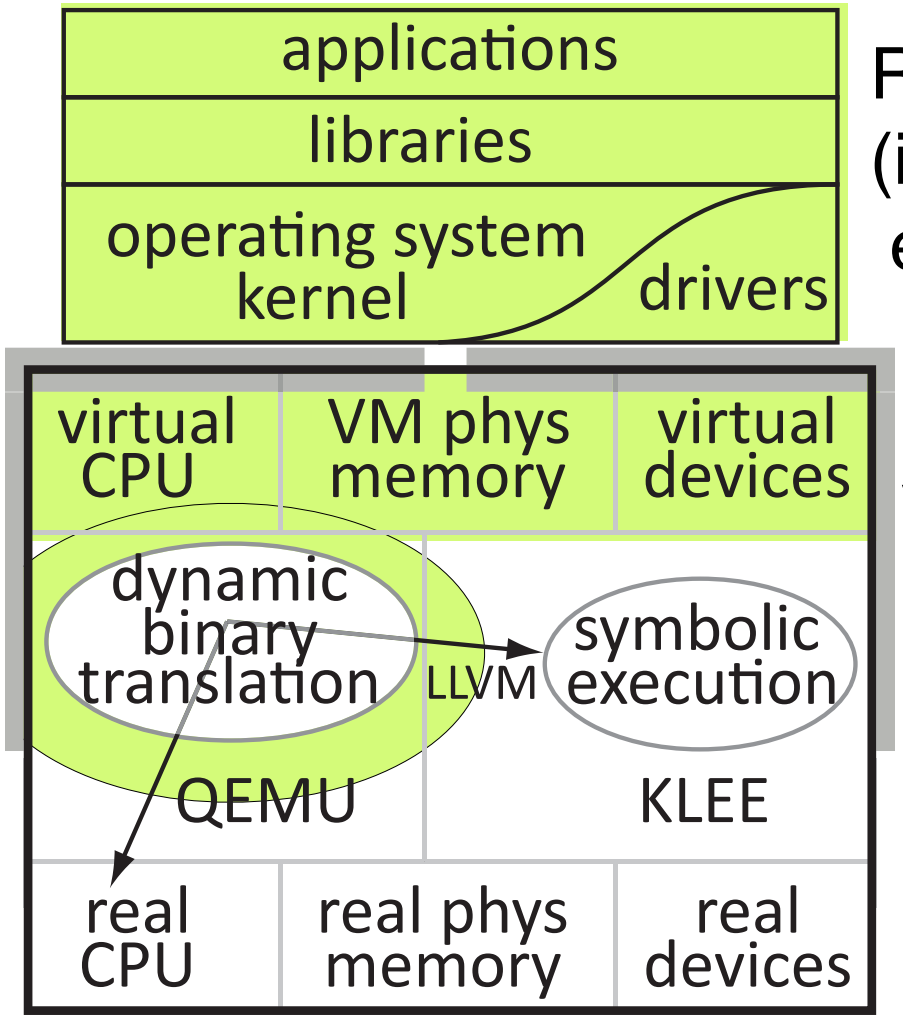




$$\text{paths} \simeq 2^{\text{program size}}$$


real environment
program
program
environment
program
environment
program

The S²E Platform



Runs unmodified x86 binaries (incl. proprietary/obfuscated/ encrypted binaries)

Customized virtual machine

Selection done at runtime
Most code runs “natively”

Summary

- Test any binary program
  - *running at any layer of the software stack*
- In-vivo analysis
  - *no modeling of the environment*
- No false positives
  - *generates tests that developers can run*
- From lab to real world
  - *ASPLOS'11, TOCS'12, USENIX'10*

Outline

- Status quo
- Our approach
- The road ahead

Which Software Needs Fixing?

Software that runs at the highest privilege level

CVE-2013-1287: USB kernel-mode drivers in Microsoft Windows 8 allow attackers to execute arbitrary code

CVE-2012-2119: Buffer overflow in the macvtap Linux device driver

CVE-2006-5882: Stack-based buffer overflow in the Broadcom wireless device driver used in Cisco Linksys.

Third-party software

Third-party testing is increasingly more important. (Veracode)

“Closed-source software is more vulnerable to backdoors” *(Bruce Schneier)*

Goal

- Get rid of low-level bugs in device drivers
- Target binary of closed-source software
- Open service that everyone can use
- Started building service for device drivers

Device driver	Bug type
Intel 82801AA AC97	Race condition
Atheros WiFi	Kernel crash (Blue screen of death)
Broadcom NetLink Gigabit	Kernel crash (Blue screen of death)
Undisclosed network driver	Kernel crash (Blue screen of death)
Intel Pro/1000	Kernel crash (Blue screen of death)
3Com EtherLink Server	Kernel crash (Blue screen of death)
3Com Ethernet	Kernel crash (Blue screen of death)
Silicom FastEthernet	Kernel crash (Blue screen of death)
NDIS subsystem	Kernel crash (Blue screen of death)
RTL8029	Multiple kernel crashes and resource leaks
Winbond PCI Ethernet	Concurrency bug
Linksys Gigabit Ethernet	Incorrect use of API
Ensoniq AudioPCI	Multiple kernel crashes and resource leaks
AMD PCNet	Multiple resource leaks

Next Challenges

- Usability
- Scale
- Provenance
- SaaS

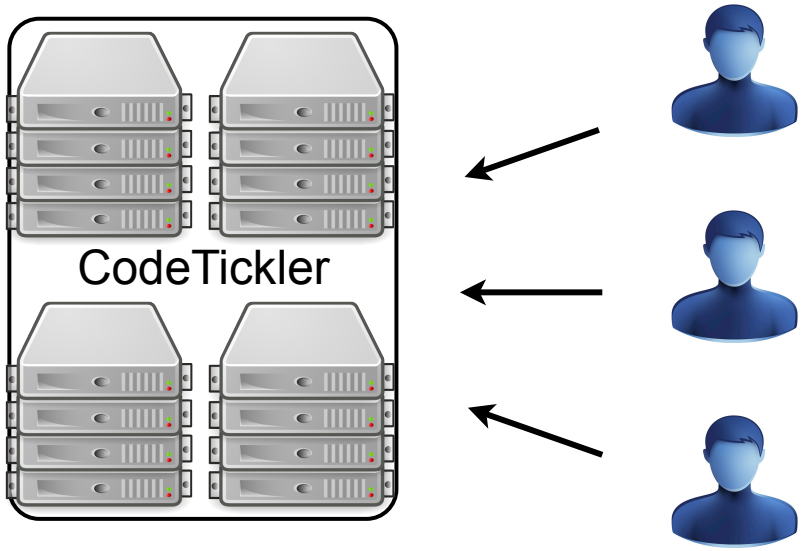
We want feedback on these.

Usability

- We want to improve developer productivity
- Challenges
  - *integrate with software development processes*
  - *produce easy-to-understand test reports*
  - *integrate with IDEs*

Scale

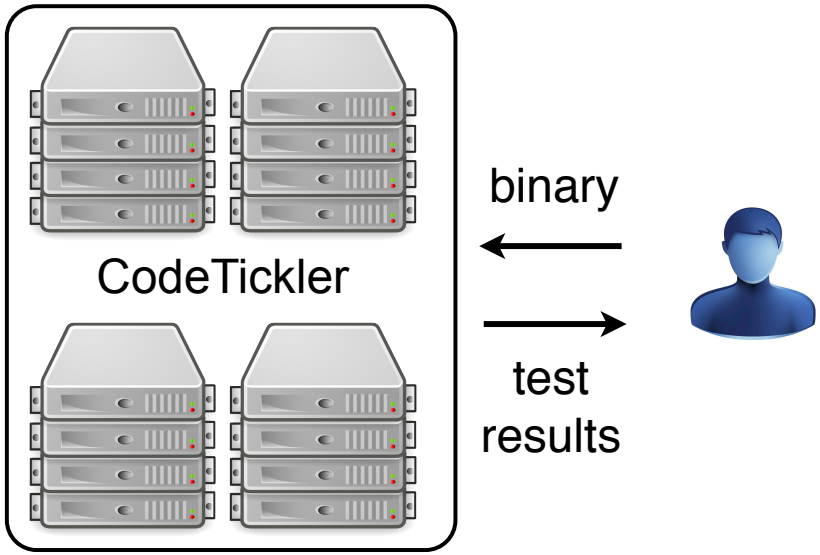
- Re-use test results
  - *libraries*
  - *frameworks*
- Big-data problem
  - *GBs of data for each device driver*



Provenance

How to identify when bad guys are using the service?

SaaS?



How to securely store program binaries?

Conclusion

- CodeTickler
  - *open, automated cloud-based testing service*
- First step
  - *get rid of low-level bugs in device drivers*
- Join us
  - *http://www.codetickler.org*

Make software testing as easy as tweeting!