3rd International KLEE Workshop on Symbolic Execution

Workshop Introduction

Cristian Cadar

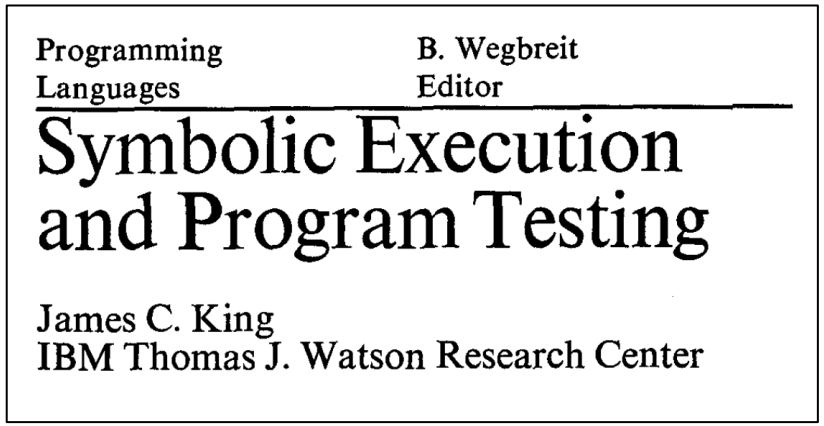
Department of Computing

Imperial College London

Imperial College London

15-16 September 2022
London, UK and Online

Symbolic Execution
A Bit of History: 1975-76

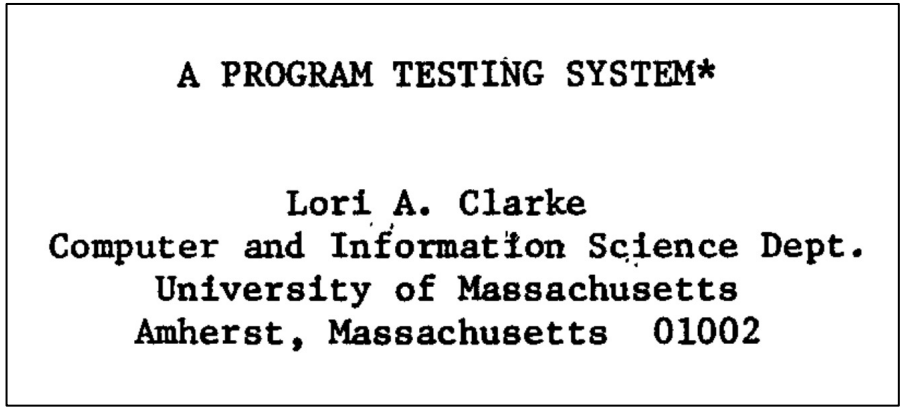


Programming Languages — B. Wegbreit Editor

Symbolic Execution and Program Testing

James C. King
IBM Thomas J. Watson Research Center

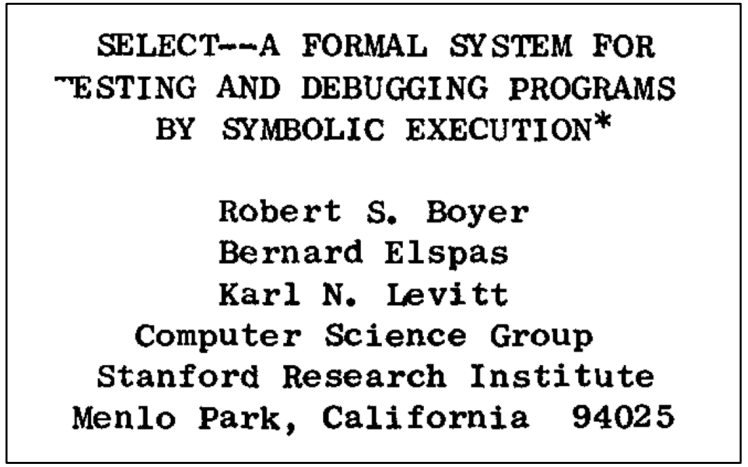
Symbolic execution of PL/I programs



A PROGRAM TESTING SYSTEM*

Lori A. Clarke
Computer and Information Science Dept.
University of Massachusetts
Amherst, Massachusetts 01002

Symbolic execution of Fortran programs



SELECT--A FORMAL SYSTEM FOR TESTING AND DEBUGGING PROGRAMS BY SYMBOLIC EXECUTION*

Robert S. Boyer
Bernard Elspas
Karl N. Levitt
Computer Science Group
Stanford Research Institute
Menlo Park, California 94025

Symbolic execution of LISP programs

Symbolic Execution
A Bit of History: 2005

Symbolic Execution for Software Testing: Three Decades Later

Mixed concrete-symbolic execution /

(dynamic symbolic execution, concolic execution, whitebox fuzzing…)

Concurrent with a revolution in SAT & SMT solving

DART: Directed Automated Random Testing

Patrice Godefroid Nils Klarlund
Bell Laboratories, Lucent Technologies
{god,klarlund}@bell-labs.com

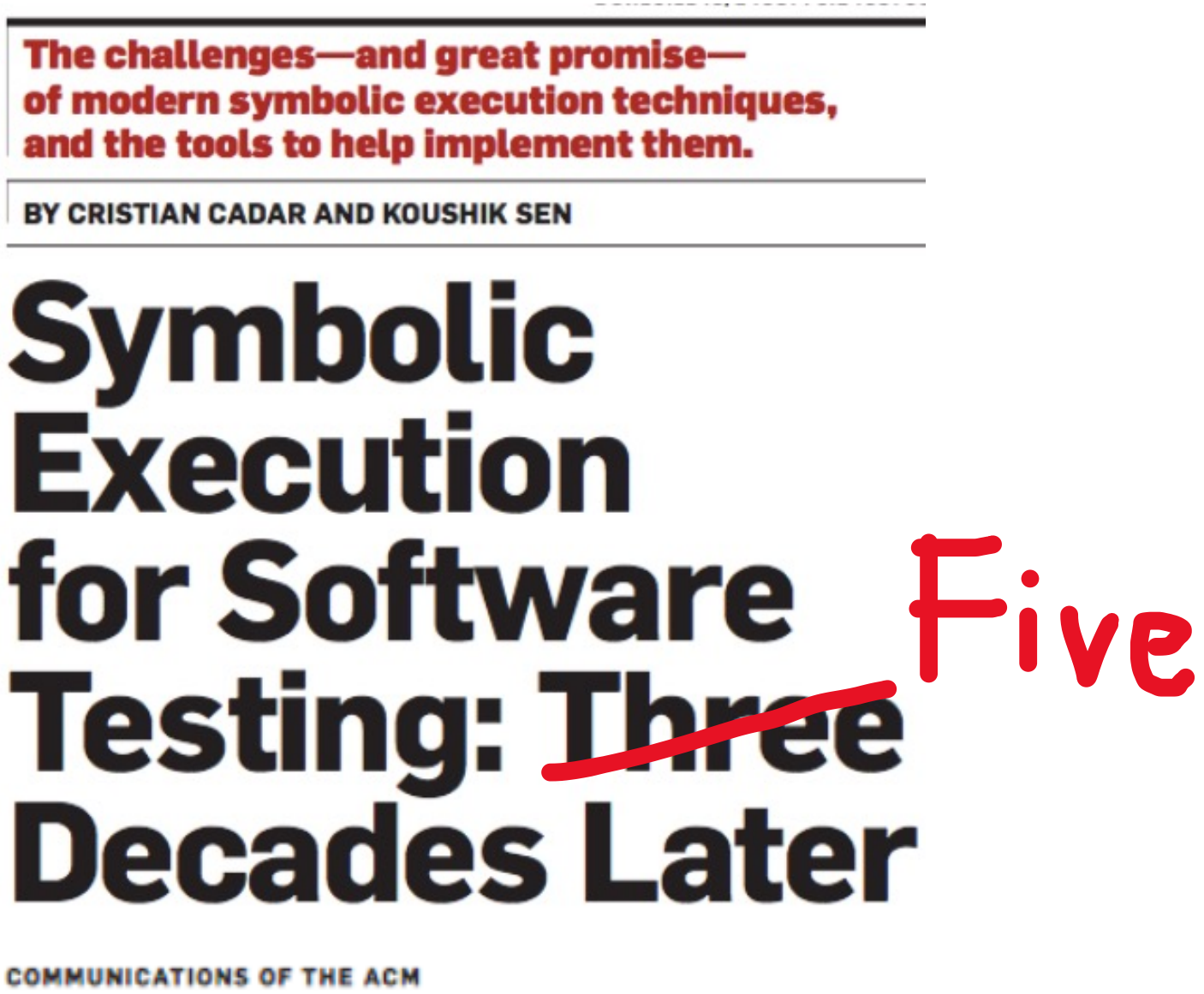
Koushik Sen
Computer Science Department
University of Illinois at Urbana-Champaign
ksen@cs.uiuc.edu

Execution Generated Test Cases: How to Make Systems Code Crash Itself

Cristian Cadar and Dawson Engler*

Computer Systems Laboratory
Stanford University
Stanford, CA 94305, U.S.A.

A Bit of History



KLEE

CREST

BINSEC

SymCC

Miasm

PathGrind

PyExZ3

SymDroid

jCUTE

TRITON

Otter

CUTE

SAGE

Savior

SymJS

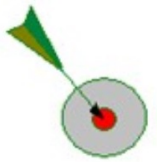
Jalangi2

Symbolic PathFinder

Manticore

angr

BinSE



DART

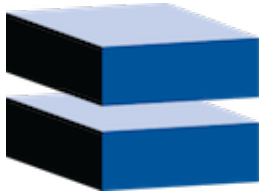
Kite

LDSE

Pex

Rubyx

JDart



S²E

CATG

CiVL

Mayhem

KLOVER

Webpage: **https://klee.github.io/**
Code: **https://github.com/klee/**
Web version: **http://klee.doc.ic.ac.uk/**

Active project

13+ years since open-sourced

9 releases

2400+ commits

Active community

100+ contributors to codebase incl. subprojects

400+ subscribers to mailing list

580+ public forks of KLEE repository

2000+ stars on GitHub

Academic Impact & Interest

- SIGOPS Hall of Fame Award (KLEE paper)
- CCS Test of Time Award (EXE paper)
- 3700+ citations to original KLEE paper
- 250+ publications and systems building upon KLEE
  - https://klee.github.io/publications/
  - From many different research communities: testing, verification, systems, software engineering, programming languages, security, etc.

Industry Impact & Interest

- Companies sponsoring 1st & 2nd & 3rd KLEE workshops:

  Baidu, Bloomberg, Fujitsu, Google, Huawei, Qualcomm, Samsung, Trail of Bits

- Two industry keynotes to the first KLEE Workshop (and two more now!):
  - Fujitsu: Utilization and Evolution of KLEE-based Technologies for Embedded Software Testing at Fujitsu
  - Baidu: ConcFuzzer: A Sanitizer Guided Hybrid Fuzzing Framework Leveraging Greybox Fuzzing and Concolic Execution
- Many different companies reporting on using/experimenting with KLEE:
  - **Baidu**: [KLEE 2018], [IEEE S&P 2020]
  - **Fujitsu**: [PPoPP 2012], [CAV 2013], [ICST 2015], [IEEE Software 2017], [KLEE 2018]
  - **Google**: [2x KLEE 2021]
  - **Hitachi**: [CPSNA 2014], [ISPA 2015], [EUC 2016], [KLEE 2021]
  - **Intel**: [WOOT 2015]
  - **NASA Ames**: [NFM 2014]
  - **Samsung**: [2x KLEE 2018]
  - **Trail of Bits**: https://blog.trailofbits.com/
  - **etc..**
- High percentage of industry participants at KLEE workshops!

KLEE and SymEx: *Beyond* Bug Finding

- Bug finding is ***extremely*** important
- But symbolic execution is applicable to ***many other*** problems!
  - Program repair
  - Verification
  - Refactoring
  - Education
  - Equivalence checking
  - Test case generation and augmentation
  - Debugging and fault localization
  - Model learning
  - Document repair
  - Reverse engineering
  - Side-channel analysis
  - Test-case reduction
  - Liveness analysis
  - Binary lifting and recompilation
  - Detecting cheating in online games

etc. etc.

KLEE Workshop 2018

Organization Sponsors

- 80+ participants from academia, industry and government
- 12 different countries across three continents
- Sponsored by EPSRC, Baidu, Bloomberg, Fujitsu, Huawei, Imperial College London
- Three academic keynotes (Khurshid, Orso, Roychoudhury)
- Two industry keynotes (Ghosh – Fujitsu, Li – Baidu)
- 17 regular talks and 5 posters
- Lunches, coffee breaks, and pub
- Fantastic feedback post-workshop

1st International KLEE Workshop on Symbolic Execution

19-20 April, 2018 • London, United Kingdom

Tweets by @kleesymex

kleesymex @kleesymex

Save the date! 1st International KLÉE

- 200+ participants from academia and industry
- 34 different countries across **six continents**
- Sponsored by Bloomberg, Samsung, Google and Imperial College London
- Keynote from Chao Wang
- 24 regular talks
- Great feedback post-workshop
- Huge support for a future in-person event

2nd International KLEE Workshop on Symbolic Execution

10-11 June, 2021 • Online

Tweets by @kleesymex

kleesymex Retweeted

KLEE Workshop 2022

3rd International KLEE Workshop on Symbolic Execution

15–16 September 2022 • London, UK and Online

Tweets from @kleesymex

kleesymex
@kleesymex · Sep 7

Participants

- 125+ participants, with ~65 onsite and ~60 online
- 29 different countries across 5 continents

- Good mix of industry and academia:
  - Around 58% academia, 36% industry, 6% other

- More registrations than participants:
  - Several participants could unfortunately not get a visa on time
  - Others had their flights/trained cancelled
  - Some will join late, this afternoon

Participants' interests (online only)

Program

- 4 keynotes: 2 from academia, 2 from industry
  - Jan Strejček, Masaryk University
  - Peter Goodman, Trail of Bits
  - Sébastien Bardin, CEA LIST, Université Paris-Saclay
  - Vitaly Chipounov, Cyberhaven

Program (cont.)

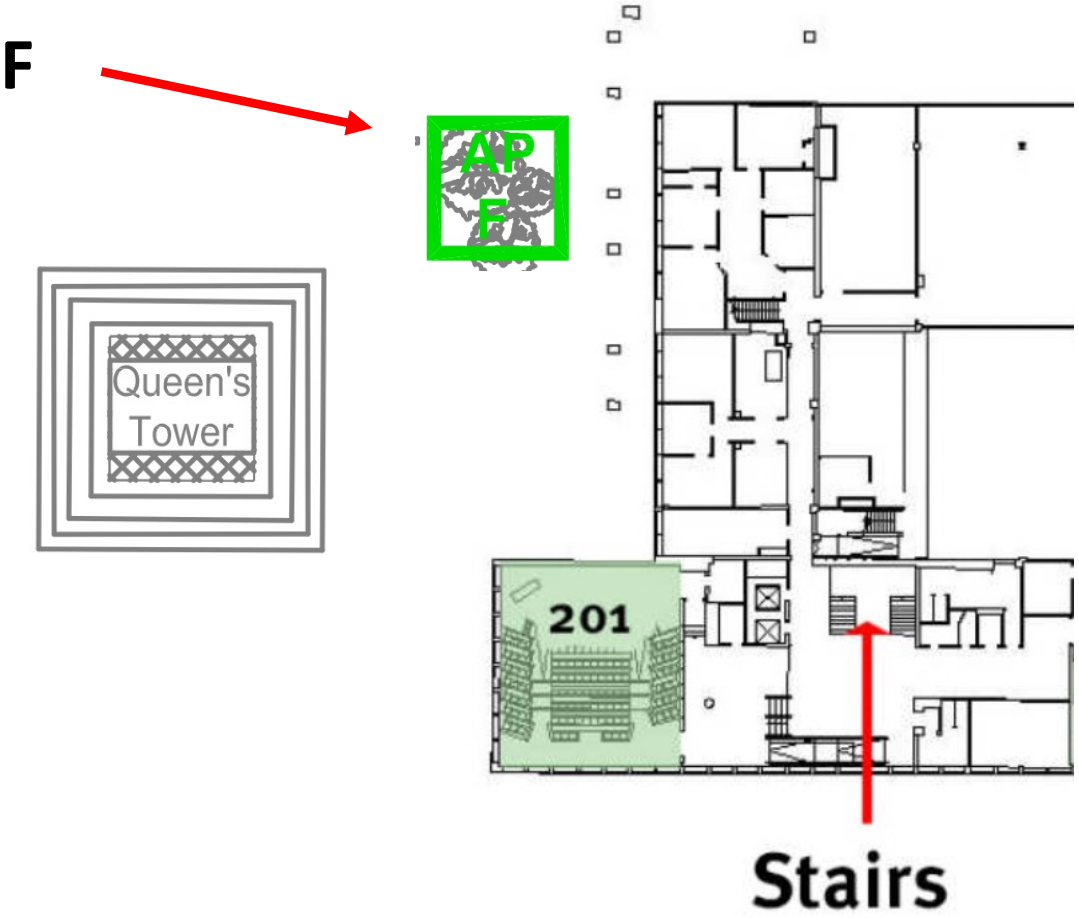
- 20 regular presentations, grouped into 7 sessions
- 10 posters, presented in two poster sessions and outside the lecture hall, with additional questions on Discord: #posters

- **A big thank you to all contributors and participants!**

Fire Alarm

In case of a fire alarm, follow exit signs and gather at assembly point

Assembly point F



Streaming and Recording

The workshop is streamed to online participants

- Speakers: please stand to the left of the podium to be seen
- We will use the podium computer for regular talks

The workshop is also recorded BUT:

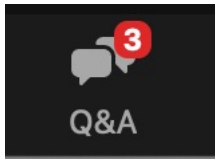
- The Q&A sessions will NOT be made available to encourage participation
- Individual talks will be made available with speaker consent via the YouTube KLEE channel

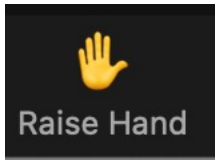
Q&A

Ask lots of questions during the workshop!
That's one of the main reasons for having the workshop in the first place!

In-person participants:

- You can raise your hand and ask your question
- Session chair or speaker should repeat it to make sure online participants hear it properly





Online participants:

- Please use Zoom's Q&A feature to ask and upvote questions
- Can also press the "Raise Hand" button to ask questions with voice
  - But with a large audience size, session chairs might prioritize written questions
- After each session, any unanswered questions are dismissed
- More permanent conversations should move to Discord

You can use Discord for more questions and to chat about other topics

Session Chairs

- Session: Chair (online chair):
  1. Memory Modelling: Peter O'Hearn (Martin)
  2. Floating Point and Incorrectness Logic: Tomasz Kuchta (Daniel)
  3. Debug Info, Reverse Engineering and Program Repair: Martin Nowack (Frank)
  4. Symbolic Execution and Greybox Fuzzing: Frank Busse (Martin)
  5. Path Exploration: Alessandro Orso (Daniel)
  6. Precondition Inference and Driver Generation: Jonathan Bell (Martin)
  7. Models, Synthesis, Specs and New Architectures: Daniel Schemmel (Frank)
- Session chairs will be assisted by an online chair (Daniel, Frank or Martin) who will point out questions from online participants

Workshop Co-chairs

Frank Busse

Martin Nowack

Daniel Schemmel

Finances and admin:

- Hassan Patel
- Jamie Perrins

Gold sponsors

Bloomberg

SAMSUNG

Silver sponsors

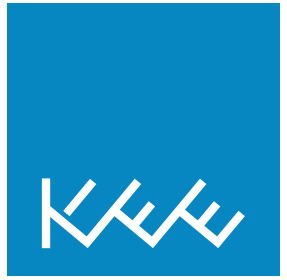
Google

Qualcomm

TRAIL OF BITS

Supported by

Imperial College London



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Thank You

To Our Sponsors

https://srg.doc.ic.ac.uk/klee22/

@kleesymex

KLEE Community

- Martin Nowack for co-maintaining KLEE for the last many years
- Frank Busse for recently joining the maintainers team and maintaining the list of publications building up on KLEE (now at 250+)
- Prior co-maintainers Daniel Liew, Andrea Mattavelli and Daniel Dunbar
- Daniel Dunbar for starting the project back in 2007!
- Our 100+ contributors
- The entire awesome KLEE community

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Tweets from @kleesymex

kleesymex
@kleesymex · Sep 7