Abhik Roychoudhury

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Provost's Chair Professor, National University of Singapore (NUS)

Director, National Satellite of Excellence in Trustworthy Software Systems

Brief Biography

Abhik Roychoudhury is a Provost's Chair Professor of Computer Science at the National University of Singapore. He is the Director of the National Satellite of Excellence in Trustworthy Software Systems at Singapore (2019-23). He has previously led the TSUNAMi research center (2015-20), a large five-year long targeted research effort funded by National Research Foundation in the domain of trust-worthy software. He is also the Chairman of the Managing Committee of the Singapore Cyber-security Consortium (2016-22), which is a consortium of 25 companies in the cyber-security space engaging with academia for research and collaboration. His research focuses on software testing and analysis, software security and trust-worthy software construction. His research on automatically repairing programs at a large scale contributes to the vision of self-healing software. He is an ACM Distinguished Member, and has been an ACM Distinguished Speaker (2013-19). His research has been funded by various agencies and companies, including the National Research Foundation (NRF), Office of Naval Research (ONR), Ministry of Education (MoE), A*STAR, Defense Research and Technology Office (DRTech), DSO National Laboratories, Microsoft and IBM. He has been a keynote speaker at different conferences (most recently APSEC 2020) and distinguished lecturer at different universities and institutes.

He is a member of the Steering committee of the two flagship conferences in Software Engineering (ICSE and FSE), the only person from Asia to be so. Specifically he has served as Program Chair of ACM International Symposium on Software Testing and Analysis (ISSTA) 2016, General Chair of ACM SIGSOFT Symposium on Foundations of Software Engineering (FSE) 2022 and Program Co-chair of International Conference on Software Engineering (ICSE) 2024. He has served as an Associate Editor of IEEE Transactions on Software Engineering (TSE) during 2014-18. He is currently serving as an Associate Editor of IEEE Transactions on Dependable and Secure Computing (TDSC) and ACM Transactions on Software Engineering and Methodology (TOSEM).

His former doctoral students have been placed at universities all over the world as academics (Peking University, University College London, Max-Planck Institute, Shandong, SUSTech, SUTD) and have received various awards for their doctoral research including an ACM SIGSOFT Outstanding Doctoral Dissertation Award. Abhik received his own Ph.D. in Computer Science from the State University of New York at Stony Brook in 2000.

Research Interests

Program Analysis, Software Testing, Software Security, Trustworthy Systems.

Education

- Ph.D. Computer Science (2000) State University of New York (SUNY) at Stony Brook (USA).
  Dissertation: Program Transformations for Verifying Parameterized Systems.
- M.S. Computer Science (1997) State University of New York (SUNY) at Stony Brook (USA).
  Grade Point Average 3.96/4
- B.E. Computer Science & Engineering (1995), Jadavpur University (India)
  First Class Honors, Grade Point Average 5/5
  Dissertation: Efficiently Computing Vertex Arboricity of Planar Graphs.

Employment

At National University of Singapore (NUS)

- Jan 2020 - Dec 2022 : Provost's Chair Professor, School of Computing, NUS (appointment for 3 years).
- July 2014 onwards: Professor, School of Computing, NUS (Tenured until June 2038).
- July 2013 - 2016: Vice Dean of Graduate Studies (with responsibility for ∼500 graduate students), School of Computing, NUS.
- Jan 2011- June 2013: Assistant Dean of Graduate Studies, School of Computing, NUS.
- July 2007 - June 2014: Associate Professor, School of Computing, NUS.
- January 2001 - June 2007: Assistant Professor, School of Computing, NUS.

Funded Research Projects as Principal Investigator

- Software Recovery using Semantic Program Repair, PI, MINDEF, 2019-22, $1.8M.
- FuzzInfer: Fuzzing Protocol Implementations, PI, DSO grant, 2019-21, $500K.
- *National Satellite of Excellence in Trustworthy Software Systems*, Lead PI and Director, $12M, 2019-23 (4 years).
- *Self-Healing Software*, Lead PI, USD 120K, Funded by Office of Naval Research (ONR), 2016-18.
- *Singapore Cyber-security Consortium*, Lead PI, $4.8 M, 2016-22 (6 years). The Consortium currently has ∼ 40 member companies. I was heavily involved for setting up this very first industry Consortium in Computer Science at Singapore.
- *A fully automated cloud based testing solution for mobile apps*, Innovation grant funded by SMART, PI, $250K, 2016-18 (2 years).
- *TSUNAMi: Trustworthy Systems from UN-trusted component Amalgamations*, Lead PI, Funded by National Research Foundation (NRF), 2015 - 2020 (5 years), $6.1 M.
- *Energy aware Programming*, PI, Funded by Ministry of Education (MoE), 2014 - 2017 (3 years), $ 466,000.
- *CODETEST: Comprehension Detection and Testing via Symbolic Execution*, PI, Funded by DSO Labs, 2013 - 15 (2 years), $ 390,000.
- *Scalable Timing Analysis Methods for Embedded Software*, PI, Funded by A*STAR Public Sector Funding (PSF), 2012 - 2015 (3 years), $ 590,000.
- *Analysis and Test Generation for Evolving Software*, PI, Funded by Ministry of Education (MoE), 2011 - 2014 (3 years), $ 831,000.
- *Symbolic Taint Analysis*, PI, Funded by Defense Research and Technology Office (DRTech) under Defence Innovative Research Program (DIRP), 2009-2012 (3 years), $ 397,290.
- *Tools and techniques for Model based Software Debugging*, PI, Funded by Agency of Science Technology and Research (A*STAR), September 2004 - 2007 (3 years), $362,000.

- *Correctness and Performance Issues in the CLI memory model*, PI, a small grant funded by Microsoft for one year (2005-2006), US$15,000.

Invited Talks and Keynotes

- *Automated Program Repair*, Keynote speech at Asia-Pacific Software Engineering Conference (APSEC), December 2020.
- *Trustworthy Software and Automated Program Repair*, Distinguished Lecture at Max-Planck Institute of Software Systems, July 2019.
- *Symbolic Execution vs. Search for Software Vulnerability Detection and Patching*
  Invited Speaker, 8th International Conference on Security, Privacy and Cryptography Engineering (SPACE), December 2018.
- *Automated Program Repair*
  Keynote Speaker, 25th Australasian Software Engineering Conference (ASWEC), Adelaide, November 2018.
- *Symbolic Execution for Software Vulnerability Detection and Repair*
  Invited Speaker, 9th International Summer School on Information Security and Protection (ISSISP), July 2018. Similar invited talks were given at other Summer Schools such as ISSTA 2019 Summer School.
- *From Timing and Energy Analysis to Testing*
  Keynote Speaker, 21st IEEE International Symposium on Real-time Computing (ISORC), May 2018.
- *Software Vulnerability Detection and Repair*
  Keynote Speaker, KLEE Workshop on Symbolic Execution, Imperial College London, April 2018.
- *Trustworthy Software*
  Distinguished Lecture at Peking University China, as part of 7th International Symposium on High Confidence Software, December 2017.
- *Future of Mobile software - Performance and Energy issues*
  Keynote at 4th IEEE/ACM International Conference on Mobile Software Engineering and Systems (MobileSoft), May 2017.
- *Binary Analysis for Vulnerability Detection*
  Distinguished Lecture, University of Luxembourg, Interdisciplinary Centre for Security, Reliability and Trust (SnT), January 2017.
- *General Summary of Program Repair and Semantic Repair*
  Overview talk at Dagstuhl Seminar on Automated Program Repair, Saarbrucken, Germany, January 2017.
- *Symbolic Techniques for Software Debugging*
  Overview talk at Dagstuhl Seminar on Symbolic Execution and Constraint Solving, Saarbrucken, Germany, October 2014.
- *SEMFIX: Automated repair via Semantic Analysis*
  at Dagstuhl Seminar on Fault Prediction, Localization and Repair - Saarbrucken, Germany, February 2013. Also, given at the CREST workshop on Search based software testing and Symbolic Execution, London, January 2014.

- *How Symbolic Reasoning can help Program Debugging and Repair*
  Workshop on Future of Debugging, International Symposium on Software Testing and Analysis (ISSTA) 2013, July 2013, Lugano, Switzerland.

- *Formal techniques for debugging software regressions*
  Invited talk at International Seminar on Program Verification, Automated Debugging and Symbolic Computation (PAS) 2012, Beijing, China. Organized by Chinese Academy of Sciences.

- *Debugging as a Science, that too, for Evolving Programs*
  Keynote given at 3rd International Workshop on Harnessing Theories for Tool Support in Software (TTSS) 2009, a workshop held along with the International Colloquium on Theoretical Aspects of Computing (ICTAC) 2009, August 2009.

- *Automated Generation of Protocol Converters from Scenario-based Specifications*
  Workshop on Predictable Software Component Assembly, Sponsored by CoLogNet (the European Network for Excellence in Computational Logic), May 2004, Venue: Manchester, UK.

- *Program Transformations for Automated Verification*
  Invited tutorial at *International Conference on Logic Programming (ICLP)*, as part of Federated Logic Conferences (FLoC), August 1 2002, Copenhagen (Denmark).

Key Research Contributions

Automated Program Repair Automated program repair is a promising new technology, which seeks to reduce manual effort from the programmer. Such a technology can also be used for automated repair of security vulnerabilities, which often remain un-fixed even after being detected and reported. We envision program repair as a specification inference process, rather than a search problem. We show that selective use of symbolic execution and concrete execution can infer specifications about how a given program should be rectified. Such specifications or constraints can again be solved either via enumerative search or via program synthesis. We investigate a variety of semantic signatures that can be efficiently inferred, develop new powerful synthesis technology based on second order logic, and conduct extensive experimentation over various large code-bases. Automated repair, and use of systematic analysis for this purpose, has been gaining practical traction. As an example, one could look into the latest tools from Facebook on automated repair. Overall, semantic program repair takes one key step towards building trustworthy self-healing software. Apart from its promise in fixing vulnerabilities, we have also studied the use of program repair in education, specifically for grading and giving feedback in programming assignments.

- **[ICSE'13]** "SemFix: Program Repair via Semantic Analysis", Hoang D.T. Nguyen, Dawei Qi, Abhik Roychoudhury, Satish Chandra, *IEEE/ACM International Conference on Software Engineering (ICSE) 2013.*

- **[ICSE'16]** "Angelix: Scalable Multiline Program Patch Synthesis via Symbolic Analysis" Sergey Mechtaev, Jooyong Yi, Abhik Roychoudhury, *ACM/IEEE International Conference on Software Engineering (ICSE) 2016.*

- **[CACM'19]** "Automated Program Repair", Claire Le Goues, Michael Pradel, Abhik Roychoudhury, *Communications of the ACM, 62(12), December 2019.*

Symbolic Execution and Fuzz Testing Fuzz testing is a popular method for security vulnerability detection in programs, with widespread and daily usage in industry. In terms of industry usage, the commonly used techniques involve black-box fuzzing which employs random mutations on the input, and grey-box fuzzing which employs compile time instrumentation to mutate inputs via a biased-random search. On the other hand, white-box fuzzing or symbolic execution, widely studied in academia, relies on program analysis and constraint solving for systematic testing. In our work, we have brought in ideas and technologies from symbolic execution for systematic fuzz testing. Conventionally symbolic execution based on testing attempts to either enhance path coverage, or perform a directed search for reaching specific program locations. We have shown how such ideas from symbolic execution can be transported to grey-box fuzz testing without incurring the overheads of constraint solving. The resultant technologies have been adopted in the widely used distribution of American Fuzzy Lop (AFL), the most widely used security-testing tool. The resultant technologies were used in DARPA Cyber Grand Challenge 2016 for faster vulnerability detection.

- **[CCS'16]** "Coverage-based Greybox Fuzzing as Markov Chain" Marcel Böhme, Van Thuan Pham, Abhik Roychoudhury *23rd ACM Conference on Computer and Communications Security (CCS) 2016.*
- **[CCS'17]** "Directed Greybox Fuzzing" Marcel Böhme, Van Thuan Pham, Manh Dung Nguyen, Abhik Roychoudhury *24th ACM Conference on Computer and Communications Security (CCS) 2017.*
- **[IEEE-SW'21]** "Fuzzing: Challenges and Reflections", Marcel Böhme, Cristian Cadar, Abhik Roychoudhury, *IEEE Software, 38(3), 2021.*

Testing and Analysis of Non-functional program properties My research group has been instrumental in building the Chronos tool, which is used in research groups and organizations worldwide to estimate the Worst-case Execution Time (WCET) of sequential programs. Building on this line of work, we have also recently studied test generation to stress non-functional properties.

- **[SCP-Journal'07]** "Chronos: A Timing Analyzer for Embedded Software", Xianfeng Li, Yun Liang, Tulika Mitra and Abhik Roychoudhury, *Science of Computer Programming*, Vol 69, December 2007.
- **[TECS'14]** A Unified WCET Analysis Framework for Multi-core Platforms Sudipta Chattopadhyay, Lee Kee Chong, Abhik Roychoudhury, Timon Kelter, Peter Marwedel, Heiko Falk *ACM Transactions on Embedded Computing Systems (TECS), 13(4s), July 2014.*
- **[FSE'14]** "Detecting Energy Bugs and Hotspots in Mobile Apps", Abhijeet Banerjee, Lee Kee Chong, Sudipta Chattopadhyay, Abhik Roychoudhury *ACM SIGSOFT International Symposium on the Foundations of Software Engineering (FSE), 2014.*

Awards and Honors

- AsiaCCS 2021, Best paper award, top paper among 370 submitted papers.
- ACM Distinguished Member.
- Appointed Provost's Chair Professor at NUS from January 2020.
- ACM Distinguished Speaker, 2013-19.
- Distinguished Reviewer Award, ASE 2018.

- ACM SIGSOFT Distinguished Paper Award (from SIGSOFT FSE 2009, ICSE 2020).
- IBM Faculty Award, 2009.
- Tan Kah Kee Young Inventor's Award, Silver Award in Open Section, for building the Java program debugging and comprehension tool JSlice, 2008.
- Award and Medal for 1st rank in Engineering Faculty, Jadavpur University (India) in freshman and sophomore years (1991-1993), and 2nd rank in Engineering Faculty, Jadavpur University (India) in junior and senior years (1993-1995).
- National Scholarship and Award for ranking 8th among all candidates in Higher Secondary Education (equivalent of A levels) in the state of West Bengal, India, 1991.
- Ranked 2nd among all candidates in the West Bengal Joint Entrance Examination for admission to Engineering colleges/institutes in the state of West Bengal, India, 1991.

Supervision and Mentoring

- *Post-doctoral Fellows*
  - Dr. Marcel Böhme, Ph.D. NUS, post-doc from 2015-18,
    faculty member at Max-Planck Institute of Security and Privacy.
  - Dr. Jooyong Lee (Yi), Ph.D. Aarhus University, Denmark, post-doc 2012-2016,
    moved to Innopolis University (Russia) as Assistant Professor.
  - Dr. Konstantin Rubinov, Ph.D. University of Lugano, Switzerland, post-doc 2013-2015.
  - Dr. Clement Ballabriga, Ph.D. University of Toulouse, France, post-doc 2012-2014,
    Assistant Professor in University of Lille, France since September 2014.
  - Dr. Bruno C.d.S. Oliveira, Ph.D Oxford University, UK, post-doc 2012 - 13,
    Moved as Assistant Professor to Hong Kong University (HKU).
  - Dr. Ansuman Banerjee, Ph.D. IIT Kharagpur India (07), post-doc 2010
    Currently Associate Professor at Indian Statistical Institute.
  - Dr. Sun Meng, Ph.D. Peking University China (05), post-doc 2005-06
    Currently Professor at Peking University.
- *PhD thesis supervised*
  - Xiang Gao, 2021, Sole supervision
    Thesis: Overfitting in Program Repair and Synthesis, Thesis submitted for examination.
  - Sergey Mechtaev, 2018, Sole Supervision
    Placement: University College London (UCL) as Lecturer (Assistant Professor)
    Thesis: Semantic Program Repair
    Winner of ACM SIGSOFT Outstanding Doctoral Dissertation Award 2019.
  - Shin Hwei Tan, 2018, Sole Supervision
    Placement: Southern University of Science and Technology (SUSTech) as Asst. Professor
    Thesis: Design of repair operators for automated program repair
    Received Dean's Graduate Award during PhD studies.
  - Van-Thuan Pham, 2017, Sole Supervision
    Thesis: Enhancing directed search in black-box, grey-box and white-box fuzz testing Placement: University of Melbourne as Lecturer (Assistant Professor).

- Abhijeet Banerjee, 2016, Sole Supervision
  Thesis: Static analysis driven testing of performance and energy consumption properties
  Received Dean's Graduate Award during PhD studies.
- Marcel Böhme, (2014), Sole Supervision
  Placement: Max Planck Institute as faculty member. *Thesis: Automated regression testing and verification of complex code changes.*
- Dawei Qi, (2013), Joint supervision with Zhenkai Liang
  Placement: WorldQuant Singapore,
  Thesis: Semantic Analyses to detect and localize software regression errors
  Recipient of NUS Presidential Graduate Fellowship, **Best PhD thesis** award 2013.
- Sudipta Chattopadhyay, (2013), Sole Supervision
  Placement: Assistant Professor at Singapore University of Technology and Design (SUTD)
  Thesis: Timing analysis of embedded software running on multi-cores
  Recipient of NUS Presidential Graduate Fellowship.
- Sandeep Kumar, (2012), Joint supervision with Siau Cheng Khoo,
  Placement: Google Mountain View
  Thesis: Dynamic analysis based Multi-view Specification Mining.
- Lei Ju, Ph.D.(2010), Joint supervision with Samarjit Chakraborty
  Placement: Shandong University (China) as Associate Professor
  Thesis: Model-driven timing analysis of embedded software.
- Ankit Goel, Ph.D., Sole supervision,
  Thesis: Parameterized Validation of MSC-based System Models.
- Vivy Suhendra, Ph.D. (graduated 2009), Co-supervised with Tulika Mitra,
  Placement: Executive Director of Singapore Cyber-security Consortium
  Thesis: Memory Optimizations for Developing Predictable Embedded Software
  Awarded Microsoft Research Asia Fellowship during PhD studies.
- Tao Wang, Ph.D. (graduated Feb 2008), Sole Supervision,
  Placement: Morgan Stanley, Currently Vice President.
  Thesis: Bytecode level Dynamic Analysis for Software Debugging
  Best PhD thesis 2008, Microsoft Research Asia Fellowship, Presidential Graduate Fellowship.
- Xianfeng Li, Ph.D. (graduated Dec 2005), Co-supervised with Tulika Mitra,
  Placement: Peking University (currently Professor)
  Thesis: Micro-architectural modeling for Timing Analysis of Embedded Software
  Awarded Dell Fellowship, Dean's Graduate Award during his PhD study at NUS.

- *Masters thesis supervised*
  - Chong Lee Kee, Graduated 2015,
    Integrated Timing Analysis of Application and Operating Systems Code.
  - Bach Khoa Huynh, (Graduated 2010),
    Timing analysis of data intensive programs.
  - Shanshan Liu, (Graduated 2009),
    Model checking of Parameterized Systems,
    First employment: DBS, Singapore.
  - Liang Guo, (Graduated 2008),
    Debugging Statechart Models via Model-code Traceability,
    First Employment: CreditSuisse, Singapore.

- Tuan-Anh Tran, M.Sc. (Graduated 2005),
  Protocol Converters from Scenario-based Specifications,
  First Employment: Friar Tuck Pte Ltd (Singapore).
- Qinghua Shen, M.Sc. (Graduated 2004),
  Multi-threaded Java from Multi-processor Perspective,
  First Employment: Creative Technology Ltd (Singapore).
- Hemendra Singh Negi, M.Sc. (Graduated 2004),
  Two Concrete Problems in Worst-Case Execution Time Analysis,
  First Employment: Mentor Graphics, New Delhi (India).
- Lei Xie, M.Sc. (Graduated 2003),
  Performance Impact of Multi-threaded Java Semantics on Multiprocessor Memory Models.

- *Undergraduate student supervision:* Supervised the final year project of at least fifteen (15) final year undergraduate students at NUS School of Computing.

Teaching Experience

- Written a textbook for senior undergraduate courses, entitled "*Embedded Systems and Software Validation*". The book has been published by Elsevier (formerly Morgan Kaufmann) Systems-on-Silicon series in 2009. It has been adopted in courses at different universities spread over various countries (USA, China, Czech Republic, New Zealand, South Korea and India). The book has been highlighted in EE Times as *Editor's Top Picks* in 2012. A Chinese translation of the book has been done at the behest of Tsinghua University Press, and the Chinese version has subsequently been adopted for teaching at various Chinese universities.

- Three of my PhD students have received the *Best PhD Thesis* award from NUS School of Computing
  - Dr. Tao Wang, Best PhD Thesis 2008, Post-mortem Dynamic Analysis for Software Debugging
  - Dr. Dawei Qi, Best PhD Thesis 2013, Semantic Analyses to detect and localize software regression errors
  - Dr. Sergey Mechtaev, Best PhD thesis 2019, Semantic Program repair

  Dr. Sergey Mechtaev also received the ACM SIGSOFT Outstanding Dissertation Award for the best PhD thesis in Software Engineering.

- Several of my PhD students have been placed at academic positions including
  - Dr. Sergey Mechtaev, Lecturer, University College London.
  - Dr. Marcel Böhme, faculty member, Max Planck Institute (MPI).
  - Dr. Sudipta Chattopadhyay, Assistant Professor, Singapore University of Technology and Design.
  - Dr. Shin Hwei Tan, Assistant Professor, Southern University of Science and Technology (SUSTech), China
  - Dr. Lei Ju, Associate Professor, Shandong University, China.
  - Dr. Xianfeng Li, Professor, Peking University, China.

- Introduced following courses at NUS in both undergraduate and graduate levels.

- CS 4239 *Software Security*
  This was a new undergraduate course proposed by me, covering software vulnerabilities and various techniques such as fuzzing to detect and prevent these vulnerabilities.
- CS 4218 *Software Testing*
  This was a new undergraduate course proposed by me. The students are exposed to techniques, tools, project work and research on testing. The students also work on a substantial hands-on project which simulates industrial realities such as personnel leaving organizations and its impact on software comprehension and testing.
- CS 6880 *Advanced Topics in Software Engineering*
  Proposed and designed this graduate advanced course with comprehensive coverage of requirements, modeling and implementation of software. The course involves paper presentation, a project on one of the cutting edge topics on Software Engineering (SaaS, Out-sourcing etc) and an examination.
- CS 5219/6214 *Automated Software Validation*
  Proposed and designed this graduate course in software validation which studies model checking, theorem proving and their combinations.
- CS 4271 *Critical Systems and their Verification*
  Designed this undergraduate course on system modeling and verification, focusing on model checking

- Contributed article on education/pedagogy based on experience in teaching courses on formal verification — "Introducing Model Checking to Undergraduates" by Abhik Roychoudhury, In Formal Methods Education Workshop 2006 (co-located with Formal Methods Symposium (FM) 2006). The paper is available from
  `http://www.comp.nus.edu.sg/~abhik/pdf/fm-ed06.pdf`

Translational Research highlights

- *AFLFast* and *AFLGo* are extended grey-box fuzzing tools, built on top of the popular AFL fuzzer, for detecting program vulnerabilities. AFLFast has been integrated to the regular AFL distribution after significant discussion within the AFL user group. AFLFast was also used in the DARPA Cyber Grand Challenge 2016 finals by the Codejitsu team for detecting vulnerabilities quickly. A distribution of AFLFast is available from `https://github.com/mboehme/aflfast` The next generation of AFL `https://github.com/vanhauser-thc/AFLplusplus` includes various power schedules, the key idea in our CCS 2016 paper, to increase the effectiveness of fuzzing in bug/crash detection.

- *Angelix* tool for automated repair of C programs using symbolic execution, has been used for intelligent tutoring systems to teach programming to large cross-sections of students in India, in collaboration with Indian Institute of Technology (IIT) Kanpur. The tool is currently being used by 80 research groups. Such systematic analysis for automated repair, has been gaining practical traction (as an example, one could look into the latest tools from Facebook on automated repair). A distribution of Angelix is available from `http://angelix.io/`

- *Chronos, a Worst-case Execution Time (WCET) analysis tool for C programs.*
  Estimating the maximum execution time of a program is a generic problem. To obtain such estimates tightly, one needs to analyze the program flow as well as the the timing effects of the underlying processor micro-architecture. Such execution time estimates are directly useful for scheduling of hard real-time systems as well as in other applications (like guiding program optimizations). Our execution time analysis tool resulted from several research papers, including the core modeling which was reported in the following.

– Modeling Out-of-order Processors for WCET Analysis, by Xianfeng Li, Abhik Roychoudhury and Tulika Mitra, Real-Time Systems Journal 2006, Preliminary version published in IEEE Real-time Systems Symposium (RTSS) 2004.

The tool is available from `http://www.comp.nus.edu.sg/~rpembed/chronos`
Its current user base includes over 100 different research groups in 16 different countries.

Research Citation Data

- *Total number of citations* $\sim$ 8300 All citation data has been collected from Google Scholar as of June 2021.
- h-index = 50, as of June 2021. h-index is the maximum value of h such that there are h papers co-authored by me with h or more citations.
- Highest cited paper is SemFix (ICSE 2013), with 560 citations as of June 2021.

Publication List

(*Publications are grouped into two related areas. All papers are full-length papers unless indicated otherwise.*)

- **Trustworthy Software, Software Testing and Analysis**
  - [**IEEE-Software'21**] "Fuzzing: Challenges and Reflections", M Böhme, C Cadar, A Roychoudhury *IEEE Software 38 (3), 79-86, 2021.*
  - [**TOSEM'21**] "Beyond Tests: Program Vulnerability Repair via Crash Constraint Extraction", X Gao, BO Wang, GJ Duck, R Ji, Y Xiong, A Roychoudhury, *ACM Transactions on Software Engineering and Methodology, 30(2), 2021.*
  - [**TOSEM'21**] "Automated Patch Transplantation", RS Shariffdeen, SH Tan, M Gao, A Roychoudhury *ACM Transactions on Software Engineering and Methodology, 30(1), 2021.*
  - [**ISSTA'21**] "Automated Patch Backporting in Linux (Experience Paper)", R Shariffdeen, X Gao, GJ Duck, SH Tan, J Lawall, A Roychoudhury *ACM SIGSOFT International Symposium on Software Testing and Analysis (ISSTA) 2021.*
  - [**AsiaCCS'21**] "Localizing Vulnerabilities Statistically From One Exploit", Shiqi Shen, Aashish Kolluri, Zhen Dong, Prateek Saxena, Abhik Roychoudhury *ACM ASIA Conference on Computer and Communications Security (AsiaCCS)2021*, **Best paper Award**.
  - [**PLDI'21**] "Concolic Program Repair" Ridwan Shariffdeen, Yannic Noller, Lars Grunske, Abhik Roychoudhury *42nd ACM SIGPLAN Conference on Programming Language Design and Implementation (PLDI) 2021.*
  - [**PLDI'20**] "Binary Rewriting without Control Flow Recovery" Gregory J. Duck, Xiang Gao, Abhik Roychoudhury *41st ACM SIGPLAN Conference on Programming Language Design and Implementation (PLDI) 2020.*
  - [**Usenix Security'20**] "BesFS: A POSIX Filesystem for Enclaves with a Mechanized Safety Proof", Shweta Shinde, Shengyi Wang, Pinghai Yuan, Aquinas Hobor, Abhik Roychoudhury, Prateek Saxena *29th Usenix Security Symposium, 2020.*
  - [**TOSEM'20**] "Smart Contract Repair" X.L. Yu, O. Al-Bataineh, D. Lo, A. Roychoudhury *ACM Transactions on Software Engineering and Methodology (TOSEM), 29(4), 2020.*

– [**TOSEM'20**] "Kleespectre: Detecting information leakage through speculative cache attacks via symbolic execution", G Wang, S Chattopadhyay, AK Biswas, T Mitra, A Roychoudhury *ACM Transactions on Software Engineering and Methodology (TOSEM), 29(3), June 2020.*
– [**TSE'20**] "Smart Greybox Fuzzing" Van-Thuan Pham, Marcel Bhme, Andrew E. Santosa, Alexandru Razvan Caciulescu, Abhik Roychoudhury *IEEE Transactions on Software Engineering, To appear.*
– [**ICSE'20**] "Time-travel Testing of Android apps", Zhen Dong, Marcel Böhme, Lucia Cojocaru and Abhik Roychoudhury, *IEEE/ACM 42nd International Conference on Software Engineering (ICSE) 2020.*
– [**ICSE'20**] "Fuzz Testing based Data Augmentation to Improve Robustness of Deep Neural Networks" Xiang Gao, Ripon K. Saha, Mukul R. Prasad, Abhik Roychoudhury *IEEE/ACM 42nd International Conference on Software Engineering (ICSE) 2020.*
– [**CACM'19**] "Automated Program Repair" Claire Le Goues, Michael Pradel, Abhik Roychoudhury *Communications of the ACM (CACM), December 2019.*
– [**ISSTA'19**] "Crash-avoiding Program Repair" Xiang Gao, Sergey Mechtaev, Abhik Roychoudhury *International Symposium on Software Testing and Analysis (ISSTA) 2019.*
– [**ASE'19**] "Re-factoring based Program Repair applied to Programming Assignments" Yang Hu, Umair Z. Ahmed, Sergey Mechtaev, Ben Leong, Abhik Roychoudhury *34th IEEE/ACM International Conference on Automated Software Engineering (ASE) 2019.*
– [**TSE'19**] "Coverage-based Greybox Fuzzing as Markov Chain", Marcel Böhme, Van Thuan Pham, Abhik Roychoudhury *IEEE Transactions on Software Engineering (TSE), 45(5), May 2019.*
– [**NDSS'19**] "Neuro-Symbolic Execution: Augmenting Symbolic Execution with Neural Constraints" Shiqi Shen, Shweta Shinde, Soundarya Ramesh, Abhik Roychoudhury, Prateek Saxena *26th Network and Distributed System Security Symposium (NDSS) 2019.*
– [**TOSEM'18**] "Test-equivalence Analysis for Automatic Patch Generation", Sergey Mechtaev, Xiang Gao, Shin Hwei Tan, Abhik Roychoudhury *ACM Transactions on Software Engineering and Methodology (TOSEM), 27(4), October 2018.*
– [**TCAD'18**] "Symbolic Verification of Cache Side Channel Freedom", Sudipta Chattopadhyay, Abhik Roychoudhury ACM International Conference on Embedded Software (EMSOFT) 2018. *Published as IEEE Transactions on Computer Aided Design (TCAD), 37(11), pages 2812-2823, November 2018.*
– [**FSE'18**] "Symbolic Execution with Existential Second-order Constraints", Sergey Mechtaev, Alberto Griggio, Alessandro Cimatti, Abhik Roychoudhury *ACM Symposium on Foundations of Software Engineering (FSE) 2018.*
– [**ASE'18**] Android Testing via Synthetic Symbolic Execution Xiang Gao, Shin Hwei Tan, Zhen Dong, Abhik Roychoudhury *ACM/IEEE International Conference on Automated Software Engineering (ASE) 2018.*
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- **Analysis of Embedded and Mobile Software**

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- **Other Papers**
  - [**ICCL'98**] "A Conservative Technique to Improve Deterministic Evaluation of Logic Programs", Abhik Roychoudhury, C.R. Ramakrishnan, I.V. Ramakrishnan and R.C. Sekar, *IEEE International Conference on Computer Languages (ICCL) 1998.*
  - [**PAP'97**] "A rule-based data standardizer for Enterprise Databases", Abhik Roychoudhury, I.V. Ramakrishnan and Terrence Swift, *International Conference on Practical Applications of Prolog (PAP) 1997.*
  - [**FST&TCS'95**] "Efficient algorithms for vertex arboricity of planar graphs", Abhik Roychoudhury and Susmita Sur Kolay, *Intl. Conf. on Foundations of Software Technology and Theoretical Computer Science (FST & TCS) 1995, Springer Verlag, LNCS 1026.*

Professional Service to the International Community (Highlights)

- Program co-chair, International Conference on Software Engineering (ICSE) 2024.
- Associate Editor, ACM Transactions on Software Engineering and Methodology (TOSEM), 2019 -22. Guest Editor-in-chief of TOSEM Continuous Special Section on Security and Software Engineering.

- Associate Editor, IEEE Transactions on Dependable and Secure Computing (TDSC), 2019 - 2023.
- Associate Editor, IEEE Transactions on Software Engineering (TSE), 2014 - 2018.
- General Chair, ACM SIGSOFT Symposium on Foundations of Software Engineering (FSE) 2022.
- Program Chair, International Symposium on Software Testing and Analysis (ISSTA) 2016.
- Member of the Selection Committee for deciding IEEE Harlan Mills Award, 2020-21.

Professional Service to the International Community (Other recent service)

- Area Chair, Dependability, International Conference on Software Engineering (ICSE) 2023.
- Co-chair, Special Section on East Asia and Oceania, Communications of the ACM, April 2020.
- Co-chair, Shonan Meeting on Fuzzing and Symbolic Execution, September 2019.
- Co-chair, Dagstuhl Seminar on Automated Program Repair, January 2017.
- Co-chair of New Ideas and Emerging Results (NIER), International Conference on Software Engineering (ICSE), 2015.
- Mentoring co-chair, International Conference on Software Engineering (ICSE) 2014.
- Doctoral Symposium co-chair, ACM SIGSOFT International Symposium on Foundations of Software Engineering (FSE) 2014.
- Invited International Member of ArtistDesign, the European Network of Excellence in Embedded Systems, 2009-12.
- Chair of Design and Verification Track in IEEE Real time Systems Symposium (RTSS) 2012.
- Program Chair of 9th International Colloquium on Theoretical Aspects of Computing (ICTAC) 2012, Proceedings available as Springer LNCS 7521.
- Co-chair of "Workshop on Future of Software Debugging", organized under Mysore Park Workshop Series, Infosys, Feb - March 2012.
- Recent Program Committee Memberships include:
  - International Conference on Software Engineering (ICSE) 2016, 2017 (program board), 2019, 2020, 2021(Program Board).
  - ACM SIGSOFT Foundations of Software Engineering (FSE) 2012, 2017, 2019, 2020, 2021
  - IEEE Real-time Systems Symposium (RTSS) 2010-14.
  - ACM International Symposium on Software Testing and Analysis (ISSTA) 2013, 2015, 2016, 2021.
  - IEEE/ACM International Conference on Automated Software Engineering (ASE) 2013, 2018, 2021.
  - IEEE Intl. Conf. on Software Testing, Verification and Validation (ICST) 2013, 2014, 2015, 2017, 2019.
  - Intl. Conf. on Languages, Compilers, Tools and Theory for Embedded Systems (LCTES) 2012, 2014.

- Intl. Conf on Embedded Software (EMSOFT) 2015.
- Design Automation and Test in Europe (DATE) 2012.
- International Conference on Theoretical Aspects on Computing (ICTAC) 2009, 13.
- International Symposium on Automated Technology for Verification and Analysis (ATVA) 2009, 2011-13.

Service to University and Local Community (Selected)

- Director, National Satellite of Excellence in Trustworthy Software Systems, since January 2019. In this role, I am responsible for charting the research program in Trustworthy Software in Singapore, involving research in the autonomous universities, companies and agencies.
- Managing Committee Chairman of *Singapore Cyber-Security Consortium* (a consortium of 25 companies), 2016-2022.
  The consortium is anchored at NUS. I was heavily involved in setting up this first industry Consortium in Computer Science, at Singapore. The Consortium provides a platform for research engagement between member companies, academia and government agencies.
- Vice Dean of Graduate Studies, at NUS School of Computing, 2013 -16.
  Started several efforts to engage PhD students with industry, including an annual Placement workshop held at NUS School of Computing.
- Assistant Dean of Graduate Studies at NUS School of Computing, 2011 - 2013.
  Started an annual workshop series for greater engagement with students and professors from Indian universities in graduate eduction and research.
- Area representative of Security research area in Computer Science Department Executive Committee (CS ExCo) 2013-16.
- Chair of the *Publications Committee*, CS Department, NUS, 2010 - 13.
  Co-ordinated a year-long exercise to develop research evaluation metrics which balance the importance given to research activity vis-a-vis long-term research impact.
- Associate Professor representative in the NUS School of Computing Executive Committee 2010.
- Member of *Graduate Studies Committee*, NUS School of Computing since 2003.
  Conducted many outreach trips to Indian universities since 2003, and to universities in Vietnam (2007).

  and Computing Student Development Fund (CSD), 2009-12.
- Assistant Professor Representative in Executive Committee of School of Computing (2002-03).
- Speaker at Governmentware 2014, Organized by Ministry of Home Affairs, Strategies empowered by Training Session, 25 September 2014, Singapore.
- Member of Scientific Committee for *National Informatics Olympiad (NOI)*, Singapore (2002-2004). NOI is a creative problem solving and programming competition for High School / JC Students. Selected candidates from NOI represent Singapore in the International Olympiad in Informatics" (IOI).

Personal Data

- Married, One son.
- Indian citizen, Singapore Permanent Resident.