

# PAUL FITERĂU-BROȘTEAN

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## WORK EXPERIENCE

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### Uppsala University

*Postdoctoral Researcher*

September 2018 -

*Uppsala, Sweden*

- Developed techniques and tools for testing network protocol implementations based on model learning and symbolic execution.

### Quintiq

*Software Developer*

February 2018 - September 2018

*'s Hertogenbosch, Netherlands*

- Developed and maintained tooling connecting a complex server application to external endpoints such as file systems, message queues and SOAP servers.

### Radboud University, Nijmegen

*PhD Candidate*

November 2013 - November 2017

*Nijmegen, Netherlands*

- Improved model learning techniques, tools in their application to testing network protocol implementations.

## EDUCATION

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### Radboud University, Nijmegen

2013-2018

PhD in Computer Science

PhD Thesis on applying active automata learning techniques to network protocols.

Supervisor: Prof. Frits W. Vaandrager

### Politehnica University, Timișoara

2011-2013

Master in Software Engineering

Master's Thesis on the semi-automatic generation of drivers for connecting systems to automata learning tools, graded with 10.

Supervisor: Prof. Ioana Șora

### Radboud University, Nijmegen

2012-2013

Erasmus exchange student for one semester

### Politehnica University, Timișoara

2007-2011

Bachelor in Computers and Information Technology

Bachelor's Thesis on extending the Fractal architecture description language as to enable description of reconfiguration operations, graded with 10.

Supervisor: Prof. Ioana Șora

## PUBLICATIONS

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- [1] Paul Fiterău-Broștean, Bengt Jonsson, Konstantinos Sagonas, and Fredrik Tåkqvist. Automata-based automated detection of state machine bugs in protocol implementations. In *NDSS*, 2023. to appear.
- [2] Hooman Asadian, Paul Fiterău-Broștean, Bengt Jonsson, and Konstantinos Sagonas. Applying symbolic execution to test implementations of a network protocol against its specification. In *2022 IEEE Conference on Software Testing, Verification and Validation (ICST)*, pages 70–81. IEEE, 2022.

- [3] Paul Fiterău-Broștean, Bengt Jonsson, Konstantinos Sagonas, and Fredrik Tåquist. DTLS-Fuzzer: A DTLS protocol state fuzzer. In *2022 IEEE Conference on Software Testing, Verification and Validation (ICST)*, pages 456–458. IEEE, 2022.
- [4] Paul Fiterău-Broștean, Bengt Jonsson, Robert Merget, Joeri de Ruiter, Konstantinos Sagonas, and Juraj Somorovsky. Analysis of DTLS implementations using protocol state fuzzing. In *29th USENIX Security Symposium (USENIX Security 20)*, 2020.
- [5] Paul Fiterău-Broștean. *Active Model Learning for the Analysis of Network Protocols*. PhD thesis, Radboud University Nijmegen, 2018.
- [6] Rick Smetsers, Paul Fiterău-Broștean, and Frits Vaandrager. Model learning as a satisfiability modulo theories problem. In *International Conference on Language and Automata Theory and Applications*, pages 182–194. Springer, 2018.
- [7] Paul Fiterău-Broștean and Falk Howar. Learning-based testing the sliding window behavior of TCP implementations. In *Critical Systems: Formal Methods and Automated Verification*, pages 185–200. Springer, 2017.
- [8] Paul Fiterău-Broștean, Toon Lenaerts, Erik Poll, Joeri de Ruiter, Frits Vaandrager, and Patrick Verleg. Model learning and model checking of SSH implementations. In *Proceedings of the 24th ACM SIGSOFT International SPIN Symposium on Model Checking of Software*, SPIN 2017, pages 142–151. ACM, 2017.
- [9] Paul Fiterău-Broștean, Ramon Janssen, and Frits Vaandrager. Combining model learning and model checking to analyze TCP implementations. In *CAV 2016*, volume 9780 of *LNCS*, pages 454–471. Springer, 2016.
- [10] Fides Aarts, Paul Fiterău-Broștean, Harco Kuppens, and Frits Vaandrager. Learning register automata with fresh value generation. In *ICTAC 2015*, volume 9399 of *LNCS*, pages 165–183. Springer, 2015.
- [11] Paul Fiterău-Broștean, Ramon Janssen, and Frits Vaandrager. Learning fragments of the TCP network protocol. In *FMICS 2014*, volume 8718 of *LNCS*, pages 78–93. Springer, 2014.

## RESEARCH SUMMARY

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**Model Learning for Network Protocol Testing** We used (active) model learning to test implementations of essential network protocols such as TCP [11, 9, 7], SSH [8] and DTLS [4, ?]. These works uncovered bugs, including vulnerabilities, leading to fixes in important libraries such as Java’s TLS implementation and the Linux TCP stack. Our works also addressed challenges arising in model learning applications. We automated analysis of learned models using model checking of requirements encoded by linear temporal logic [9, 8], and more recently, by deterministic finite automata [?]. We also improved model learning algorithms and tools for register automata [10, 7], a rich formalism that can better capture the behavior of complex systems compared to the finite state automata traditionally supported by model learning. In a related work [6], we developed an extensible model learning framework based on SMT solvers, which supports a wider range of formalisms.

**Symbolic Execution for Network Protocol Testing** We present a methodology which leverages symbolic execution to test implementations of network protocols [6]. The idea is to guide symbolic execution, using assertions and assumptions, towards paths in the SUT that violate protocol requirements. We implement our methodology using the KLEE symbolic execution engine and apply it to test DTLS implementations. Our testing revealed bugs in all four libraries tested, including a promptly-fixed memory bug in OpenSSL.

## TEACHING

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Lecturer for the Secure Computer Systems course, academic year 2021-2022.

Lecturer for the Programming Embedded Systems course, academic year 2019-2020.

Teaching assistant for the Computer Networking course for three consecutive years 2014-2017.

Teaching assistant for the Testing Techniques course, academic year 2014-2015.

## SUPERVISION

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Fredrik Tåkvist, PhD Student since February 2022.

Hooman Asadian, PhD Student since September 2019.

Rahbar Ghorji, 2021, Master's Thesis *Protocol-aware fuzzing of DTLS*.

Fredrik Tåkvist, 2020, Bachelor's Thesis *Analysis of DTLS Implementations Using State Fuzzing*.

Toon Laenarts, 2017, Bachelor's Thesis *Improving Protocol State Fuzzing of SSH*.

Ramon Jansen, 2015, Master's Thesis *Learning and Model Checking Real-world TCP Implementations*.

## RESEARCH INTERESTS

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Network Protocol Testing

Active and Passive Model Learning

Symbolic Execution

Application of Formal Methods

## SERVICE

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(Sub-)Reviewer for Computer Networks 2022, FM 2021 and 2019, Computer Communications Journal 2018, ICFEM 2017 and MARS 2017.

## AWARDS

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VERSEN PhD Award 2019, First Place.

## JUNIOR WORK EXPERIENCE

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**Alcatel Lucent**

*Junior Software Developer*

February 2013 - April 2013

*Timișoara*

- Contributed to the development of a license manager tool.

**e-Austria**

*Junior Researcher*

July 2012 - August 2013

*Timișoara*

- Developed framework for automatically generating model learning setups for Java and web applications.

**Alcatel Lucent**

*Junior Software Developer*

October 2011 - July 2012

*Timișoara*

- Contributed to the development of a radio network planning tool.

## LANGUAGES

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Romanian      native

English        full working proficiency

Dutch          basic