

# Denis Efremov

*System Developer/Formal Verification Engineer*

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## Education

- 2006–2011 **Specialist**, *Lomonosov Moscow State University (MSU)*, Moscow, Specialist in mathematics and system programming  
Specialist degree programme (equals to Bachelor's programme + Master's programme)  
Main courses: Calculus, Linear Algebra, Probability Theory and Statistics, Algorithms and Data Structures, Operating Systems, Computer Networks. Overview courses: Computer Vision and Graphics etc.  
Diploma qualification work is about hardware virtualization (AMD-V SVM) based firewall.
- 2015–2018 **PhD Candidate**, *National Research University Higher School of Economics*, Moscow, Physics and Mathematics  
Verification Methods for Software Systems With Access Control Functions Based on Formal Models

## Experience

### Vocational

- June 2022 **Consulting Software Engineer**, *Oracle*, Dubai  
Present Led the design and implementation of Ksplice's core live patching engine features, enabling zero-downtime security updates across multiple Linux kernel versions and distributions including Oracle Linux, RHEL, and Ubuntu. Developed QA and performance testing frameworks which helped to preserve system stability across millions of production servers. Established engineering best practices and mentored a team of 10 engineers, elevating technical capabilities in kernel programming and low-level systems development. Collaborated cross-functionally with Oracle Cloud Infrastructure teams to optimize live patching for cloud environments.
- Mar 2021 **Principal Developer**, *Oracle*, Moscow
- May 2022 Linux kernel developer, Ksplice team. Main responsibilities:
- Runtime updates preparation for Linux kernel releases.
  - Maintainance of RHEL EL9 and EL10 release classes.
  - Linux Kernel QA/testing/fuzzing.
  - Linux Kernel CVE tracking and security commits tagging.

- July 2011 **Researcher/Developer/Formal Verification Engineer, ISP RAS, Moscow**
- Mar 2021 **Institute for System Programming of the Russian Academy of Sciences** belongs to the Division of Mathematical Sciences of the RAS. My research projects:
- Took a part in development of "GOST R 59453.4-2025" standard "Information protection. Formal access control model. Part 4. Recommendations for verification of information security features that implement access control policies based on formal descriptions of the access control model";
  - Formal specification and verification of a Linux security module of AstraLinux distro. Developed formal specifications and proofs with Frama-C/Coq. Developed tools for writing formal specifications for kernel code. Developed fuzzing rules. Integrated various static analysis tools. Established continuous verification workflow. This project allowed RusBiTech company to pass government certifications on a highest secrecy level (FSB and FSTEK certifications). [AstraVer project page](#);
  - Verification of a Linux security module of Elbrus distro. Developed rules for static analysis tools and fuzzers. Developed tools for tracing system calls (kretprobes based) and replay (animate) gathered traces on a formal model in Event-B language. Proof of concept for runtime verification system demonstrated. Information leaks found. Differences between formal model and implementation highlighted;
  - Network access control system for applied and system software based on domains separation with remote system call execution mechanism. Team project;
  - Virtual machines manager (based on KVM) with exclusive access to hardware on the base of AMD x86-64 architecture;
  - Reliable activation and deactivation of security systems in untrusted environments;
  - Protection of IPC between trusted applications in untrusted environment;
- Jan 2019 **Research Intern, Fraunhofer FOKUS, Berlin**
- Apr 2019 Worked in the verification team of System Quality Center lab. Short-term research internship for establishing scientific collaboration between ISPRAS and Fraunhofer FOKUS. Main projects: Vessedia and ACSL-By-Example. The internship resulted in collaboration agreement between ISPRAS and Fraunhofer Fokus institutes.
- Vessedia: formal verification of IoT OS Contiki. Primary responsibilities: development of ACSL specifications and development of continuous verification framework for Frama-C and Contiki.
  - ACSL-By-Example is a book of formal verification examples from STL library. Primary responsibilities: improvement of existing specifications (implicit axiomatic definitions - > explicit ones), inconsistencies fixes, Coq proofs for lemmas, new examples for the book, CI.
- Oct 2017 **Software Developer, Yandex, Moscow**
- May 2018 Worked in the backend team of the project "[Partner Interface 2.0](#)" (Google AdSense analog). Features developed:
- RestApi for Video Pages and Blocks (video ads);
  - Indoor Pages and Blocks (ads for malls, airports, taxi, ...);
  - Statistics comparison, aggregation and exporting;
  - Action logs refactoring with support for RestApi (logging of ads setting changes);
  - Business rules (advanced settings for ads based on viewer's region, browser, timezone ...);
- 2013 **Software Developer, Google Summer of Code program**  
Verification of Linux file systems drivers by combination of static and dynamic analysis. Developed concolic testing tool (based on S2E tool) for Linux kernel file system drivers.
- 2012 **Software Developer, Google Summer of Code program**  
Formalization of Correct Usage of Kernel Core API. [Developed 12 formal models](#) for Linux Driver Verification tool. Implemented new approach for automatic construction of a Linux kernel code model.

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## Computer skills

Languages	C, Perl, Python, ACSL, Shell scripts
Tools	ansible, qemu, git, gdb, gcc, libfuzzer, Coccinelle, Frama-C, Why3, Coq, Event-B, ProB
Linux Kernel	syzkaller, SystemTap, gcov
GNU/Linux distributions	Gentoo, Fedora, Debian/Ubuntu

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## Teaching

- Construction of the Operating System Kernel (in russian). (MSU Spring 2013, Fall 2014, 2015, 2016, 2017, 2018; HSE Fall 2016, 2017, 2018; MIPT Fall 2015, 2016, 2017, 2018)
- Software Verification (in russian). (HSE Spring 2016, 2017)

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## Conferences

- Linux Security Summit 2021, D. Efremov "[CVEHound: Audit Kernel Sources for Missing CVE Fixes](#)"
- ZeroNights X 2021, D. Efremov "[CVEhound: check Linux sources for known CVEs](#)"
- PHDays X 2021, D. Efremov "[Formal verification of operating system kernels](#)"
- OSSDev 2021, D. Efremov and A. Khoroshilov "[Linux kernel testing](#)"
- Formal Methods 2019 (FM 2019), D. Efremov and I. Shchepetkov "Runtime verification of Linux Security Module"
- Frama-C and SPARK Day 2019 (FCSD 2019), D. Efremov and J. Gerlach "[Continuous deductive verification with Frama-C](#)"
- 8th International Symposium On Leveraging Applications of Formal Methods, Verification and Validation (ISoLA 2018)
- Yandex Perl Meetup (2018) D. Efremov "[Practical Language for Extracting Data from Source Codes and Preparing Them for Analysis](#)"
- ISPRAS Open (2017) D. Efremov "Security Policy Modeling and Verification (part 3)"
- PHDays VII (2017) D. Efremov "[Formal Verification of C Code](#)"

## Open Source Contribution

- Own Projects
  - [CVEhound](#): Scan linux kernel sources for known CVEs
  - Custom kernel for Samsung S10/Note10 models with Github Actions integration and top-level build system with use-flags (gentoo alike). A number of system tools, like adb root, implemented as Magisk modules. ([GitHub](#), [XDA](#))
  - [Magisk modules](#) for debugging
  - [VerKer](#): Formal Verification of Linux Kernel Library Functions
  - [Spec-Utills](#): Tools for writing ACSL specifications for Linux kernel
- Linux Kernel
  - Floppy driver maintainer since July 2019
  - Coccinelle rules (commits [kfree\\_mismatch](#), [flexible\\_array](#), [kvmalloc](#), [excluded\\_middle](#), [uninitialized\\_var](#), [kobj\\_to\\_dev](#), [kzfree](#), [array\\_size\\_dup](#), [device\\_attr\\_show](#))
  - Floppy driver fixes (commits [CVE-2019-14284](#), [2](#), [3](#), [CVE-2019-14283](#), [5](#))
  - modpost check for static EXPORT\_SYMBOL\* functions ([commit](#))
  - [Full list of commits](#)
- Syzkaller
  - integrity (IMA/EVM) driver [rules](#)
  - smack driver [rules](#)
  - floppy driver [rules](#)
  - cdrom driver [rules](#)
  - i2c driver [rules](#)
  - [Full list of PRs](#)
- Gentoo Portage [Ebuilds](#)

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## Publications

- [1] D. V. Efremov, A. K. Petrenko, B. A. Pozin, and V. A. Semenov. Overview of hardening mechanisms in operating systems and user applications. *Proceedings of the Institute for System Programming of the RAS*, 37(3):325–354, 2025.
- [2] A. K. Petrenko, P. N. Devyanin, D. V. Efremov, A. A. Karnov, E. V. Kornychkin, V. V. Kuliamin, and A. V. Khoroshilov. Methods of runtime verification of industrial information security tools based on formal access control models. *Proceedings of the Institute for System Programming of the RAS*, 37(3):277–290, 2025.
- [3] A. K. Petrenko, D. V. Efremov, E. V. Kornychkin, V. V. Kuliamin, and V. A. Semenov. Runtime verification of industrial information security tools based on formal access control models. *Software & Systems*, 38(2):374–380, 2025.
- [4] D. V. Efremov, V. V. Kopach, E. V. Kornychkin, V. V. Kuliamin, A. K. Petrenko, A. V. Khoroshilov, and I. V. Shchepetkov. Runtime verification of operating systems based on abstract models. *Programming and Computer Software*, 49(7):559–565, 2023.
- [5] D. V. Efremov, V. V. Kopach, E. V. Kornychkin, V. V. Kuliamin, A. K. Petrenko, A. V. Khoroshilov, and I. V. Shchepetkov. Runtime verification of operating systems based on abstract models. *Proceedings of the Institute for System Programming of the RAS*, 33(6):15–26, 2021.
- [6] A. K. Petrenko, D. V. Efremov, E. V. Kornychkin, V. V. Kuliamin, A. V. Khoroshilov, and I. V. Shchepetkov. Monitoring and testing based on multi-level program specifications. *Proceedings of the Institute for System Programming of the RAS*, 32(6):7–18, 2020.
- [7] Denis Efremov and Ilya Shchepetkov. Runtime verification of linux kernel security module. In Emil Sekerinski, Nelma Moreira, José N. Oliveira, Daniel Ratiu, and et al., editors, *Formal Methods. FM 2019 International Workshops*, volume 12233 of *Lecture Notes in Computer Science*, pages 185–199, Cham, 2020. Springer International Publishing.
- [8] P. N. Devyanin, D. V. Efremov, V. V. Kuliamin, A. K. Petrenko, A. V. Khoroshilov, and I. V. Shchepetkov. *Modeling and Verification of Access Control Security Policies in Operating Systems*. Goryachaya Liniya – Telekom, Moscow, Russian Federation, 2019.
- [9] Jens Gerlach, Denis Efremov, Tim Sikatzki, et al. ACSL by Example: Towards a formally verified standard library. *Fraunhofer FOKUS Technical Report*, June 2019.
- [10] Denis Efremov, Mikhail Mandrykin, and Alexey Khoroshilov. Deductive verification of unmodified linux kernel library functions. In Tiziana Margaria and Bernhard Steffen, editors, *Leveraging Applications of Formal Methods, Verification and Validation. Verification*, volume 11245 of *Lecture Notes in Computer Science*, pages 216–234, Cham, 2018. Springer International Publishing.

- [11] Grigoriy Volkov, Mikhail Mandrykin, and Denis Efremov. Lemma functions for Frama-C: C programs as proofs. In *Proceedings of the 2018 Ivannikov ISPRAS Open Conference (ISPRAS-2018)*, pages 31–38. IEEE, 2018.
- [12] Denis Efremov and Mikhail Mandrykin. Formal verification of linux kernel library functions. *Proceedings of the Institute for System Programming of the RAS*, 29(6):49–76, 2017.
- [13] D. V. Efremov, N. Yu. Komarov, and A. V. Khoroshilov. *Construction of the Operating System Kernel*. Publishing Department of the CMC Faculty of Lomonosov Moscow State University; MAKS Press, Moscow, 2015.
- [14] Denis Efremov and Nikita Komarov. Tools support for linux kernel deductive verification workflow. In *Proceedings of the Spring/Summer Young Researchers' Colloquium on Software Engineering (SYRCoSE)*, volume 8, pages 39–44, Saint Petersburg, Russia, 2014.
- [15] Denis Efremov and Nikolay Pakulin. Sevigator: Network confinement of malware applications and untrusted operating systems. In *Proceedings of the International Conference on Security and Cryptography (SECRYPT 2012)*, pages 395–398, Rome, Italy, 2012. SciTePress.
- [16] Denis Efremov. Protection of the applications' privacy running untrusted operating system. In *Proceedings of the Russian Conference on Actual Problems of System and Software Engineering (APSSE)*, 2011.
- [17] Denis Efremov and Pavel Iakovenko. An approach to on-the-fly activation and deactivation of virtualization-based security systems. In *Proceedings of the Spring/Summer Young Researchers' Colloquium on Software Engineering (SYRCoSE)*, volume 4, pages 157–161, Nizhny Novgorod, Russia, 2010.
- [18] Denis Efremov. CVEhound: Audit kernel sources for missing CVE fixes. Linux Security Summit 2021 (LSS2021), 2021. Conference talk. Slides: <https://speakerdeck.com/efremov/cvehound-audit-kernel-sources-for-missing-cve-fixes>.
- [19] Denis Efremov. CVEhound: проверка исходников Linux на известные CVE. ZeroNights 2021, 2021. Conference talk. Slides: <https://speakerdeck.com/efremov/cvehound-audit-kernel-sources-for-missing-cve-fixes>.
- [20] Denis Efremov. Инструменты тестирования ядра Linux. OSSDEVCONF-2021, June 2021. Conference presentation. Slides: <https://speakerdeck.com/efremov/instrumenty-tiestirovaniia-iadra-linux>.
- [21] Denis Efremov. Формальная верификация ядер операционных систем. Positive Hack Days X (PHDays X), 2021. Conference talk. Slides: <https://speakerdeck.com/efremov/formal-verification-of-operating-system-kernels>.
- [22] Denis Efremov. Формальная верификация кода на языке C. Positive Hack Days VII (PHDays VII), 2017. Conference talk. Slides: <https://www.slideshare.net/slideshow/efremov-verification-animation-final/77881985>.