Lecture Notes in Computer Science

Commenced Publication in 1973 Founding and Former Series Editors: Gerhard Goos, Juris Hartmanis, and Jan van Leeuwen

Editorial Board Members

David Hutchison Lancaster University, Lancaster, UK Takeo Kanade Carnegie Mellon University, Pittsburgh, PA, USA Josef Kittler University of Surrey, Guildford, UK Jon M. Kleinberg Cornell University, Ithaca, NY, USA Friedemann Mattern ETH Zurich, Zurich, Switzerland John C. Mitchell Stanford University, Stanford, CA, USA Moni Naor Weizmann Institute of Science, Rehovot, Israel C. Pandu Rangan Indian Institute of Technology Madras, Chennai, India Bernhard Steffen TU Dortmund University, Dortmund, Germany Demetri Terzopoulos University of California, Los Angeles, CA, USA Doug Tygar University of California, Berkeley, CA, USA

More information about this series at http://www.springer.com/series/7410

Roberto Perdisci · Clémentine Maurice · Giorgio Giacinto · Magnus Almgren (Eds.)

Detection of Intrusions and Malware, and Vulnerability Assessment

16th International Conference, DIMVA 2019 Gothenburg, Sweden, June 19–20, 2019 Proceedings



Editors Roberto Perdisci University of Georgia Athens, GA, USA

Georgia Institute of Technology Atlanta, GA, USA

Giorgio Giacinto University of Cagliari Cagliari, Italy Clémentine Maurice D University of Rennes, CNRS, IRISA Rennes, France

Magnus Almgren Chalmers University of Technology Gothenburg, Sweden

ISSN 0302-9743 ISSN 1611-3349 (electronic) Lecture Notes in Computer Science ISBN 978-3-030-22037-2 ISBN 978-3-030-22038-9 (eBook) https://doi.org/10.1007/978-3-030-22038-9

LNCS Sublibrary: SL4 - Security and Cryptology

© Springer Nature Switzerland AG 2019

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, expressed or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Switzerland AG The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

On behalf of the Program Committee, it is our pleasure to present the proceedings of the 16th International Conference on Detection of Intrusions and Malware and Vulnerability Assessment (DIMVA), which took place in Gothenburg, Sweden, June 19–20, 2019. Since 2004, DIMVA has been bringing together leading researchers and practitioners from academia, industry, and government to present and discuss novel security research in the broader areas of intrusion detection, malware analysis, and vulnerability assessment. DIMVA is organized by the Special Interest Group – Security, Intrusion Detection, and Response (SIDAR) – of the German Informatics Society (GI).

This year, DIMVA received 80 valid submissions from academic and industrial organizations from more than 40 different institutions across 16 countries. Each submission was carefully reviewed by at least three Program Committee members or external experts. The submissions were evaluated on the basis of scientific novelty, importance to the field, and technical quality. The final selection of papers was decided during a day-long Program Committee meeting that took place at the Georgia Institute of Technology in Atlanta, USA, on April 8, 2019. The Program Committee selected 23 full papers for presentation at the conference and publication in the proceedings, resulting in an acceptance rate of 28.8%. The accepted papers present novel ideas, techniques, and applications in important areas of computer security, including Web and browser security, malware analysis and defense, security of industrial systems and cyber physical systems, attack mitigation, network security, and software security. The conference program also included two insightful keynote talks by Prof. Mathias Payer (École polytechnique fédérale de Lausanne) and Prof. Frank Piessens (Katholieke Universiteit Leuven).

A successful conference is the result of the joint effort of many people. We would like to express our appreciation to the Program Committee members and external reviewers for the time spent reviewing papers, participating in the online discussion, attending the Program Committee meeting in Atlanta, and shepherding some of the papers to ensure the highest quality possible. We also deeply thank the members of the Organizing Committee for their hard work in making DIMVA 2019 such a successful event. We are wholeheartedly thankful to our sponsors Trend Micro, Svenska kraftnät, Recorded Future, Palo Alto Networks, and Springer for generously supporting DIMVA 2019. We also thank Springer for publishing these proceedings as part of their LNCS series and the DIMVA Steering Committee for their continuous support and assistance.

Finally, DIMVA 2019 would not have been possible without the authors who submitted their work and presented their contributions, as well as the attendees who

came to the conference. We would like to thank them all, and we look forward to their future contributions to DIMVA.

June 2019

Roberto Perdisci Clémentine Maurice Giorgio Giacinto Magnus Almgren

Organization

DIMVA was organized by the special interest group Security – Intrusion Detection and Response (SIDAR) of the German Informatics Society (GI).

Organizing Committee

General Chair	
Magnus Almgren	Chalmers University of Technology, Sweden
Program Chair	
Roberto Perdisci	University of Georgia and Georgia Institute of Technology, USA
Program Co-chair	
Clémentine Maurice	CNRS, IRISA, France
Publications Chair	
Giorgio Giacinto	University of Cagliari, Italy
Publicity Chair	
Kyu Hyung Lee	University of Georgia, USA
Sponsor Chair	
Xavier Bellekens	Abertay University, UK
Local Arrangements Chair	
Pablo Picazo-Sanchez	Chalmers University of Technology and University of Gothenburg, Sweden
Steering Committee (Ch	nairs)
Ulrich Flegel	Infineon Technologies AG, Germany
Michael Meier	University of Bonn and Fraunhofer FKIE, Germany
Steering Committee	
Magnus Almgren	Chalmers University of Technology, Sweden
Sébastien Bardin	CEA, France
Gregory Blanc	Télécom SudParis, France

Herbert Bos Danilo M. Bruschi Roland Bueschkes Juan Caballero Lorenzo Cavallaro Hervé Debar Sven Dietrich Cristiano Giuffrida Bernhard Haemmerli Thorsten Holz Marko Jahnke Klaus Julisch Christian Kreibich Christopher Kruegel Pavel Laskov Federico Maggi Michalis Polychronakis Konrad Rieck Jean-Pierre Seifert Robin Sommer Urko Zurutuza

Program Committee

Manos Antonakakis Marco Balduzzi Leyla Bilge Lorenzo Cavallaro Gabriela Ciocarlie Baris Coskun Lorenzo De Carli Hervé Debar Sven Dietrich Brendan Dolan-Gavitt Adam Doupé Manuel Egele Ulrich Flegel Yanick Fratantonio Giorgio Giacinto Neil Gong Thorsten Holz Kyu Hyung Lee Sotiris Ioannidis Vasileios Kemerlis Katharina Krombholz

Vrije Universiteit Amsterdam, The Netherlands Università degli Studi di Milano, Italy RWE AG, Germany IMDEA Software Institute, Spain Royal Holloway, University of London, UK Télécom SudParis, France City University of New York, USA Vrije Universiteit Amsterdam, The Netherlands Acris GmbH and HSLU Lucerne, Switzerland Ruhr-Universität Bochum, Germany CSIRT, German Federal Authority, Germany Deloitte, Switzerland ICSI. USA UC Santa Barbara, USA Universität Liechtenstein, Liechtenstein Trend Micro Research, Italy Stony Brook University, USA TU Braunschweig, Germany Technical University Berlin, Germany ICSI/LBNL. USA Mondragon University, Spain

Georgia Institute of Technology, USA Trend Micro Research, Italy Symantec Research Labs, France, King's College London, UK SRI International. USA Amazon Web Services, USA Worcester Polytechnic Institute, USA Télécom SudParis, France City University of New York, USA NYU. USA Arizona State University, USA Boston University, USA Infineon Technologies AG, Germany EURECOM, France University of Cagliari, Italy Iowa State University, USA Ruhr-Universität Bochum, Germany University of Georgia, USA FORTH, Greece Brown University, USA CISPA Helmholtz Center for Information Security, Germany

Andrea Lanzi Corrado Leita Zhiqiang Lin Martina Lindorfer Xiapu Luo Federico Maggi Michael Meier Jelena Mirkovic Nick Nikiforakis Anita Nikolich Daniela Oliveira Christina Poepper Georgios Portokalidis Christian Rossow

Deborah Shands Kapil Singh Gianluca Stringhini Juan Tapiador Heng Yin Stefano Zanero

Additional Reviewers

Ioannis Agadakos Omar Alrawi Davide Ariu Thanos Avgetidis Babak Amin Azad Ala' Darabseh Erick Bauman Battista Biggio Gregory Blanc Marcus Botacin Daniel Capecci Fabrício Ceschin Aokun Chen Sanchuan Chen Igino Corona Vasu Devan Sergej Epp Matthias Fassl Tobias Fiebig

Matthias Gusenbauer Mohit Jangid University of Milan, Italy Lastline. UK Ohio State University, USA TU Wien, Austria The Hong Kong Polytechnic University, HK Trend Micro Research, Italy University of Bonn and Fraunhofer FKIE. Germany USC ISI, USA Stony Brook University, USA Illinois Institute of Technology, USA University of Florida, USA New York University Abu Dhabi, UAE Stevens Institute of Technology, USA CISPA Helmholtz Center for Information Security, Germany SRI International, USA IBM T.J. Watson Research Center, USA Boston University, USA Universidad Carlos III, Spain University of California Riverside, USA Politecnico di Milano, Italy

SRI International, USA Georgia Institute of Technology, USA Pluribus One, Italy Georgia Institute of Technology, USA Stony Brook University, USA NYU Abu Dhabi, UAE Ohio State University, USA University of Cagliari, Italy Télécom SudParis, France Federal University of Paraná, Brazil University of Florida, USA Federal University of Paraná, Brazil University of Florida, USA Ohio State University, USA Pluribus One, Italy Stony Brook University, USA Palo Alto Networks, Germany CISPA Helmholtz Center for Information Security, Germany TU Delft, The Netherlands SBA Research, Austria Ohio State University, USA

Konstantinos Karakatsanis Georgia Institute of Technology, USA Kleanthis Karakolios Georgia Institute of Technology, USA Georgia Institute of Technology, USA Panagiotis Kintis Georgia Institute of Technology, USA Athanasios Kountouras Shoufu Luo City University of New York, USA Davide Maiorca University of Cagliari, Italy Naimeh Miramirkhani Stony Brook University, USA NYU Abu Dhabi, UAE Muhammad Shujaat Mirza Liang Niu NYU Abu Dhabi, UAE Jaehyun Nam KAIST, Republic of Korea Thomas Papastergiou Georgia Institute of Technology, USA Fabio Pierazzi King's College London, UK University of Florida, USA Nikolaos Sapountzis Siemens AG, Germany Thomas Schreck City University of New York, USA Jeremy Seideman University of Florida, USA Mirela Silva Ruimin Sun University of Florida, USA Ruhr-University Bochum, Germany Dennis Tatang Phani Vadrevu University of New Orleans, USA NYU Abu Dhabi, UAE Mathy Vanhoef Matthias Wübbeling University of Bonn and Fraunhofer FKIE, Germany Mengya Zhang Ohio State University, USA

xi

Sponsors





Recorded Future





Contents

Wild Wild Web

Wild Extensions: Discovering and Analyzing Unlisted Chrome Extensions Aidan Beggs and Alexandros Kapravelos	3
New Kid on the Web: A Study on the Prevalence of WebAssembly in the Wild	23
Marius Musch, Christian Wressnegger, Martin Johns, and Konrad Rieck	
Morellian Analysis for Browsers: Making Web Authentication Stronger with Canvas Fingerprinting	43
Pierre Laperdrix, Gildas Avoine, Benoit Baudry, and Nick Nikiforakis	
On the Perils of Leaking Referrers in Online Collaboration Services Beliz Kaleli, Manuel Egele, and Gianluca Stringhini	67
Cyber-Physical Systems	
Detecting, Fingerprinting and Tracking Reconnaissance Campaigns	
Targeting Industrial Control Systems	89
Overshadow PLC to Detect Remote Control-Logic Injection Attacks Hyunguk Yoo, Sushma Kalle, Jared Smith, and Irfan Ahmed	109
A Security Evaluation of Industrial Radio Remote Controllers Federico Maggi, Marco Balduzzi, Jonathan Andersson, Philippe Lin, Stephen Hilt, Akira Urano, and Rainer Vosseler	133
Understanding the Security of Traffic Signal Infrastructure Zhenyu Ning, Fengwei Zhang, and Stephen Remias	154
Malware	
Practical Enclave Malware with Intel SGX Michael Schwarz, Samuel Weiser, and Daniel Gruss	177

How Does Malware Use RDTSC? A Study on Operations Executed	
by Malware with CPU Cycle Measurement	197
Yoshihiro Oyama	

On Deception-Based Protection Against Cryptographic Ransomware Ziya Alper Genç, Gabriele Lenzini, and Daniele Sgandurra	
PowerDrive: Accurate De-obfuscation and Analysis of PowerShell Malware	240
Software Security and Binary Analysis	
Memory Categorization: Separating Attacker-Controlled Data Matthias Neugschwandtner, Alessandro Sorniotti, and Anil Kurmus	263
TypeMiner: Recovering Types in Binary Programs Using Machine Learning Alwin Maier, Hugo Gascon, Christian Wressnegger, and Konrad Rieck	288
SAFE: Self-Attentive Function Embeddings for Binary Similarity Luca Massarelli, Giuseppe Antonio Di Luna, Fabio Petroni, Roberto Baldoni, and Leonardo Querzoni	309
Triggerflow: Regression Testing by Advanced Execution Path Inspection Iaroslav Gridin, Cesar Pereida García, Nicola Tuveri, and Billy Bob Brumley	330
Network Security	
Large-Scale Analysis of Infrastructure-Leaking DNS Servers Dennis Tatang, Carl Schneider, and Thorsten Holz	353
Security in Plain TXT: Observing the Use of DNS TXT Records in the Wild	374
No Need to Marry to Change Your Name! Attacking Profinet IO Automation Networks Using DCP Stefan Mehner and Hartmut König	396
DPX: Data-Plane eXtensions for SDN Security Service Instantiation Taejune Park, Yeonkeun Kim, Vinod Yegneswaran, Phillip Porras, Zhaoyan Xu, KyoungSoo Park, and Seungwon Shin	415

Attack Mitigation

Practical Password Hardening Based on TLS	441
Constantinos Diomedous and Elias Athanasopoulos	

Contents x	v
------------	---

Role Inference + Anomaly Detection = Situational Awareness	
in BACnet Networks	461
Davide Fauri, Michail Kapsalakis, Daniel Ricardo dos Santos,	
Elisa Costante, Jerry den Hartog, and Sandro Etalle	
BINTRIMMER: Towards Static Binary Debloating Through	
Abstract Interpretation	482
Nilo Redini, Ruoyu Wang, Aravind Machiry, Yan Shoshitaishvili,	
Giovanni Vigna, and Christopher Kruegel	
Author Index	503