

Syed Rafiul Hussain

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AREA OF INTERESTS My research interests span the areas of **network and system security** with a focus on fundamental enhancement of the security and privacy investigation of emerging networks and cyber-physical systems, including **cellular networks** and **Internet-of-Things (IoT)**.

EDUCATION 🎓 **Purdue University** Fall 2018
Ph.D. in Computer Science
Thesis: *A Systematic Framework for Analyzing the Security and Privacy of Cellular Networks.*
Advisor: Elisa Bertino

🎓 **North Carolina State University** Spring 2013
Master in Computer Science

🎓 **Bangladesh University of Engineering and Technology (BUET)** Spring 2009
B.Sc. in Computer Science and Engineering

PROFESSIONAL EXPERIENCE **Assistant Professor** Fall 2020 - Present
Computer Science and Engineering, Pennsylvania State University

Postdoctoral Researcher Spring 2019 - Summer 2020
Purdue University, Hosts: Elisa Bertino and Ninghui Li

Research Assistant Fall 2013 - Fall 2018
Purdue University, Supervisor: Elisa Bertino

Research Associate Intern Summer 2015 & Summer 2016
Hewlett-Packard Labs, Mentors: Shahriar Nirjon, Shruti Sanadhya, Manager: Kyu-Han Kim

HONORS AND AWARDS 2019 Distinguished paper award, ACSAC'19.
2019 Inducted twice by GSMA in the Mobile Security Research Hall of Fame for identifying security and privacy flaws in 4G and 5G networks.
2019 Distinguished paper award honorable mention, NDSS'19.
2019 Awarded \$10K as research gift by Qualcomm for evaluating their modems.
2017 Nominated for the best paper award, ACM SIGBED EWSN'17.
2017 Intel Security RAship award for Spring 2017.
2016 IEEE Symposium on Security & Privacy travel grant award.
2005-2009 University merit scholarship during my B.Sc. at BUET.
2005-2009 Dean's list award in BUET during my B.Sc. at BUET.

GRANTS ○ 2021: "Principled Security Analysis of Intel's Bluetooth Implementation. Amount \$27K."

CONFERENCE PUBLICATIONS [C16] Moosa Yahyazadeh, Syed Rafiul Hussain, Endadul Hoque, and Omar Chowdhury, Pa-trIoT: Policy Assisted Resilient Programmable IoT System, *20th International Conference on Runtime Verification (RV)*, 2020.

- [C15] Weicheng Wang*, Fabrizio Cicala*, Syed Rafiul Hussain, Ninghui Li, and Elisa Bertino, Analyzing the Attack Landscape of Zigbee-enabled IoT System sand Reinstating Users Privacy, *13th ACM Conference on Security and Privacy in Wireless and Mobile Networks (WiSec)*, 2020.
- [C14] Ankush Singla*, Syed Rafiul Hussain, Omar Chowdhury, Ninghui Li, and Elisa Bertino, Protecting the 4G and 5G Cellular Paging Protocols against Security and Privacy Attacks, *The 20th Privacy Enhancing Technologies Symposium (PETS)*, 2020.
- [C13] Elisa Bertino, Syed Rafiul Hussain, and Omar Chowdhury, 5G Security and Privacy: A Research Roadmap, *Computing Community Consortium (CCC)*, 2020.
- [C12] Syed Rafiul Hussain, Mitziu Echeverria, Imtiaz Karim, Omar Chowdhury, and Elisa Bertino, 5GReasoner: A Property-Directed Security and Privacy Analysis Framework for 5G Cellular Network Protocol, *The 26th ACM Conference on Computer and Communications Security (CCS)*, 2019.
- [C11] Imtiaz Karim*, Fabrizio Cicala*, Syed Rafiul Hussain, Omar Chowdhury, and Elisa Bertino, Opening Pandora’s Box through ATFuzzer: Dynamic Analysis of AT Interface for Android Smartphones, *The 35th Annual Computer Security Applications Conference (ACSAC)*, 2019. (★ Distinguished Paper Award)
- [C10] Syed Rafiul Hussain, Mitziu Echeverria, Omar Chowdhury, Ninghui Li, and Elisa Bertino, Privacy Attacks to the 4G and 5G Cellular Paging Protocols Using Side Channel Information. *The 26th Network and Distributed Systems Security (NDSS)*, 2019. (★ Distinguished Paper Award Honorable Mention)
- [C9] Syed Rafiul Hussain, Mitziu Echeverria, Ankush Singla, Omar Chowdhury, and Elisa Bertino, Insecure Connection Bootstrapping in Cellular Networks: The Root of All Evil, *The 12th ACM Conference on Security and Privacy in Wireless and Mobile Networks (WiSec)*, 2019. (This work has been discussed by FCC in the *Managing Security Risk in the Transition to 5G* working group.)
- [C8] Syed Rafiul Hussain, Shahriar Nirjon, and Elisa Bertino, Securing the Insecure Link of Internet-of-Things Using Next-Generation Smart Gateways, *The 15th IEEE International Conference on Distributed Computing in Sensor Systems (DCOSS)*, 2019.
- [C7] Syed Rafiul Hussain, Omar Chowdhury, Shagufta Mehnaz, and Elisa Bertino, LTEInspector: A Systematic Approach for Adversarial Testing of 4G LTE, *The 25th Network and Distributed Systems Security (NDSS)*, 2018.
- [C6] Syed Rafiul Hussain, Shagufta Mehnaz, Shahriar Nirjon, and Elisa Bertino, SeamBlue: Seamless Bluetooth Low Energy Connection Migration for Unmodified IoT Devices, *The 14th ACM SIGBED International Conference on Embedded Wireless Systems and Networks (EWSN)*, 2017. (★ Nominated for the Best Paper Award)
- [C5] Syed Rafiul Hussain, Asmaa Sallam, and Elisa Bertino, DetAnom: Detecting Anomalous Database Transactions by Insiders, *The 5th ACM Conference on Data and Application Security and Privacy (CODASPY)*, 2015.
- [C4] Syed Rafiul Hussain, Changda Wang, Salmin Sultana, and Elisa Bertino, Secure Data Provenance Compression Using Arithmetic Coding in Wireless Sensor Networks, *The 33rd IEEE International Performance Computing and Communications Conference (IPCCC)*, 2014.
- [C3] Syed Rafiul Hussain, Ala Odeh, Amrut Shivakumar, Shalini Chauhan, and Khaled Har-

*The author completed the work under my research supervision.

foush. Real-time Traffic Congestion Management and Deadlock Avoidance for Vehicular Ad Hoc Networks, *The 10th IEEE High Capacity Optical Networks and Emerging/Enabling Tech. (HONET-CNS)*, 2013.

[C2] Subrata Saha, Syed Rafiul Hussain, and Ashikur Rahman, RBP: Reliable Broadcasting Protocol in Large Scale Mobile Ad Hoc Networks, *The 24th IEEE International Conference on Advanced Information Networking and Applications (AINA)*, 2010.

[C1] Syed Rafiul Hussain, Subrata Saha, and Ashikur Rahman, An Efficient and Scalable Address Autoconfiguration in Mobile Ad Hoc Networks, *The 8th International Conference on Ad Hoc Networks and Wireless (ADHOC-NOW)*, 2009.

JOURNAL

PUBLICATIONS [J6] Imtiaz Karim*, Fabrizio Cicala*, Syed Rafiul Hussain, Omar Chowdhury, and Elisa Bertino, ATFuzzer: Dynamic Analysis Framework of AT Interface for Android Smartphones, *ACM Digital Threats: Research and Practice (DTRAP)*, 2020.

[J5] Syed Rafiul Hussain, Shagufta Mehnaz, Shahriar Nirjon, and Elisa Bertino, Secure Seamless Bluetooth Low Energy Connection Migration for Unmodified IoT Devices, *IEEE Transaction on Mobile Computing (TMC)*, 2018.

[J4] Lorenzo Bossi, Elisa Bertino, Syed Rafiul Hussain, A System for Profiling and Monitoring Database Access Patterns by Application Programs for Anomaly Detection, *IEEE Transaction on Software Engineering (TSE)*, 2017.

[J3] Asmaa Sallam, Elisa Bertino, Syed Rafiul Hussain, David Landers, R. Michael Lefler, and Donal Steiner, DBSAFE - An Anomaly Detection System to Protect Databases from Exfiltration Attempts, *IEEE Systems Journal*, 2015.

[J2] Syed Rafiul Hussain[†], Changda Wang[†], and Elisa Bertino, Dictionary Based Secure Provenance Compression for Wireless Sensor Networks *IEEE Transaction on Parallel and Distributed Systems (TPDS)*, 2014. ([†] indicates equal contribution)

[J1] Syed Rafiul Hussain, Subrata Saha, and Ashikur Rahman, SAAMAN: Scalable Address Autoconfiguration in Mobile Ad Hoc Networks, *Journal of Network and System Management (JNSM)*, Springer, 2011.

PATENTS

[PA2] Syed Rafiul Hussain, and Kyu-Han Kim, **Mobile Virtual Private Network Configuration**. *US Patent App. 16/070,948*, 2019.

[PA1] Syed Rafiul Hussain, Shruti Sanadhya, and Kyu-Han Kim, **Deterrence of User Equipment Device Location Tracking**. *US Patent App. 15/369,508 and 10/154,369*, 2018.

POSTERS

[PS2] SYED RAFIUL HUSSAIN, SHAGUFTA MEHNAZ, SHAHRIAR NIRJON, AND ELISA BERTINO, Seamless and Secure Bluetooth LE Connection Migration, *Seventh ACM on Conference on Data and Application Security and Privacy (CODASPY)*, 2017.

[PS1] ELISA BERTINO, L. BOSSI, SYED RAFIUL HUSSAIN, ASMAA SALLAM, Monitoring DBMS Activity for Detecting Data Exfiltration by Insiders, *The 16th Annual Information Security Symposium*, 2015. (🏆 **Best Poster Award Runner-up**)

INDUSTRIAL CONFERENCE

[I2] Syed Rafiul Hussain, Side Channel Attacks in 4G and 5G Cellular Networks, *The Black Hat Europe, London, UK*, 2019.

[I1] Syed Rafiul Hussain, Omar Chowdhury, Shagufta Mehnaz, and Elisa Bertino, LTEInspec-

tor: A Systematic Approach for Adversarial Testing of 4G LTE, *Qualcomm Security Summit 2018*.

SOFTWARE ARTIFACTS FROM RESEARCH

- **5GReasoner (2019)**: Formal verification framework for 5G control-plane protocols. 📄: <https://github.com/relentless-warrior/5GReasoner> (20+ stars)
- **ATFuzzer (2019)**: A grammar-guided, evolutionary fuzzing framework for testing the AT interface in Android phones. 📄: <https://github.com/Imtiazkarimik23/ATFuzzer> (90+ stars)
- **LTEInspector (2018)**: Formal verification framework for 4G NAS layer protocols. 📄: <https://github.com/relentless-warrior/LTEInspector> (115+ stars)

REPORTED VULNERABILITIES

- **CVD-2019-0029**: 11 new vulnerabilities in the NAS and RRC layers of 5G networks.
- **CVE-2019-16400**: Samsung phones accept AT commands over Bluetooth resulting in several Denial of Service (DoS) attacks.
- **CVE-2019-16401**: Samsung phones accept AT commands over Bluetooth resulting in exposure of sensitive information, such as IMSI, IMEI, call status, and Internet service status.
- **CVD-2018-0014**: Static paging occasion of 4G and 5G networks, IMSI exposure through paging with IMSI, and IMSI-Cracking in 4G and 5G networks.

RESEARCH IMPACT

- Uncovered 20+ new protocol flaws in 4G and 5G networks affecting billions of cellular devices which resulted in a number of changes in the 4G and 5G cellular standards.
- Uncovered 5+ implementation flaws of operational networks worldwide and cellular devices, and helped the affected stakeholders to fix the flaws.
- Helped two major cellular modem vendors in USA— Qualcomm and Intel to set up their adversarial test-beds in 2018-19.
- Since 2018, working with Intel to find vulnerabilities using our formal verification and dynamic analysis frameworks.
- Our proposed defense [C9] against fake base stations has been discussed by FCC for protecting users' security and privacy against the Stingray-type attacks.

PUBLIC MEDIA

- **5GReasoner**: Wired, TechCrunch, Forbes, MIT Technology Review, Yahoo Finance, and 70+ other media outlets worldwide.
- **ATFuzzer**: TechCrunch, Xiaomi, Deep Security News, My Digi Tech, Android Police, and 40+ other media outlets all over the world.
- **Bluetooth Security**: Wired, Medium, Business Telegraph, and 30+ tech-media worldwide.
- **ToRPEDO, PIERCER, and IMSI-Cracking**: Washington Post, Wired, TechCrunch, MSN News, HackerNews, The Threat Post, and 80+ other media outlets all over the world.
- **LTEInspector**: New York Times, Forbes, CNet, ACM Tech News, ZDNet, The Register, Ars Technica and 80+ other media outlets all over the world.

TALKS

- Side Channel Attacks in 4G and 5G Cellular Networks, The BlackHat Europe'19.
- 5GReasoner: A Property-Directed Security and Privacy Analysis Framework for 5G Cellular Network Protocol, CCS'19.
- Privacy Attacks to the 4G and 5G Cellular Paging Protocols Using Side-Channel Information, NDSS'19.
- Insecure Connection Bootstrapping in Cellular Networks: The Root of All Evil, WiSec'19.
- LTEInspector: A Systematic Approach for Adversarial Testing of 4G LTE, NDSS'18.
- DetAnom: Detecting Anomalous Database Transactions by Insiders, CODASPY'15.

○ Secure Data Provenance Compression Using Arithmetic Coding in Wireless Sensor Networks, IPCC'14.

INVITED
TALKS

- Automated Reasoning of Security and Privacy of Cellular Networks, Intel SCAP Workshop, 2020.
 - Automated Reasoning of Security and Privacy of Networks and Systems, Bangladesh University of Engineering and Technology, 2020.
 - Principled Frameworks for Analyzing Security and Privacy Postures of Cellular Networks: University of Iowa, 2019.
 - Systematic Analysis Frameworks for Cellular Networks: Intel SCAP Workshop, 2019.
 - LTEInspector: A Systematic Approach for Adversarial Testing of 4G LTE.
 - Huawei Midwest IoT Security Summit 2018.
 - Midwest Verification Workshop 2018.
 - Intel/NSF Annual Workshop at Intel, 2018.
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ACADEMIC
SERVICE

- **Program Committee:** NDSS: 2021; The WebConf: 2021; ASIACCS: 2021; ESORICS: 2020; PerIoT (co-located with PERCOM): 2019, 2020, NSys: 2020, 2021.
 - **Conference (External) Review:** Oakland 2019, 2020; CCS 2019; WWW 2019; PST 2019; CODASPY 2017; ASIACCS 2015; COMPSAC 2015.
 - **Journal Review:** IEEE Transactions on Dependable and Secure Computing (TDSC), ACM Transactions on Internet of Things (TIOT), IEEE Systems, Sensors.
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TEACHING
EXPERIENCE

- **Pennsylvania State University**
 - CS 543: Computer Security (Fall'20).
 - **Purdue University (Guest Lecturer)**
 - CS 528: Network Security, Purdue University (Spring 2019 and Spring 2020).
 - CS 590: Data Security and Privacy, Purdue University (Spring 2019).
 - CS 541: Database Management, Purdue University (Spring 2018, Fall 2019).
 - **Purdue University (Teaching Assistant)**
 - CS 307: Software Engineering (Fall 2017, Spring 2018).
 - CS 180: Problem Solving and Object-Oriented Programming (Fall 2015, Spring 2016).
 - **NC State University (Teaching Assistant)**
 - Operating Systems (Fall 2011).
 - Internet Protocols (Spring 2012).
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STUDENTS
ADVISING

- **Parth Vidyadhar Natu**, 2nd year MS student, Penn State (Area: network security).
 - **Rasesh Rout**, 2nd year MS student, Penn State (Area: network and systems security).
 - **Suramya Mishra**, 2nd year MS student, Penn State (Area: software security).
 - **Imtiaz Karim**, 3rd year PhD student, Purdue University (Area: cellular network security). Lead author of ACSAC'19 and co-author of CCS'19 papers.
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