Security, Management and Ownership of Data and Networks in the Industrial Internet

CENIIT Project (17.01) 2017-2022. Final Report, March 2023

Project leader: Andrei Gurtov

A summary of the most important scientific results

The main research results are so far obtained in the following areas:

5G security development. Analyzing threat landscape and design options for 5G security architecture [2,8,9,18]. In 2020, the main contribution was writing and editing 6G Whitepapers on Security and Networking [24]. In 2021, a vision of 6G security and privacy was created [26].

Identifying Internet-exposed vulnerable Industrial IoT devices. Using Shodan tool to find SCADA and IoT devices [12]. Developing mitigation techniques for increased resilience [1,5,6]. In 2020, a journal article on identifying and hiding industrial devices was published [19]. Also, a journal paper on detecting tampering in vehicular Electronic Control Units (ECUs) was accepted [25].

Virtual Private LANs Services. P2P protocols for scalability and resilience [10]. A case study for industrial partner LFV [10]. In 2020, two book chapters on software-defined VPLS were published [21,22]. In 2021, a survey on VPLS is published [27].

Development of HIP and SDN protocols. Collaborative HIP [3], deployment strategies [4], resilience to man-in-the-middle attacks [5], smart metering security [6], mobile IoT relay [11]. In 2020, a journal article on opportunistic HIP mode was published [20]. In 2021, an update to OpenHIP v2 open-source implementation was developed with help of TDDE21 course at LiU.

A summary of the degrees and promotions the project has contributed to

PI (Dr. Gurtov) was promoted from associate to full professor;

Several PhD students and postdocs were recruited during the project.

A summary of the masters thesis works that have been performed within the project

PI had examined 8 Master theses during the project time.

A summary of persons funded by the project

Abhinav Rawat started as RA but left Sweden and the project in December of 2019 and a recruitment of a new Research Assistant was started. The selected candidate was Mohammed Borhani. Due to

COVID-19 crisis, IDA department made a decision that new employees can start earliest in October 2020. In practice, Borhani arrived to Sweden in January 2021 and started to work in the project at 82% rate (18% teaching as TA). From September 2021, he was admitted as a PhD student and funded by CUGS. PI salary costs were also partly covered by the project.

A summary of which industrial connections the project has had and how scientific results have been transferred to the industrial partners. In those cases where scientific results have directly affected commercial products, this should be emphasized.

Industrial collaboration on Security of Data Communication in Aviation was performed with Swedish Civil Aviation Authority (LFV), Billy Josefsson, Manager Automation & Human Performance, Research & Innovation. The study resulted in a joint paper of Pilot Data Link Security and industrial PhD project application. In 2020, a separate research project and funding started with LFV within "Automation program II".

Another industrial connection is Ericsson Kista in Sweden and NomadicLab in Finland. Contact persons include head of standardization Gonzalo Comarillo (Kista), researchers Mika Komu, Jan Melen, Jouni Mäenpää (NomadicLab Jorvas). The PI collaborated for over a decade with Ericsson in the past. PI supervised a Master thesis at Ericsson Linköping with David Partain and future joint projects are expected with SDN area. Also in 2021, a Master thesis at Ericsson co-supervised by PI received the award.

PI collaborated with Scania/Volvo with a site visit during a Master thesis by M. Khodari on Attestation of Electronic Control Units. This resulted into a publication [17] and the thesis in nominated for the Best Thesis award at LiU.

A summary of connections with other CENIIT projects and possible common results

New projects were funded:

1. Automation Program 2. A 2+3 years project on research in air traffic cybersecurity with Trafikverket and Luftfartsverket. 2020-2025

2. Secure Transparent Communications in the Industrial Internet, ELLIIT (Excellence Center at Linköping-Lund in Information Technology) Pre-Project for postdoc, 2021-22.

3. Enabling sustainable AiR MObility in URrban contexts via emergency and medical services (AirMOUR), H2020-MG-2018-2019-2020, 2021-2023.

A description of the extent the project has contributed to creating a new research group

This project was very helpful in creating a new research group AeGIS (Air and Ground Information Security) at ADIT, IDA. The group presently includes the PI, a postdoc, two PhD students and several master thesis students.

A list of publications and patents

The project contributed to the following publications:

1. Hasan, D. Lagutin, A. Lukyanenko, A. Gurtov, A. Yla-Jaaski, CIDOR: Content Distribution and Retrieval in Disaster Networks for Public Protection, in Proc. of the Fourth International Workshop on Emergency Networks for Public Protection and Disaster Relief, 2017

2. I. Ahmad, T. Kumar, M. Liyanage, J Okwuibe, M. Ylianttila, A. Gurtov, 5G Security: Analysis of Threats and Solutions, in Proc. of IEEE CSCN'17, September 2017.

3. P. Porambage, A. Braeken, P. Kumar, A. Gurtov and M. Ylianttila, CHIP: Collaborative Host Identity Protocol with Efficient Key Establishment for Constrained Devices in Internet of Things, Wireless Personal Communications, 2017.

4. I. Ahmad, M. Liyanage, M. Ylianttila, A. Gurtov, Analysis of Deployment Challenges of Host Identity Protocol, in Proc. of EuCNC'2017, 2017.

5. A. Fuchs, A. Stulman, A. Gurtov, Hardening Opportunistic HIP, in ACM MSWiM'17, 2017.

6. P. Kumar, A. Gurtov, M. Sain, A. Martin, P. Hoai, Lightweight Authentication and Key Agreement for Smart Metering in Smart Energy Networks, to appear in IEEE Transactions on Smart Grids, 2018.

7. A. Gurtov, T. Polishchuk and M. Wernberg, Controller-Pilot Data Link Communication Security, MDPI Sensors 2018, 18(5), 1636.

8. M. Liyanage, I. Ahmad, A. Abro, A. Gurtov, M. Ylianttila (eds). A comprehensive Guide to 5G Security, Wiley&Sons, ISBN 9781119293040, March 2018.

9. I. Ahmad, T. Kumar, M. Liyanage, J. Okwuibe, M. Ylianttila, A. Gurtov, Overview of 5G Security Challenges and Solutions. IEEE Communications Standards Magazine 2(1): 36-43 (2018)

10. A. Gurtov, J. Koskela, D. Korzun. Cyclic ranking in single-resource peer-to-peer exchange. Peer-to-Peer Networking and Applications 11(3): 632-643 (2018)

11. M. Manzoor, P. Porambage, M. Liyanage, M. Yliantila, A. Gurtov, DEMO: Mobile Relay Architecture for Low-Power IoT Devices, in Proc. of IEEE WoWMoM, 2018.

12. A. Hansson, M. Khodari, A. Gurtov, Analyzing Internet-Connected Industrial Equipment, in Proc. of ICSigSys'18, IEEE, 2018.

13. H. Islam, D. Lagutin, A. Yla-Jaaski, N. Fotiou, A. Gurtov, Transparent CoAP Services to IoT Endpoints through ICN Operator Network, MDPI Sensors, 2019.

14. A. Rajakaruna, A. Manzoor, P. Porambage, M. Liyanage, M. Ylianttila, A. Gurtov. Enabling End-to-End Secure Connectivity for Low-Power IoT Devices with UAVs, in Proc. of 2nd Workshop on Intelligent Computing and Caching at the Network Edge, IEEE WCNC'19, 2019.

15. D. Bhattacherjee, A. Gurtov, T. Aura, Watch your step! Detecting stepping stones in programmable networks, in Proc. IEEE ICC'19, May 2019.

16. P. Porambage, A. Manzoor, M. Liyanage, A. Gurtov, M. Ylianttila, Managing Mobile Relays for Secure E2E Connectivity of Low-Power IoT Devices, in Proc. of IEEE CCNC'19, January 2019.

17. M. Khodari, A. Rawat, M. Asplund, A. Gurtov, Decentralized Firmware Attestation for In-Vehicle Networks, in Proc. of 5th ACM Cyber-Physical System Security Workshop (CPSS 2019), July 2019.

18. I. Ahmad, S. Shahabbuddin, T. Kumar, J. Okwube, A. Gurtov, M. Ylianttila, Security for 5G and Beyond, IEEE Communication Surveys and Tutorials, 21(4): 3682-3722, 2019.

19. D. Hasselquist, A. Rawat, A. Gurtov, Trends and Detection Avoidance of Internet-Connected Industrial Control Systems, IEEE Access, 2019.

20. A. Fuchs, A. Stulman and A. Gurtov, "IoT and HIP's Opportunistic Mode," in IEEE Transactions on Mobile Computing, vol. 20, no. 4, pp. 1434-1448, 1 April 2021, doi: 10.1109/TMC.2020.2967044.

21. C. Mas-Machuca, F. Musumeci, P. Vizaretta, D. Pezaros, S. Jouet, M. Tornatore, A. Hmaity, M. Liyanage, A. Gurtov, A. Braeken, Reliable Control and Data Planes for Softwarized Networks. In J. Rak, D. Hutchison (eds), Guide to Disaster-resilient Communication Networks, Springer, 2020.

22. M. Borhani, M. Liyanage, A. Sodhro, P. Kumar, A. Jurcut, and A. Gurtov, Secure and Resilient Communications in the Industrial Internet, In J. Rak, D. Hutchison (eds), Guide to Disaster-resilient Communication Networks, Springer, 2020.

23. C. Nykvist, M. Larsson, A. Sodhro, A. Gurtov, A Lightweight Portable Intrusion Detection Communication System for Auditing Applications, International Journal of Communication Systems, Wiley, 33(7), May 2020.

24. M. Ylianttila, R. Kantola, A. Gurtov, L. Mucchi, I. Oppermann (eds), 6G White paper: Trust, Security and Privacy. 6G Flagship, University of Oulu, June 2020.

25. A. Rawat, M. Khodari, M. Asplund, A. Gurtov, Decentralized Firmware Attestation for In-Vehicle Networks, ACM Trans. Cyber-Phys. Syst. 5, 1, Article 7 (January 2021), 23 pages. DOI:https://doi.org/10.1145/3418685

26. P. Porambage, G. Gur, D. P. M. Osorio, M. Liyanage, A. Gurtov, M. Ylianttila. The Roadmap to 6G Security and Privacy, IEEE Open Journal of the Communications Society, vol 2, pp 1094 - 1122, May 2021.

27. K. Gaur, A. Kalla, J. Grover, M. Borhani, A. Gurtov, M. Liyanage. A Survey of Virtual Private LAN Services (VPLS): Past, Present and Future, to appear in Computer Networks, 2021.