Quarterly Progress Report:
Project Number and Title: *4.3. Towards Quantitative Cybersecurity Risk Assessment in Transportation Infrastructure*
Research Area: *Thrust 4 Connectivity for enhanced asset and performance management*
PI: *Dr. Song Han, Assistant Professor and Castleman Term Professor in Engineering Innovation, Department of Computer Science and Engineering, University of Connecticut*
Reporting Period: *January 1st, 2020 – March 31st, 2020*
Submission Date: *March 31st, 2020*

Overview: (Please answer each question individually)

During the reporting period, the research team at UConn has continued to study cybersecurity risk assessment in low-power real-time wireless network infrastructure mainly designed for long-term structural monitoring. The research team has been working on improving the specification-based intrusion detection system (IDS) design for Rank-related attacks for 6TiSCH wireless networks. The submission that the research team made during the last reporting period to ACM/IEEE IPSN 2019 was not accepted but valuable comments were received from the reviewers to further improve this work. Based on those review comments, the research team has extended the study to both centralized and distributed IDS design to support four types of rank-related internal attacks. This extended work was submitted to the 3rd IEEE International Conference on Industrial Cyber-Physical Systems (ICPS-2020) in early February 2020 and recently got accepted. The research team will present this work during June 9-12, 2020 in Tampere, Finland.

The research team is also making progress towards the 6TiSCH real-time wireless network testbed development which targets to include 100 low-power nodes to form into a mesh network topology. Several web services have been developed to support important network management functions to ensure real-time and reliable data services. These functions include but are not limited to the network topology visualization, the RSSI information between each pair of the devices, the residual energy information for individual devices, and the noisy zone detected in the network due to either temporary or permanent interference. Based on this testbed, the research team is designing a novel network anomaly detection system based on the channel-level RSSI information. The key design principle is that packet transmission patterns in such low-power real-time wireless networks are stable and unique, and thus RSSI features can be used to recognize devices at the data link layer. Our initial results showed that even traditional classification method (Random Forest) can achieve an accuracy of 99.92%, but impact of network topology change and RSSI variation need further study.

During the reporting period, the PI also led a large research team at UConn (including 24 faculty from 7 departments across 3 schools at UCONN) to develop a proposal entitled: "The Acquisition of an Autonomous Vehicle (AV) to Advance AV Research under Challenging Topography and Weather Conditions". This proposal was successfully submitted to the NSF MRI program on Jan. 21st, 2020. This proposal aims to procure one AV and requisite software and support to operate this vehicle, and support research activities including but not limited to V2X communication, resilient control, cybersecurity, machine learning and decision making. The PI also worked as a Co-PI on another proposal entitled: "A Secure Freight Data Sharing and Smart Contract Framework via Efficient Blockchain Designs", which was submitted to the FHWA Exploratory Advanced Research Program 2020 on March 31st, 2020.

Table 1: Task Progress

Task Number	Start Date	End Date	% Complete
Task 1: Context establishment	Oct. 1st, 2018	Sept. 30th, 2019	100%
Task 2: Threat identification	Oct. 1st, 2019	Sept. 30th, 2020	50%
Task 3: Consequence identification and impact assessment	Oct. 1st, 2020	Sept. 30th, 2021	20% (some parts of Task 2 are concurrent with Task 3)
Overall Project:	Oct. 1st, 2018	Sept. 30th, 2021	Around 60%

Table 2: Budget Progress

Project Budget	Spend – Project to Date	% Project to Date*
$241,250	$89,184.87	36.97% (3/31/2020)

Training/professional development: During the reporting period, two PhD students have participated in this research project. One PhD student, Ms. Areej Althubaity, focuses on the intrusion detection system (IDS) design for 6TiSCH

wireless networks to identify Rank-related attacks. Her research paper entitled: "Specification-based Distributed Detection of Rank-related Attacks in RPL-based Resource-Constrained Real-Time Wireless Networks" has recently been accepted in IEEE ICPS 2020, which will be presented during June 9-12, 2020 in Tampere, Finland. Areej has also completed her research proposal exam in February 2020. The other student, Mr. Jiachen Wang, is working on the cybersecurity risk assessment in V2X infrastructure and the development of the 6TiSCH wireless network testbed.

Dissemination of research results: During the reporting period, the research team has got one research paper accepted in major international conference. The details of this paper can be found in Table 4. The PI also gave a Thrust Area 4 quarterly presentation to the colleagues in TIDC on February 14th, 2020 to summarize his research progress so far.

Table 3: Presentations at Conferences, Workshops, Seminars, and Other Events

Title	Event	Type	Location	Date(s)
6TiSCH wireless network testbed	Online web service https://6tisch.amyang.xyz/	Public testbed	ITE Building at UConn Storrs Campus	Starting from Nov. 1st, 2019

Table 4: Publications and Submitted Papers and Reports

Type	Title	Citation	Date	Status
Conference Paper	Specification-based Detection of Rank-related Attacks in RPL-based Resource-Constrained Real-Time Wireless Networks	Areej Althubaity, Tao Gong, Kim-Kwang Raymond, Mark Nixon, Reda Ammar, Song Han, "Specification-based Distributed Detection of Rank-related Attacks in RPL-based Resource-Constrained Real-Time Wireless Networks", accepted and to appear in the 3rd IEEE International Conference on Industrial Cyber-Physical Systems (ICPS 2020).	March 31st, 2020	Accepted

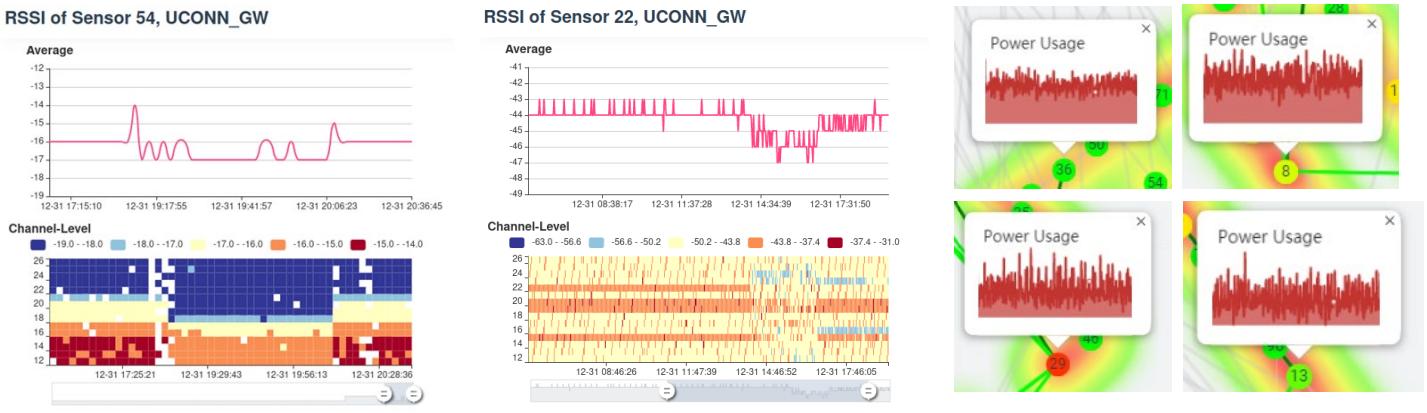

Figure 1. An overview of the network anomaly detection system based on the channel-level RSSI information

Participants and Collaborators:

Table 5: Active Principal Investigators, faculty, administrators, and Management Team Members			
Individual Name	**Email Address**	**Department**	**Role in Research**
Song Han	song.han@uconn.edu	CSE@UConn	Principle Investigator

Use the table below to list all students who have participated in the project during the reporting. (This includes all paid, unpaid, intern, independent study, or any other student that participated in this project.)

Table 6: Student Participants during the reporting period				
Student Name	**Email Address**	**Class**	**Major**	**Role in research**
Jiachen Wang		PhD	Computer Science	Student Researcher
Areej Althubaity		PhD	Computer Science	Student Researcher

Table 7: Student Graduates			
Student Name	**Role in Research**	**Degree**	**Graduation Date**
N/A	N/A	N/A	N/A

Table 8: Research Project Collaborators during the reporting period						
Organization	**Location**	**Contribution to the Project**				
		Financial Support	**In-Kind Support**	**Facilities**	**Collaborative Research**	**Personnel Exchanges**
N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 9: Other Collaborators			
Collaborator Name and Title	**Contact Information**	**Organization and Department**	**Contribution to Research**
Peter J. Calcaterra, Transportation Planner	Peter.Calcaterra@ct.gov	Connecticut Department of Transportation	Technical Champion

Changes: No significant changes on the scope and methodology design in the project.

Planned Activities: Based on the study in this reporting period, we are planning the following activities in the project:

- We plan to continue to work on the 6TiSCH network testbed design and development. Once the testbed is mature, the proposed IDS will be implemented on the testbed for design validation and performance evaluation.
- We plan to continue to work on the network anomaly detection system based on the channel-level RSSI information. The future work will introduce in more features (e.g., sensing value predictions, latency, power usage) and deep learning approaches for anomaly detection, and perform real-world replay attack to evaluate the effectiveness.
- PI Han will recruit undergraduate students at UConn to join the PI's research lab to work with the PhD student researchers on R&D tasks related to this project.