Adeel Nasrullah

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Interests

Trustworthy system software design; Hardware Trusted Execution Environment (TEE) based applications and operating system services; Networked embedded systems and Internet of Things; Machine Learning Applications for System Security and Time Series data; Sensor signal processing.

Education

PhD, Electrical and Computer Engineering
2025, Amherst, MA

University of Massachusetts Amherst

- **Dissertation Topic**: **Trustworthy Time Architecture for the Network Edge.**
- **Courses:** Advanced System Software Design, Algorithms, Computer Networks, Security Engineering, Advanced Information Assurance.

BEE, Electrical Engineering
2017, Islamabad, Pakistan

National University of Science and Technology

- **Awarded a merit-based financial scholarship** throughout the program.
- **Ranked in the top 5%** of a cohort of over 150 graduates.
- **Courses:** Machine Learning, Computer Networks, Embedded Systems, Algorithms and Data Structures

Experience

Graduate Researcher
Jan 2020-Present, Amherst, MA

Emerging Embedded Technologies Lab, UMASS Amherst

My work focuses on building trustworthy time architecture for networked cyber physical systems at the network edge. As part of this work, I designed trustworthy local time services that are robust to manipulations by privileged adversaries such as operating systems or hypervisors.

Trusted Timing Services with TimeGuard.
- TimeGuard provides a system wide secure timestamping service by leveraging secure memory and interrupt primitives provided by trusted execution environments (TEEs) such as ARM Trustzone on commodity platforms.
- This service enables an adjustable trade-off between security (accuracy of the trusted time) and cost imposed on the system and can provide time accuracy ranging from 10's milliseconds to a few microseconds even when the operating system is compromised.
- **Platforms, Tools, Skills employed:** NXP iMX6 Quad development board; Yocto Project Tools; Linux kernel module development; developing modules for OPTEE, a secure OS for ARM TrustZone; Network based system boot using NFS and TFTP for faster development.

SeTi: Secure Timing Services for the Virtualized Edge.
- SeTi, provides guest Virtual Machines (VMs) running atop an untrusted hypervisor secure access to a trusted time source in the hardware. I leverage RDMA based network infrastructure and system management mode to realize this design. SeTi also seeks to enable the guest VMs to verify that the virtual timer interrupts were delivered without any malicious delays by the untrustworthy hypervisors. Both the secure counter and timer interrupts are indispensable to the

guest VMs' ability to maintain accurate time.

- SeTi provides sub-millisecond level secure time to the guest VMs, without incurring significant network or computational costs to the virtualized machine.
- **Platforms, Tools, Skills employed:** Test bed with an Intel i9700K processor, Z370 chipset, and RDMA-enabled Mellanox ConnectX Lx 4 NIC; Xen hypervisor hosts Linux-based guest VMs; System Management Interrupts (SMIs); RDMA-based network application; Hypervisor and guest VM behavior profiling with *xentrace* and modeling it with machine learning algorithms.

I have also designed sensing based time synchronization schemes for networked embedded devices as an alternative to traditional network based time synchronization. These approaches diversify time sources available to the devices at the network edge that can be used to detect and mitigate threats posed by man-in-the-middle adversaries to the sensor network time synchronization.

HAEST: Harvesting Ambient Events to Synchronize Time across heterogeneous IoT devices.

- HAEST leverages *passively* sensed ambient events sensed by embedded devices to synchronize their local clocks. We leverage the fact that co-located sensing devices pick up different aspects originating from the same physical event simultaneously and use them for synchronizing device clocks.
- HAEST achieves time synchronization accuracy up to a milli-second outperforming NTP in similar conditions while the participating sensing devices consume 36% less power compared to NTP.
- **Platforms, Tools, Skills employed:** Test bed comprising ESP32 dev board (ESP-IDF), TI Sensortag CC2650 (Ti RTOS), and Atmega32 (Arduino) based sensing devices; Sensor data streaming applications for ESP32 (WiFi/BLE), TI Sensortag CC2650 (BLE), and Atmega32 (serial connection); Python-based server application for receiving, decompressing, and processing sensor data; Trained and optimized fully connected neural network based auto-encoders for light-weight and scalable runtime inference to detect change-points (events) in the streaming sensor data.

Universal Timestamping with Ambient Sensing.

- In this design, we *actively* broadcast unique Electric Network Frequency (ENF) based timing codes modulated over sensing signals. These signals are picked up by ambient sensors and can be decoded by the embedded devices to obtain this timing information.
- **Platforms, Tools, Skills employed:** Implemented an analog to digital circuit for sampling power grid voltage from the power socket; Particle photon based FSK modulation of the ENF data; sensor data processing for demodulating the ENF information.

Machine Learning Engineer
Sept 2018-Dec 2020, Islamabad, Pakistan
PackageX, Inc.

- **Contributed to the development of mail package label address parsing technology by:** i) designing a knowledge-based address extraction and parsing algorithm for unstructured mail package label text, with support for over 10 languages, and ii) developing an end-to-end data processing pipeline operating in a serverless environment, integrating with various internal and external APIs.
- **Developed an experimental multi-modal deep learning-based address extraction and parsing algorithm** to replace the existing knowledge-based solution. This involved leveraging CNNs for image processing and LSTMs with word embeddings for text processing.
- **Mentored 2 summer interns** to expedite the development of the new learning-based address extraction and parsing algorithm.
- **Utilized Git for code management, Python for general software development, Regex for information parsing, and Keras with TensorFlow for machine learning model development.**

Machine Learning Engineer
VisionX, Inc.   Sept 2017-Sept 2018, Islamabad, Pakistan

- **Led research and development for deep learning-based music symbol detection and recognition in sheet music images.** Utilized hybrid CNN and LSTM models for symbol detection and recognition tasks, and employed OpenCV for image noise removal.
- **Facilitated regular project update meetings** with an international client to ensure effective communication and project alignment.

Publications

Universal Timestamping with Ambient Sensing. Adeel Nasrullah, Momin Ahmad Khan, Fatima M. Anwar	IEEE SECON 2022 *Virtual*
HAEST: Harvesting Ambient Events to Synchronize Time across heterogeneous IoT devices. Adeel Nasrullah, Fatima M. Anwar	IEEE RTAS 2024 *Hong Kong*
Trusted Timing Services with TimeGuard. Adeel Nasrullah, Fatima M. Anwar	IEEE RTAS 2024 *Hong Kong*
TWIN: Time synchronization Woven into IoT Network sensing fabric.	*Under Review*
SeTi: Secure Timing Services for the Virtualized Edge.	*In Progress*
SoK: State of the time: On Trustworthiness of Digital Clocks.	*In Progress*

Skills

Programming: Python, C/C++, R.
Software Platforms: Linux, OPTEE OS, Keras, Xen, Ti RTOS, ESP-IDF.
Hardware Platforms: Intel i9700K + Z370 chipset + Mellanox ConnectX Lx 4 NIC, NXP iMX6, BeagleBoneBlack, Raspberry Pi, ESP32, CC2650, Atmega32.
Tools: Yocto Toolkit, Git, Jupyter, Bash/Shell scripting, trace-cmd (ftrace), xentrace, LaTex.
Others: System software programming, Hardware TEE based trusted system software and application design, Machine Learning, Computer networks.

Teaching

Graduate Teaching Assistant
University of Massachusetts Amherst

ECE697/597 Advanced Networked Embedded Systems   Fall 2020-22
- Course projects design.
- Guest lectures: Machine Learning for Embedded Systems.
- Mentored students for their class projects.

ECE231 Introduction to Embedded Systems   Spring 2020-22,24
- Assignment design and grading.
- Helped students address technical issues with their assignments.

ECE325 Computer Networking   Spring 2023

ECE241 Advanced Programming   Fall 2023

Community Service

Young Investigator Project
Springfield High School, MA
Summer 2021

Participated in the "Young Investigator" project organized by UMass College of Engineering targeted at K12 students.
- Project proposal drafting.
- Content design for the student project.

Chadar
Islamabad, Pakistan
2016-2020

Founding member of a social organization "Chadar". As part of the organization, I was engaged in planning events, organizing teams and leading execution of the various community service projects.

Awards
- Employee of the year award (PackageX) 2019
- Ranked 1st in NUST entrance examination 2013
- Ranked 2nd in PIEAS entrance examination 2013