Abu Bakar | Curriculum Vitae

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Research Interests

My research focuses on exploring new **hardware designs**, **systems**, and **tools** to build smart, battery-free, ubiquitous sensing devices and wearables that reliably execute programs with constrained resources under unpredictable energy harvesting conditions that cause frequent power failures. I develop energy-aware adaptive runtime systems for efficient use of harvested energy, explore new energy harvesting techniques for powering **battery-free wearables**, and reimagine **machine learning** algorithms to perform **on-device**, **low-latency**, and **low-energy inferences**.

My work has appeared in ACM SenSys, ACM IMWUT, ACM ASPLOS, and ACM BuildSys, has received a People's Choice Award, and has been featured in Forbes, Scientific American, ACM Tech News, Daily Mail, The Independent, and many others. I was selected as a **Cyber-Physical Systems (CPS) Rising Star**.

Education

2022 - Present — **Georgia Institute of Technology**
Ph.D. in Computer Science
Advisor: Josiah Hester
Focus: Battery-free systems

2018 - 2022 — **Northwestern University**
M.S. in Computer Science
Ph.D. in Computer Science [**Transferred**]
Advisor: Josiah Hester
Focus: Adaptive and Energy-aware Intermittent Computing Systems

2016 — **National University of Computer and Emerging Sciences (NUCES)**
B.S. in Electrical Engineering

Awards and Honors

2023 **ACM SIGMOBILE Research Highlight** for "Protean" work **(GetMobile 2023)**

2022 **Cyber-Physical Systems (CPS) Rising Star**. Sponsored by National Science Foundation

2022 **ACM SIGMOBILE Research Highlight** for "Heuristic Adaptation" work **(GetMobile 2022)**

2020 **SIG Travel Award** for attending **ASPLOS 2020**

2018 **NSF Travel Award** for attending **ACM SenSys 2018**

2017 **People's Choice Award** for "Inverted HVAC" at **ACM BuildSys 2017**

2017 **ACM SIGMOBILE Travel Award** for attending **ACM BuildSys 2017**

2015 **Dean's Honor List** for outstanding academic performance at **NUCES**

2014 **Silver and Bronze medal** for outstanding semester performance at **NUCES**

2014 **Best Intern Award** for completing internship tasks and going beyond at **SysNet Lab**

Publications

Conference Papers

C09 **Protean: An Energy-Efficient and Heterogeneous Platform for Adaptive and Hardware-Accelerated Battery-free Computing**
Abu Bakar, Rishabh Goel, Jasper de Winkel, Jason Huang, Saad Ahmed, Bashima Islam, Przemysław Pawełczak, Kasım Sinan Yıldırım, Josiah Hester
ACM Conference on Embedded Networked Sensor Systems (**SenSys'22**)
SIGMOBILE GetMobile Research Highlight 2023

C08 **Adaptive Intelligence for Batteryless Sensors Using Software-Accelerated Tsetlin Machines**
Abu Bakar, Tousif Rahman, Alessandro Montanari, Rishad Shafik, Fahim Kawsar
ACM Conference on Embedded Networked Sensor Systems (**SenSys'22**)

C07 **FaceBit: Smart Face Masks Platform**
Alexander Curtiss, Blaine Rothrock, **Abu Bakar**, Nivedita Arora, J. Huang, Zachary Englhardt, Aaron-Patrick Empedrado, Chixiang Wang, Saad Ahmed, Yang Zhang, Nabil Alshurafa, Josiah Hester
ACM Conference on Pervasive and Ubiquitous Computing (**UbiComp'22**)
Published in PACM IMWUT, Volume 5, Issue 4
Fast Company 2022 Innovation by Design Award—Finalist in the Students category
Featured in Forbes, Scientifc American, Gizmodo, TechCrunch, Engadget, Daily Mail and many others

C06 **REHASH: A Flexible, Developer Focused, Heuristic Adaptation Platform for Intermittently Powered Computing**
Abu Bakar, Alexander G. Ross, Kasım Sinan Yıldırım, Josiah Hester
ACM Conference on Pervasive and Ubiquitous Computing (**UbiComp'21**)
Published in PACM IMWUT, Volume 5, Issue 3
SIGMOBILE GetMobile Research Highlight 2022

C05 **BFree: Enabling Battery-free Sensor Prototyping with Python**
Vito Kortbeek, **Abu Bakar**, Stefany L. Cruz, Kasım Sinan Yıldırım, Przemysław Pawełczak, Josiah Hester
ACM Conference on Pervasive and Ubiquitous Computing (**UbiComp'21**)
Published in PACM IMWUT, Volume 4, Issue 4
Featured in TechTimes, The Independent, Make: Magazine

C04 **Time-sensitive Intermittent Computing Meets Legacy Software**
Vito Kortbeek, Kasim Yildirim, **Abu Bakar**, Jacob Sorber, Josiah Hester, Przemysław Pawełczak
ACM Conference on Architectural Support for Prog. Languages and Operating Systems (**ASPLOS'20**)

C03 **The Betrayal of Constant Power × Time: Finding the Missing Joules of Transiently-Powered Computers**
Saad Ahmed, **Abu Bakar**, Naveed Anwar Bhatti, M. Hamad Alizai, Junaid Haroon Siddiqui, Luca Mottola
ACM SIGPLAN/SIGBED Conference on Languages, Compilers, and Tools for Embedded Systems (**LCTES'19**)

C02 **Inverting HVAC for Energy Efficient Thermal Comfort in Populous Emerging Countries**
Khadija Hafeez, Yasra Chandio, **Abu Bakar**, Ayesha Ali, Affan A. Syed, Tariq M. Jadoon, M. Hamad Alizai
ACM Conference on Systems for Energy-Efficient Built Environments (**BuildSys'17**)
People's Choice Award

C01 **Design of a Laser Tracker Using 2-DOF Stepper Controlled Platform**
Abu Bakar, Neelam Nasir, Mukhtar Ullah, Zeashan Hameed Khan
IEEE Conference on Robotics and Artificial Intelligence (**ICRAI'16**)

Journal Papers

J02 **Demystifying Energy Consumption Dynamics in Transiently Powered Computers**
Saad Ahmed, M. Nawaz **Abu Bakar**, Naveed A. Bhatti, M. Hamad Alizai, Junaid H. Siddiqui, Luca Mottola
ACM Transactions on Embedded Computing Systems (**TECS**), Volume 19 , Issue 6 October 2020

J01 **Inverted HVAC: Greenifying Older Buildings, One Room at a Time**
Samar Abbas, **Abu Bakar**, Yasra Chandio, Khadija Hafeez, Ayesha Ali, Tariq M. Jadoon, M. Hamad Alizai
ACM Transactions on Sensor Networks (**TOSN**), Volume 14 , Issue 3-4 December 2018

Workshop Papers

W02 **Logic-based Intelligence for Batteryless Sensors**
Abu Bakar, Tousif Rahman, Alessandro Montanari, Jie Lei, Rishad Shafik, Fahim Kawsar
ACM Workshop on Mobile Computing Systems and Applications (**HotMobile'22**)

W01 **Making Sense of Intermittent Energy Harvesting**
Abu Bakar, Josiah Hester
ACM Workshop on Energy Harvesting & Energy-Neutral Sensing Systems (**ENSsys'18**)

Posters and Demo Abstracts

P02 **Harnessing Power from the Soil: Long-Term, Stable Power Production from Terrestrial Microbial Fuel Cells Integrated into Green Infrastructure**
Weitao Shuai, Bill Yen, Laura Jaliff, **Abu Bakar**, Jason Huang, Alexander Curtiss, Colleen Josephson, Josiah Hester, Pat Pannuto, George Wells
Assoc. of Environmental Engineering and Science Professors Research and Education Conference (**AEESP'22**)

P01 **The Energy Harvesting Mode Abstraction**
Abu Bakar, Josiah Hester
ACM Conference on Embedded Networked Sensor Systems (**SenSys'18**)

Work Experience

2022 - Present **Georgia Institute of Technology**
Graduate Research Assistant
Advisor: Josiah Hester

- Leading research in designing **battery-free health-sensing wearables** powered by user's physical activities
- Designing a small, light-weight, and portable **electromagnetic inertial harvester** that generates power from user's movements
- Developing **signal processing algorithms** to extract physiological signals from **PPG sensor** data
- Mentoring undergrad and master students in energy harvesting, system and experiment design, and sensor data collection

2018 - 2022 **Northwestern University**
Graduate Research Assistant
Advisor: Josiah Hester

- Led a team to design a **low-power**, **plug-and-play hardware** platform consisting of sensors, harvesters, and microcontrollers for rapid prototyping of energy-harvesting battery-free applications, with adaptive machine learning capabilities
- Developed energy-efficient **operating systems** using **bare-metal programming** on MSP430 and ARM-based microcontrollers
- Collaborated with other teams to build a smart face mask platform that measured heart and respiratory rate using energy harvested from breathing inside the mask
- Mentored undergrad and master students in projects on **firmware development**, **hardware design**, and **PCB development**
- Wrote and published **six research articles** in top computer system venues and presented works at conferences and workshops

Fall 2021 **Nokia Bell Labs—Pervasive Computing Group**
Research Intern
Advisor: Fahim Kawsar, Alessandro Montanari

- ✦ Implemented Tsetlin Machine(TM), a first of its kind low-power logic-based ML algorithm, on battery-free devices
- ✦ Optimized TM arch. to boost **energy efficiency by 14x**. Achieved **12x lower inference latency** against binary neural networks
- ✦ Designed encoding techniques for compressing TM models up to **99%**
- ✦ Developed firmware for MSP430 device to evaluate TM's performance on various energy harvesting conditions
- ✦ Published **two research articles** and one (in process) **patent**

2016 - 2018 **LUMS School of Science and Engineering—SysNet Lab**
Research Assistant
Advisor: Muhammad Hamad Alizai

- ✦ Developed and deployed an energy-efficient smart HVAC system using sensors and distributed air-conditioning units (window ACs, heaters, fans) based on ASHRAE standards and achieved 6% energy savings with a market penetration of only 20%
- ✦ Developed a server on Raspberry Pi that pulled data from sensors and controlled appliances via smart switches

Summer 2014 **NUCES—SysNet Lab**
Undergraduate Research Intern
Advisor: Affan A. Syed
Focus: Wireless Sensor Networks, Wireless Power Transfer

- ✦ Worked on wirelessly powering battery-free sensor nodes across a building using laser deployed at a distance of up to 100m

Teaching Experience

Spring 2023 **Teaching Assistant**—C7470: Mobile and Ubiquitous Comping
Georgia Institute of Technology

Spring 2022 **Teaching Assistant**—CE465: Internet-of-things Sensors, Systems, and Applications
Northwestern University

Spring 2021 **Teaching Assistant**—CE346: Microprocessor System Design
Northwestern University

Spring 2020 **Teaching Assistant**—CE346: Microprocessor System Design
Northwestern University

Spring 2017 **Teaching Assistant**—CS365: Data Communication & Networks
Information Technology University

Fall 2016 **Teaching Assistant**—CS677: Internet of Things
LUMS School of Science and Engineering

Fall 2015 **Teaching Assistant**—CS214: Programming Fundamentals
National University of Computer and Emerging Sciences

Fall 2014 **Teaching Assistant**—EE112: Programming for Engineers-II
National University of Computer and Emerging Sciences

Spring 2014 **Teaching Assistant**—EE110: Programming for Engineers-I
National University of Computer and Emerging Sciences

Professional Services and Leadership Experience

2022-Present **Paper Reviewer**
Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies **(IMWUT)**
1-2 reviews per quarter

2022 **Group Meeting Coordinator — Northwestern University**
Organized and sometimes led weekly group meetings at Ka Moamoa Lab

2019-Present **Student Mentor**
Ryan Tougas (MS)
Vivek Kumar Sing (MS)
Jason Huang (BS)
Alejandra Almonte (BS)
Julia Persche (MS)
Rishabh Goel (MS), PhD student at **Georgia Institute of Technology**
Alexander Ross (BS/MS), Electronics Engineer at **Gerresheimer**
Eugene Choe (BS/MS), Firmware Engineer at **Samsung Semiconductor**
Jackson Schuster (BS/MS), Software Engineer at **Microsoft**
Julian Richey (BS/MS), ASIC Design Engineer at **Amazon**

2019 - 2020 **Treasurer Toastmasters International — Northwestern University**
Managed finances for the university club including student memberships.

2019 **Volunteer for Graduate Student Seminars — Northwestern University**
Organized biweekly seminars for Computer Engineering department where students presented recent research papers in their fields.

2016 **President IEEE FAST Electrica — NUCES**
Organized 26 competitions, workshops and seminars under the umbrella of university's annual 3-day tech event. Supervised a team of 60 students who were a part of operations, logistics, sponsorship, marketing, photography and event management teams.

2016 **Finance Secretary of National Solution Convention (NaSCon) — NUCES**
Lead a team of 5 students to manage the budget and expenses of 50+ social and technical events that included talks, workshops, seminars, and robotics & coding competitions. Also served as a liaison between the university and external sponsors.

2015 - 2016 **Chairperson IEEE Student Branch — NUCES**
Managed a team of 10 people and organized competitions, workshops, and seminars for students. All activities were focused on research and technology trends in industry and academia.

2015 **President IEEE Robotics Club — NUCES**
Organized workshops and maintained a maker space to help students learn, practice, and polish their skills in robotics

Skills

Programming: C, C++, Assembly, Python (Pandas, SciPy, NumPy, Matplotlib), VHDL, Verilog, Shell, GDB, Make, HTML, CSS

Hardware: ARM Cortex, nRF52 SoCs, TI MSP430, STM32, Arduino, Teensy, FPGA, PCB Design, Beaglebone, Raspberry Pi

Software: Keil, Eclipse, VS Code, Mbed, SEGGER J-Link, Arduino, Proteus, Eagle, LTspice, RTOS, MATLAB, Jupyter Notebook

Lab Equipment: Oscilloscope, Logic Analyzer, Energy Profiler, Digital Multi Meter, Soldering Iron

Last Updated: Jan 30, 2023