Abu Bakar

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Research Interests

How can we sustainably sense and compute with the next trillion battery-free IoT devices? This is the core question that motivates my research. My research enables the adoption of batteryless sensors at a large scale by making them efficient and robust to dynamic energy harvesting conditions. I explore new hardware designs, build runtime systems with novel energy-aware computing techniques, and develop interactive tools to create functional, and intelligent applications capable of real-time inference and self-adaptation in extreme energy harvesting conditions.

Education

2018 - Present	**Northwestern University** Ph.D. in Computer Science, GPA: 3.89/4.0 Advisor: Josiah Hester Focus: Adaptive and Energy-aware Intermittent Computing	Evanston, IL, USA
2016	**National University of Computer and Emerging Sciences (NUCES)** B.S. in Electrical Engineering, GPA: 3.59/4.0	Islamabad, Pakistan

Work Experience

2019 - Present	**Northwestern University** **Graduate Research Assistant** Advisor: Josiah Hester Working on hardware and runtime support for adaptive batteryless systems and exploring the use of new energy harvesting sources for battery-free health and environment-sensing applications	Evanston, IL, USA
Fall 2021	**Nokia Bell Labs—Pervasive Computing Group** **Research Intern** Advisor: Fahim Kawsar, Alessandro Montanari Focus: Machine Learning, Batteryless Computing, Tsetlin Machines Designed logic-based machine learning (differing from arithmetic-based neural networks) applications for batteryless sensors, introduced new encoding techniques for compressing model size and reducing inference latency, and developed adaptation techniques for adjusting model complexity at runtime based on available harvested energy on batteryless sensors.	Cambridge, UK
2016 - 2018	**LUMS School of Science and Engineering—SysNet Lab** **Research Assistant** Advisor: Muhammad Hamad Alizai Focus: Intermittent computing, Embedded systems, Building systems Worked on developing: energy-efficient inverted HVAC system, hardware platform for evaluating a runtime system designed for battery-free devices, and a mechanism for estimating dynamic energy consumption of battery-free devices at compile time.	Lahore, Pakistan

Summer 2014 **NUCES—SysNet Lab** Islamabad, Pakistan
Undergraduate Research Intern
Advisor: Affan A. Syed
Focus: Wireless Sensor Networks, Wireless energy transference

Worked on wirelessly powering sensor nodes using a 808nm laser.

Publications

Conference Papers

C7 **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 (**To Appear** in UbiComp'22)
Published in PACM IMWUT, Volume 5, Issue 4

C6 **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

C5 **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

C4 **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)

C3 **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)

C2 **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)

C1 **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

J2 **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

J1 **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

W2 **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)

W1 **Making Sense of Intermittent Energy Harvesting**
Abu Bakar, Josiah Hester
ACM Workshop on Energy Harvesting & Energy-Neutral Sensing Systems (ENSsys'18)

Posters and Demos

P2 **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)

P1 **The Energy Harvesting Mode Abstraction**
Abu Bakar, Josiah Hester
ACM Conference on Embedded Networked Sensor Systems (SenSys'18)

Awards and Honors

2022 **CPS Ring Star** at University of Virginia

2020 **SIG Travel Grant** for attending **ASPLOS'20**

2018 **NSF Travel Grant** for attending **ACM SenSys'18**

2017 **People's Choice Award** for "Inverted HVAC" at **ACM BuildSys'17**

2017 **ACM SIGMOBILE Travel Grant** for attending **ACM BuildSys'17**

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**

Teaching Experience

Spring 2022	**CE465: Internet-of-things Sensors, Systems, and Applications** Northwestern University	Evanston, IL, USA
Spring 2021	**CE346: Microprocessor System Design** Northwestern University	Evanston, IL, USA
Spring 2020	**CE346: Microprocessor System Design** Northwestern University	Evanston, IL, USA
Spring 2017	**CS365: Data Communication & Networks** Information Technology University	Lahore, Pakistan

Fall 2016	**CS677: Internet of Things** LUMS School of Science and Engineering	Lahore, Pakistan
Fall 2015	**CS214: Programming Fundamentals** National University of Computer and Emerging Sciences	Islamabad, Pakistan
Fall 2014	**EE112: Programming for Engineers-II** National University of Computer and Emerging Sciences	Islamabad, Pakistan
Spring 2014	**EE110: Programming for Engineers-I** National University of Computer and Emerging Sciences	Islamabad, Pakistan

Other Projects

32-bit Pipelined CPU Based on MIPS Architecture
Implemented CPU design in VHDL which supported 15 assembly instructions with full-forwarding and hazard detection capabilities

C-like Language Compiler
Designed and efficiently implemented a compiler able to generate Intel x86_64 machine code from a high level C-like programming language

PID-Based Autonomous Line Following Mobile Robot
Designed using IR sensors and implemented PID algorithm for efficient motion control. Won many competitions including zonal round of International Robotics Challenge (IRC) in Pakistan

Video Graphics Array (VGA) on FPGA
Implemented a Pac-Man like game and displayed it on a monitor directly from FPGA in real time

Leadership Experience

2019 - 2020	**Treasurer Toastmasters International — Northwestern University** Managed finances for the university club including student memberships	Evanston, IL, USA
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.	Islamabad, Pakistan
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.	Islamabad, Pakistan
2015 - 2016	**Chairperson IEEE Student Branch — NUCES** Managed a team of 10 people and organized workshops and seminars that were focused on technology trends in industry for students.	Islamabad, Pakistan
2015	**President IEEE Robotics Club — NUCES** Organized workshops and maintained a conducive learning environment to help students learn and polish their skills in robotics	Islamabad, Pakistan

Skills

General: System Programming, Firmware Development, PCB Designing, Makefile, Testing/Debugging, Version Control

Programming: C, Embedded C, C++, Python, VHDL, Verilog, Assembly, Shell, HTML, GDB

Hardware Architectures: ARM Cortex, MSP430, Atmel, FPGA, AI8x Accelerators

Lab Equipment: Oscilloscope, Logic Analyzer, Function Generator, Digital Multi Meter, Soldering Iron

Platforms and Tools: Mbed, Arduino, MATLAB, Keil, Proteus, Eagle, TinyOS, Contiki, Modelsim, Microwind, Xilinx Spartan-3

Last Updated: May 15, 2022