Statement of Purpose

I want to create the next generation of **mega-scale distributed and embedded systems**, ensuring they also strengthen and uplift underserved communities. Growing up in Multan, a city in underdeveloped southern Punjab, meant seeing inequity in disaster preparedness, education, and even healthcare. The haves and have-nots lived two different lives, and seeing myself as part of the haves meant that I felt a sense of responsibility. My work in LUMS would soon make me realize the potential of distributed and embedded systems to bridge regional and class divides.

As a sophomore research assistant under Dr. Malik Jahan, I collaborated with the Centre for Water Informatics and Technology to deploy AIoT solutions for disaster preparedness. My field studies with IoT sensors and cameras allowed me to analyze environmental data and identify key contributors to flood severity. The research equipped me with the skills to design efficient distributed and embedded frameworks for real-time data collection and analysis. I discovered that integrating these systems with predictive modeling could play a crucial role in disaster prevention, especially in regions like Multan. Motivated by this, I began exploring distributed systems and impact-driven projects to solve large-scale equity challenges.

In regulated fields like healthcare, ensuring secure, user-friendly, and auditable access to sensitive data and AI models is critical. However, strict privacy regulations and the need for transparency make it difficult for authorities to trust the public with their datasets and for healthcare professionals to access them securely. To address these challenges, I collaborated with Dr. Basit Shafiq (LUMS) and Dr. Jaideep Vaidya (Rutgers) on the "**Blockchain-Based AI Model Governance and Auditable Policy Compliance System**". Inspired by healthcare inequities in Multan, I developed a platform integrating an LLM-based architecture that converts natural language queries into composite BPMN (Business Process Model and Notation) workflows, with smart contract approvals ensuring compliance (a paper is currently in writing). By ensuring compliance, transparency, and accessible LLM-based natural language interactions, this system motivates authorities to share data and simplifies access for healthcare providers.

My work involved converting XACML-based policies into smart contracts using INFURA APIs over the Sepolia Testnet, leveraging INFURA's blockchain infrastructure and Sepolia's stable, low-cost environment. Further, I created an interactive workflow visualization combining the industry-standard Cox and Kaplan-Meier models for survival analysis of 400,000+ patients. The React-based frontend, which included BPMN Modeler, improved navigation and workflow efficiency. Addressing LLM-generated BPMN inaccuracies, which could lead to potential misdiagnosis, I employed chain-of-thought prompting with examples of correct XML code, improving interpretability. A RAG-based implementation is in progress to ensure workflows incorporate context-specific knowledge. Among the first to link LLMs with auditable workflows in healthcare, this research demonstrated how this multilayered approach can democratize access to healthcare assets while ensuring compliance. The project taught me to manage complex codebases, refine AI workflows, and, most importantly, innovate solutions when refining the workings of a complex distributed system.

Motivated to use large-scale systems for disaster preparedness, I pursued a research internship at the Centre for Water Informatics and Technology. Tasked with creating a cost-effective, low-complexity edge solution for real-time flood detection in remote areas, I collaborated with Dr. Talha Manzoor to develop an **Edge AIoT system** using the ESP-32 Cam. Its accessible development environment and integrated camera reduced hardware costs to a tenth of traditional devices, making it ideal for TinyML. I employed YOLOv5-based TinyML (Edge Impulse) for accurate detection and

supplemented it with LLMs for broad generalizability. I also integrated a serverless Google Drive for reliable data transfer without on-site servers. To address connectivity challenges, a GSM module was incorporated for long-distance communication and sleep modes were introduced for energy efficiency and resilience. This adaptable architecture is now being refined for deployment in Pakistan's Northern Areas, paving the way for applications such as soil moisture and wildlife detection.

Building on this experience, I joined a WWF initiative with Dr. Murtaza Taj to **address forest fires** in Pakistan's remote regions. Using Hikvision IP cameras integrated with CLIP-based LLM and YOLO models, I localized fire hotspots through image analysis. By optimizing Pan, Tilt, and Zoom with the Hikvision API, I captured overlapping images for recursive analysis, pinpointing fire locations. With OpenCV, I created GIFs of capture events to aid interventions. The integrated LLM-YOLO system achieved 99% true positive accuracy and is now being deployed across five cameras to enhance disaster prevention. These projects showed me how the use of embedded technology with a problem-solving mindset can yield scalable IoT solutions that address real-world challenges.

Teaching has always been something that I have loved to do ever since I joined LUMS. I was the first teaching assistant from my Batch and started my teaching journey in the fall of my sophomore year where I took up teaching CS 100(Computation problem solving). Since then, I have been a teaching assistant for 2 more Computer Science Core courses(Head TA CS 100 and Discrete Maths) and have been a full-time TA for a graduate-level Computer Science Elective(Blockchain: Technology and Applications). These experiences have allowed me to learn everything there is to managing a course: from conducting weekly office hours to designing and teaching tutorials for a class of over 200, from redesigning assignments (e.g., set theory, pointers, and smart contract deployment) to checking them and running auto-grading tools to running plagiarism checks (MOSS); from invigilating exams and grading them to creating and checking quizzes; these experiences have been extremely rewarding and have given me an opportunity to give back to the community.

In addition to my passion for teaching, I am currently interning with a U.S.-based neuroscience stealth startup dedicated to leveraging neuroscience-inspired artificial intelligence to drive meaningful global change. In this role, I am exploring innovative machine learning frameworks modeled after cognitive neuroscience principles to enhance the efficiency of cognitive models. My work focuses on designing scalable distributed systems and real-time applications, bridging the gap between neuroscience and cutting-edge AI technologies.

Beyond academics and research, I co-founded and served as the General Secretary of E-Gaming at LUMS, the university’s first dedicated esports society. I led the organization of high-profile esports events that attracted over 1,000 attendees and secured sponsorships totaling over 200,000 PKR. Managing a 50+ member team, I successfully built a thriving gaming community on campus, turning a passion for gaming into a structured platform for competitive and recreational esports engagement. This leadership experience allowed me to develop strategic planning, team management, and organizational skills that I continually apply in both academic and professional settings.

Pursuing a thesis-based MS in Computer Science will equip me with the expertise and versatility to translate my passion for distributed systems into truly impactful solutions. The focused research approach with rigorous courses will help me quickly develop expertise, build a strong professional network, and position myself at the forefront of cutting-edge distributed systems research. All in all, an MS at a reputed university would provide me with an excellent faculty coupled with state-of-the-art research labs, primarily focused on creating an impact by leveraging distributed systems and a vibrant community of like-minded scholars.