

Dr. Basharat Hussain

PhD | AI Researcher | Software Architect | Agentic Systems

✉ basharat@live.com | 📞 +92 300 510 6398 | 🔗 [linkedin.com/in/basharathussain](https://www.linkedin.com/in/basharathussain) | 🐙 github.com/basharathussain
🌐 bash-portfolio.rayandispatch.com | 🎓 Google Scholar | 🆔 ORCID: 0000-0001-7492-5725 | 📍 Islamabad, Pakistan

Research Summary

AI researcher working on **adaptive multi-agent systems and runtime organizational control**, with a doctoral background in **distributed and federated learning**. My PhD developed cluster-based and vertical federated learning for intelligent transportation systems — problems in which the central question is *how a distributed system should organize itself under communication, cost, and reliability constraints*. Published in IEEE Transactions venues with impact factors up to **10.9**.

My current work extends that question from distributed *learning* to distributed *agentic execution*: when an LLM-based multi-agent system is already running, how should it decide to change its execution topology, agent granularity, or degree of human involvement — and when is that change not worth its overhead? I have built and deployed a working graph-driven multi-agent prototype in this space (see **Research Systems & Prototypes**).

This research direction is grounded in **24+ years of systems and software architecture experience**, including globally-deployed platforms and production LLM pipelines. That background is directly relevant to the empirical program I propose: it provides both a realistic industrial testbed and the engineering depth required to build and instrument a runtime control framework rather than only simulate one.

Research Interests

- **Runtime organizational control of multi-agent systems** — treating workflow topology and agent organization as decision variables selected *during* execution rather than fixed at design time.
- **Adaptive execution topologies** — sequential, parallel, event-driven, and arbitrated execution; adaptation of agent granularity between coarse generalists and narrow specialists.
- **Cost, risk, and overhead-constrained adaptation** — adapt-or-stay control policies that explicitly account for switching, coordination, recovery, and human-intervention overhead.
- **State consistency and provenance-aware recovery** — authoritative task state, selective re-entry, and recovery without unnecessary recomputation.
- **Human-in-the-loop as an explicit control mode** — HITL as a routed, first-class execution state rather than an emergency fallback.
- **Federated and distributed learning** — cluster-based and vertical federated learning, graph neural networks, communication-efficient coordination.
- **Applied testbeds** — structured industrial workflow automation (logistics carrier onboarding) and automated software vulnerability diagnosis and patching.

Education

- **Ph.D. in Computer Science (Artificial Intelligence)** — [COMSATS University](#), Islamabad — 2025
Thesis: Traffic Flow Prediction using Deep Neural Networks: A Cluster-based Federated Learning Approach
Advisor: Dr. M.K. Afzal
- **M.S. in Computer Science** (CGPA: 4.0/4.0 — With Distinction) — International Islamic University, Islamabad — 2016
- **M.Sc. in Computer Science** (CGPA: 3.57/4.0) — International Islamic University, Islamabad — 2001
- **B.Sc. Mathematics & Physics** — University of the Punjab — 1997

Peer-Reviewed Publications

Full list and citation metrics: [Google Scholar](#).

Journal Articles

1. Hussain, B., et al. "Optimizing Content Cache With Vehicular Edge Computing: A Deep Federated Learning-Based Novel Predictive Study." *IEEE Transactions on Consumer Electronics*, vol. 71, no. 2, 2025. **(Impact Factor: 10.9)**
2. Hussain, B., & Afzal, M.K. "Optimizing Urban Traffic Incident Prediction with Vertical Federated Learning." *IEEE Transactions on Network Science and Engineering*, vol. 12, no. 1, 2025. **(Impact Factor: 6.7)**
3. Hussain, B., et al. "A Novel Graph Convolutional Gated Recurrent Unit Framework for Network-Based Traffic Prediction." *IEEE Access*, vol. 11, 2023. **(Impact Factor: 3.6)**
4. Hussain, B., Hussain, A., & Islam, M. "Pose and Illumination Invariant Face Recognition in Video via Motion Analysis and Texture Feature Optimization." *IET Image Processing*, vol. 19, no. 1, Dec. 2025. **(Impact Factor: 2.3)**

Book Chapters

5. Hussain, B. "Pedestrian Digital Twins for Smart Transportation." Chapter 24 in *Digital Twins for Smart Transportation*, ed. Prof. Mariusz Kostrzewski.

Research Systems & Prototypes

Carrier State Agent Graph — graph-driven adaptive multi-agent system (2026, deployed). carrier-state-agent-graph.desidhabawah.com

- Working prototype of the substrate underlying my proposed research: a **LangGraph** execution graph driving LLM agents over an **authoritative, incrementally-completed task state** (facts, goals, dependencies, confidence, provenance) for autonomous logistics carrier acquisition and onboarding.
- **Human-in-the-loop implemented as an explicit routed control mode** — low-confidence extraction, compliance red flags, and safety-rating escalations transition the graph into an approve/reject state rather than failing over to a fallback path.
- **Provider-agnostic LLM port** with a deterministic non-LLM execution mode, giving a reproducible baseline for controlled ablation of agent behaviour against identical task state.
- Autonomous **hunt loop** advances each entity through the graph, emitting per-transition provenance suitable for offline analysis of execution traces and switching behaviour.
- Real-data grounded: public FMCSA / Socrata regulatory sources (census, crash, licensing & insurance) with deterministic qualification criteria; verified end-to-end over a seeded cohort of real carriers.
- Python, FastAPI, PostgreSQL, WebSocket live state board, containerized deployment.

DataVenture — large-scale heterogeneous data integration (2025–present). Architected a platform aggregating **89 structured regulatory datasets** (SEC, CFTC, FDIC, USPTO, DOL) covering **180,000+ securities** across **73 exchanges**, with event-sourced, idempotent ingestion — infrastructure directly reusable for large-scale execution-trace collection.

LLM extraction pipelines at scale (2025). End-to-end LLM pipelines for structured extraction from heterogeneous global financial filings, achieving **91% precision** on benchmark datasets, combining fine-tuned models with rule-based verification.

Research Experience

Doctoral Researcher — **COMSATS University, Islamabad**

Feb 2019 – Feb 2025

- Developed **cluster-based federated learning** for traffic flow prediction, addressing client heterogeneity and communication cost through learned cluster formation — an organizational-configuration problem in distributed learning.
- Developed **vertical federated learning** for urban traffic incident prediction across feature-partitioned data holders (IEEE TNSE).
- Developed **graph convolutional GRU** architectures for network-based traffic forecasting (IEEE Access), and deep federated predictive caching for vehicular edge computing (IEEE TCE, IF 10.9).
- Four peer-reviewed journal publications and an invited book chapter; sustained collaboration with the ITS and federated learning research community.

Research Supervision — **FAST-NUCES**

- Supervising MS-level research students in **autonomous vehicles, federated learning, and intelligent transportation systems**.

Teaching Experience

Assistant Professor — FAST-NUCES

Islamabad, Pakistan | Since Jan 2021

- Student feedback scores of **82–83%+** across AI and Cloud Computing modules.

Courses Taught

Course	Code	Level	Semester
AI Product Development	AI4013	Graduate	Spring 2026
Cloud Computing	CS4075	Graduate	Spring 2025, Fall 2026
Data Mining	CS4038	Undergraduate	Fall 2025
Machine Learning for Robotics	CS4090	Graduate	Spring 2025
Software Engineering	CS3009	Undergraduate	Fall 2024

Academic Service

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- **Peer Reviewer** — IEEE Access and related AI venues.
 - **Curriculum design** — AI/ML and Cloud Computing programme design at university level.

Industry Experience (24+ years — condensed)

Lead Platform Architect — DataVenture / SigmaTrov

Remote | Nov 2025 – Present

- Architected a large-scale public-data securities platform (Python/FastAPI, PostgreSQL); event-sourced ingestion, idempotent upserts, fault-tolerant scheduling under advisory locks.

AI & LLM Consultant — 2iQ Financial Services

Frankfurt, Germany (Remote) | Jan 2025 – Aug 2025

- LLM pipelines for structured extraction (**91% precision**); fine-tuned models with rule-based verification; unsupervised clustering for anomaly detection and automated correction.

Co-founding Chief Technology Officer — FindVaccineNow LLC

Texas, USA | June 2017 – Dec 2023

- Architected a global COVID-19 vaccine availability platform adopted in **135+ countries**; crawler-centric real-time aggregation at scale.
- Delivered public-health data integrations with **Apple Inc., WHO, and Gavi** — external validation of data quality at global scale.
- Built and led a distributed engineering and data science team across multiple time zones.

Chief Architect / Solution Architect — Route Trading (London, UK); Put & Track (Denmark)

Concurrent engagements | 2016 – 2020

- Enterprise FinTech platforms: AML, regulatory compliance, cross-border remittance, fraud detection; microservices migration improving reliability by **40%**.
- Real-time asset tracking with service-oriented back-end and push-based state propagation.

Earlier roles — Synergy IT, TEO International, Ciklum, Buraq Integrated Solutions

Islamabad, Pakistan | 2001 – 2016

- Technical lead and architect on enterprise publishing, insurance, and CMS platforms for Danish and EU clients (Gyldendal, Dangaard); on-site requirements work in Denmark.
- Systems-level engineering foundation: high-performance **peer-to-peer file sharing engine in C++/STL**; rule-based **workflow automation engine** routing multi-step approval chains (VC++, COM/DCOM) — early work on the execution-routing problems that motivate my current research.

Technical Skills

Research Domains: Multi-Agent Systems, LLM Orchestration, Federated Learning (Cluster-based, Vertical), Graph Neural Networks, Time-Series Forecasting, Computer Vision, NLP, ITS

Agentic & LLM Frameworks: LangGraph, LangChain, Groq, Ollama, Hugging Face; agent graph design, tool routing, structured extraction, LLM fine-tuning

ML Frameworks: PyTorch, TensorFlow, Scikit-learn, NumPy, Pandas

Languages: Python, C++, C#, Java, SQL, Shell

Systems & Infrastructure: FastAPI, PostgreSQL, Docker, Kubernetes, AWS, Azure, microservices, event-driven and high-concurrency architectures, CI/CD

LLM-Assisted Development: Production software development using LLM-native workflows and AI pair programming (Claude Code, OpenAI Codex)

Certifications (online courses)

- Introduction to Machine Learning on AWS — Coursera (Amazon Web Services), 2024
- Automated Reasoning — Coursera (EIT Digital), 2020