

Federated Causal Intelligence for Explainable and Secure Cloud Cybersecurity**Dr. Ammber Nosheen**

Institute for Smart and Advanced Digital Opportunities
School of Computing, University Utara Malaysia, Malaysia

Dr. Ijaz Yusuf

Associate Professor, Business Department, School of Business,
Forman Christian College (A chartered University), Lahore, Pakistan

Abstract

Advanced cloud computing environments, where cybersecurity grows complex in distributed and dynamic settings, face evolving threats, data privacy challenges, distributed attacks, and limited transparency in security decision-making. This paper explores how Federated Learning AI applications can strengthen resilience and cybersecurity in a cloud setting. The research highlights cloud security as a distributed intelligence problem based on local security data and the limitations of data sharing due to sensitive raw information. Federated learning delivers security models while protecting information in collaborative environments. Furthermore, explainable AI causal intelligence helps identify factors behind security events and supports interpreting security predictions.

The research paper develops a federated intelligence conceptual framework, with a particular focus on privacy-preserving collaborative learning, distributed security monitoring, cloud cybersecurity, quality-aware model aggregation, anomaly detection, and causal analysis. The proposed research mainly focuses on developing a distributed architecture and advancing local detection models, with local cloud clients processing security data and sending updates to a federated server for aggregation. The resulting global intelligence across participating cloud environments is subsequently used to support security decision-making and explainable resilience.

Additionally, the paper's contribution is intended to provide a framework development with a structured basis for improving cybersecurity mechanisms, enabling sensitive data exchange without requiring direct or core data sharing. In particular, integrating explainable intelligence and federated learning can support transparent security analysis and privacy awareness in cybersecurity-related factors. This research study aims to design and develop a more secure, interpretable framework that helps organisations collaboratively improve security intelligence while maintaining control over their sensitive data.

Keywords: Federated Learning, Cloud Cybersecurity, Explainable Artificial Intelligence, Causal Intelligence, Anomaly Detection, Privacy-Preserving Security, Cloud Resilience