

**A Comprehensive Security Framework for Edge Computing: Development, Validation,  
and Adoption Drivers**



A THESIS

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## **DECLARATION**

I hereby declare that this thesis is my original research work and wherever others ideas or words have been included I have indicated this clearly, with proper reference to the literature and have acknowledged related research and discussions. I have adhered to the principles of academic honesty and integrity and have not misrepresented any fact and source in my written submission.

(Shijo Joy)

## ABSTRACT

Edge computing is an important technology in the digital era, enabling organizations to have the data and the compute closer to the edge location where the data is processed and achieve lower latency and enhanced operational efficiency. In the case of cloud computing, the governance and controls are more centralized, while with edge computing the control and the people managing the device is decentralized. Edge computing also has issues of intermittent connectivity and multiple personas managing the edge device which introduces security challenges that are not adequately addressed by existing frameworks. The present study investigates these challenges by combining insights from interviews with experts in edge computing with quantitative validation among practitioners. We then develop and empirically test a robust security framework tailored for edge computing.

In our study we first map the landscape of edge computing adoption across various sectors. We identify its growing prevalence in industries such as retail, manufacturing, healthcare, and transportation. Through an extensive literature review and a series of in-depth interviews with subject matter experts, the study identifies a spectrum of security threats unique to edge environments. These include authentication and authorization complexities, difficulties in malware detection and vulnerability assessment, application and physical security risks, and the operational challenges of managing devices outside traditional organizational perimeters. The findings reveal that many organizations often attempt to adapt to existing frameworks such as National Institute of Standards and Technology (NIST) Cyber Security Framework (CSF), ISO 27001, and COBIT 5 to their edge deployments. These standards though do not fully address the challenges which include the decentralized, dynamic, and multi-party nature of edge computing.

To address this gap, the thesis proposes an extended cybersecurity framework that builds upon NIST CSF 2.0, introducing edge-specific controls and aligning them with the dimensions of

organizational readiness. The framework emphasizes the need for strategic alignment of security objectives with business goals, robust IT and network management, continuous learning and training for both internal staff and external vendors. The framework also ensures that there is a security-first culture across all organizational layers. It also highlights the importance of partnership readiness, resource allocation, and a shift in organizational mindset to view security as a business enabler rather than a cost center. The proposed framework incorporates practical measures such as zero trust architectures, device identity attestation, staged updates under bandwidth constraints, immutable backups, and enhanced physical security protocols.

The empirical phase of the study employs a quantitative survey of 210 practitioners, grounded in the Technology Threat Avoidance Theory (TTAT). We validate the relationships between individual threat appraisal, organizational intervention, and the willingness to implement the proposed edge security framework. Through the analysis we demonstrate that both perceived severity and vulnerability of threats, as well as the perceived efficacy and cost of security measures, significantly influence practitioners' motivation to avoid risks. The study identifies that organizational intervention manifested through clear communication, targeted training, and leadership support plays a mediating role in translating individual motivation into actual adoption of security frameworks. The results also indicate that demographic factors such as age can moderate this relationship, with older employees exhibiting greater risk aversion and a higher propensity to embrace security measures. Gender and organization size do not show significant effects.

The implications of these findings are far-reaching for both practitioners and policy makers. For organizations, the research provides a blueprint for designing, implementing, and auditing edge security controls. This helps organizations in moving beyond ad hoc adaptations of cloud or IT security policies. It highlights the necessity of regular policy communication, rigorous

vendor evaluation, and continuous policy review to maintain agility with evolving threats. Our study highlights the urgent need to update existing frameworks and certification schemes to reflect the realities of edge computing, including distributed assets, intermittent connectivity, and multi-party management. The research also contributes to academia by extending the organizational readiness framework with new constructs specific to edge security and empirically validating their relevance.

In conclusion, this thesis addresses a critical gap in the field of security within edge computing by proposing and validating a comprehensive, edge-specific cybersecurity framework. By integrating organizational readiness and threat avoidance perspectives, the study offers actionable guidance for practitioners, which includes policy makers, and academia seeking to strengthen security in the rapidly evolving landscape of edge computing. The findings highlight the importance of both technical controls and organizational factors in achieving robust security outcomes. It forms the basis for future research on the adoption and effectiveness of security frameworks in emerging technology domains.

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