MODELING A GLOBALLY SCALABLE AND COMPLIANT MULTI-TENANT SAAS ARCHITECTURE

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MSc in Computer Science

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DECLARATION

I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other University or Institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text. I retain the right to use this content in whole or part in future works (such as articles or books).

Signature: Date: 06/06/2025

The above candidate has carried out research for the Masters thesis under my supervision. I confirm that the declaration made above by the student is true and correct.

Name of Supervisor: Dr. Buddhika Karunarathne

Signature of the Supervisor: Date: 22/06/2025

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ABSTRACT

The rapid growth of cloud computing has established Software as a Service (SaaS) as the dominant software delivery model. The increasing adoption of SaaS creates opportunities for SaaS providers to expand globally and capture emerging markets. However, global expansion introduces significant challenges in balancing global scalability, data residency compliance, and operational efficiency. Existing research often addresses these requirements in isolation, resulting in suboptimal solutions.

This research proposes and validates a novel SaaS architecture that reconciles these competing requirements. The architecture comprises two key components: (1) a logically centralized yet physically distributed Control Plane, which enables operational efficiency through unified management of Application Planes and tenants, and (2) regionally distributed Application Planes, supporting global scalability while complying with regional data residency regulations.

The proposed solution (fully distributed nCPxnAP model) is evaluated against two alternative deployment models (single region 1CPx1AP and hybrid 1CPxnAP). Through comprehensive comparative analysis of three architectural variants, we demonstrate that our fully distributed nCPxnAP model achieves optimal performance, ensures full compliance with data residency laws, and preserves operational efficiency. The key contributions of this research are: (1) an architectural model for a globally scalable, compliant, and operationally efficient multi-tenant SaaS; (2) empirical validation via real world implementation and testing; and (3) practical guidelines for SaaS providers at various growth stages.

The findings offer a clear pathway for SaaS providers transitioning from single region deployments to global distribution while maintaining data residency compliance and operational efficiency. The research establishes new design principles for compliant global SaaS deployments and provides actionable implementation blueprints and performance benchmarks. It not only advances academic research but also provides industry professionals with a validated architectural model for navigating the complexities of modern global SaaS delivery.

Keywords: Cloud Computing, SaaS, Global Scalability, Data Residency Compliance, Operational Efficiency

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

Abbreviation	Description
AP	Application Plane
API	Application Programming Interface
AWS	Amazon Web Services
CD	Continuous Deployment
CI	Continuous Integration
CP	Control Plane
DB	Database
DNS	Domain Name System
ECR	Elastic Container Registry
ERD	Entity Relationship Diagram
IaC	Infrastructure as Code
ID	Identification
IT	Information Technology
MTA	Multi Tenant Architecture
SaaS	Software as a Service
SLA	Service Level Agreement
S3	Simple Storage Service
TPMS	Third Party Management Systems
UI	User Interface
URL	Uniform Resource Locator

LIST OF APPENDICES