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LLM-Based Banking System for Microfinance Companies in Rural Areas Using Blockchain and Artificial Intelligence

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Microfinance institutions (MFIs) in rural areas play a vital role in financial inclusion but continue to face operational inefficiencies, limited transparency, and security vulnerabilities due to heavy reliance on manual workflows. Particularly in developing countries such as Sri Lanka, these challenges are further exacerbated by unreliable network connectivity and weak digital infrastructure. Therefore, to address these difficulties, this study investigates whether integrating a fine-tuned Large Language Model (LLM) with a permissioned blockchain can deliver a secure, scalable, and accurate digital banking platform tailored for rural microfinance environments. The proposed system introduces a novel five-stage methodology of an AI-driven framework that integrates LLM-based loan assessment with Hyperledger Fabric blockchain, enabling secure transactions, blockchain-enforced role-based access control, and full auditability. The methodology comprises dataset preparation using real-world microfinance records from a Sri Lankan MFI, natural-language prompt transformation, parameter-efficient fine-tuning of a Llama-based model using LoRA adapters, baseline model development using traditional machine learning and transformer-based encoders, and multi-dimensional evaluation across classification, regression, and text-generation tasks. To address rural connectivity limitations, the system adopts a hybrid networking architecture that supports offline transaction processing with later blockchain synchronization. Experimental results demonstrate that the fine-tuned Llama model consistently outperforms baseline models in loan eligibility, repayment capacity, and fraud risk classification, achieving macro-averaged F1 scores of 88%, representing an improvement of 11% over traditional approaches. For regression-based predictions of optimal loan amount and tenure, the proposed model achieves MAE and RMSE values of LKR 25,000 and LKR 50,000, respectively. Unlike existing blockchain-based microfinance systems, the proposed approach uniquely incorporates LLM-driven structured JSON output generation for explainable loan decisions, validated using BLEU (61.9), ROUGE-L (62.5), and BERTScore (83.0) metrics. Security evaluation under three attack scenarios—credential theft, token theft, and private key compromise—shows that blockchain-based authentication maintains a maximum successful attack rate of only 10%, even under full private key compromise, compared to 21% for MFA-only systems and 90% for non-MFA systems. Load testing with 100–500 concurrent users confirms stable system performance, achieving a throughput of 0.79 transactions per second with error rates below 60%.

Keywords: AI — Artificial Intelligence, LLM — Large Language Model, MF — Microfinance, MFA — Multi-Factor Authentication