SDN マルチコントローラ環境における負荷分散を目的とした BiLSTM による負荷予測

Load Prediction Using BiLSTM for Load Balancing in SDN Multi-Controller Environments

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Software-Defined Networking (SDN) is an innovative paradigm that decouples the control plane from the data plane, allowing centralized management and configuration of network rules through controllers. As SDN networks scale up, multi-controller environments become essential to efficiently manage the increasing control load. However, static switch-to-controller mappings create an imbalance in load distribution, degrading overall network performance. Traditional load balancing methods struggle with dynamic traffic variations, necessitating predictive approaches for optimal controller workload distribution.

Recent advancements in deep learning (DL) have significantly improved network traffic forecasting. Various models such as MLP, CNN, RNN, LSTM, GRU, Transformer, and GNN have been applied to network traffic prediction, each offering unique advantages. Prior studies have highlighted the effectiveness of RNN-based models, particularly LSTM, in capturing long-term dependencies in time-series data.

Our research explores BiLSTM-based load prediction to enhance load balancing strategies in SDN multi-controller environments. By forecasting controller workload based on Packet-In message arrival rates, the study proposes a method to dynamically migrate switches, reducing controller overload and improving network efficiency.

The study employs a publicly available SDN dataset for training and evaluation. Data preprocessing involves MinMax scaling and sliding window transformation to construct time-series input sequences. The BiLSTM model is trained using Google Colab with GPU acceleration, leveraging early stopping and learning rate adjustment mechanisms.Performance evaluation is conducted using standard metrics, including Mean Squared Error (MSE), Root Mean Squared Error (RMSE), and Mean Absolute Error (MAE). The BiLSTM model demonstrates superior accuracy compared to traditional LSTM, achieving an optimal validation loss of 0.00003828 with a look-back window size of six.

Future work will focus on integrating reinforcement learning techniques to refine switch migration policies further. Additionally, large-scale real-world deployments will be explored to validate model generalization across diverse network topologies and traffic pattern.