Project Proposal
Advanced Computer Architecture (CMSC 611)

Title: Cache Replacement Using Reinforcement Learning
Team: Rohit Kumar (ZR66734), Arti Singh (LN22810), Aishwarya Sapkale (DP73694)
Software/Tools: Python, Jupyter Notebook

Context

Cache replacement algorithms (also called Cache Algorithms) are algorithms which can be utilized by a program or hardware system to manage a cache of information stored on the computer. The algorithm must choose which items to discard in order to make room for the new ones when the cache is full. Each replacement strategy is a compromise between hit rate and latency. Replacement policies have evolved over the years. Some of these are Random Replacement, LRU, FIFO, MRU and Least Frequently Used. However, all these algorithms take the past behaviour into consideration to discard an item, and past cannot always be reliable.

Bélády's algorithm is a recent algorithm which discards the item based on its future use and hence overcomes other algorithm's disadvantages. An item not to be used in near future has higher probability of being discarded by this algorithm. Though, we are predicting future by taking the historical data, it requires enormous resources to train the predictive model. Additionally, due to the enormous data to train the model, it sometimes takes hours, days, or months and the model once trained is used online, where the target may change, and hence the model is not adaptable.

In this project, we aim to experiment with Reinforcement learning to build a model, which learns in the online environment over the time. We plan to implement Q-learning algorithm to build model which would reduce the cache miss rate. We would take a database table or a python array as dummy cache memory which needs replacement. Following the Q-learning algorithm, any hit would be considered a reward to the strategy, and any miss would result in losing some reward. We would consider a threshold for cache miss rate in order to update the Q-table, after a certain number of epochs we can integrate the model with the hardware for cache replacement which will continue learn as it encounters more and more cache misses.

Below are the papers that are reference for this project:

- Deep Reinforcement Learning for Adaptive Caching in Hierarchical Content Delivery Networks [July 2019, Alireza Sadeghi, Gang Wang, and Georgios B. Giannakis]
- A Q-learning-based network content caching method [Dec 2018: Haijun Chen and Guanzheng Tan]
- Applying Deep Learning to the Cache Replacement Problem [Oct 2019: Zhan Shi, Xiangru Huang, Akanksha Jain, and Calvin Lin]