# Reliable Cache Control in Unreliable Edge Environments Using Reinforcement Learning

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## 1. INTRODUCTION

### Background and Problem Statement

- **Mobile Edge Caching (MEC)** places cache servers close to users to reduce latency and backhaul traffic.
- In practice, a large number of **edge servers (ESs) are low-cost and unreliable**, suffering from frequent failures.
- To improve reliability, **erasure coding** (e.g., Reed–Solomon / MDS codes) is applied by splitting contents into multiple chunks.
- A content can be successfully restored if at least **k chunks** are obtained from available ESs.

### Challenges

❑ Existing studies mainly assume:
- Static content placement
- Fixed caching policies
- Known and stable environments

❑ In reality:
- Content popularity changes dynamically
- ES availability varies over time
- Static cache control causes over-caching of popular contents and low diversity of chunks
- ➡️ Dynamic cache control considering unreliability is required.

## 2. PROPOSED METHOD

### Placement method

We propose a **reinforcement learning (RL)–based cache control method** for unreliable edge environments using erasure coding.
The cache insertion probability $f_m$ for each content $m$ is optimized dynamically.
RL learns appropriate insertion actions based on observed system states.

### Optimization methods

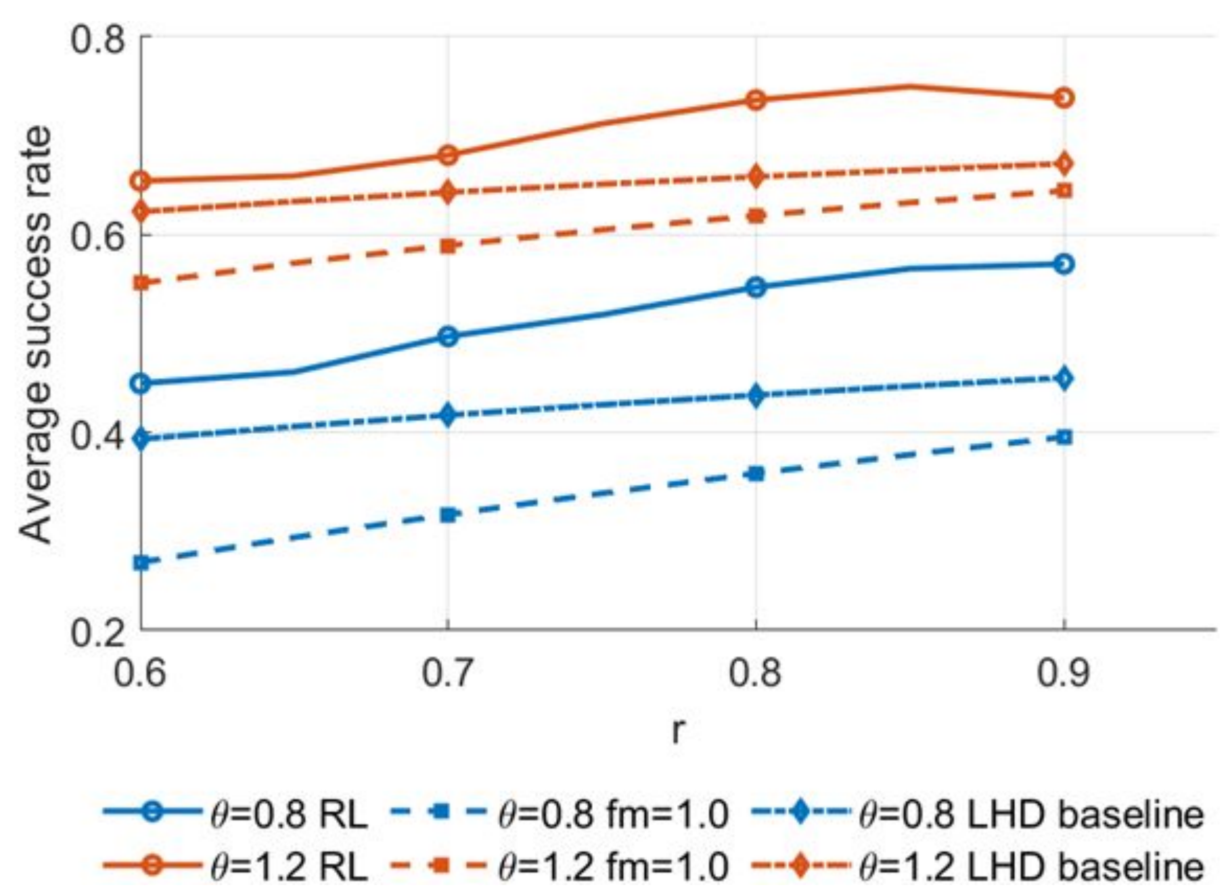
- Optimization methods such as HomoCP and reinforcement learning are used to optimize cache control parameters under unreliable edge environments.

## 3. EVALUATION

### Evaluation Metrics

❑ Average Successful Recovery Rate
- Ratio of contents successfully restored using only chunks obtained from ESs

❑ Comparison with baseline methods:
- Fixed insertion probability ($f_m = 1.0$)
- **(RL)–based** caching
- Leave-Hot-Down (LHD)




### Results

❑ The proposed method achieves:
- Higher recovery success under dynamic environments
- Better chunk diversity across ESs

❑ When ES availability is high:
- Baseline methods suffer from over-concentration of popular contents
- The proposed method avoids unnecessary redundancy

❑ The RL-based policy generalizes well to unseen environments without retraining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