

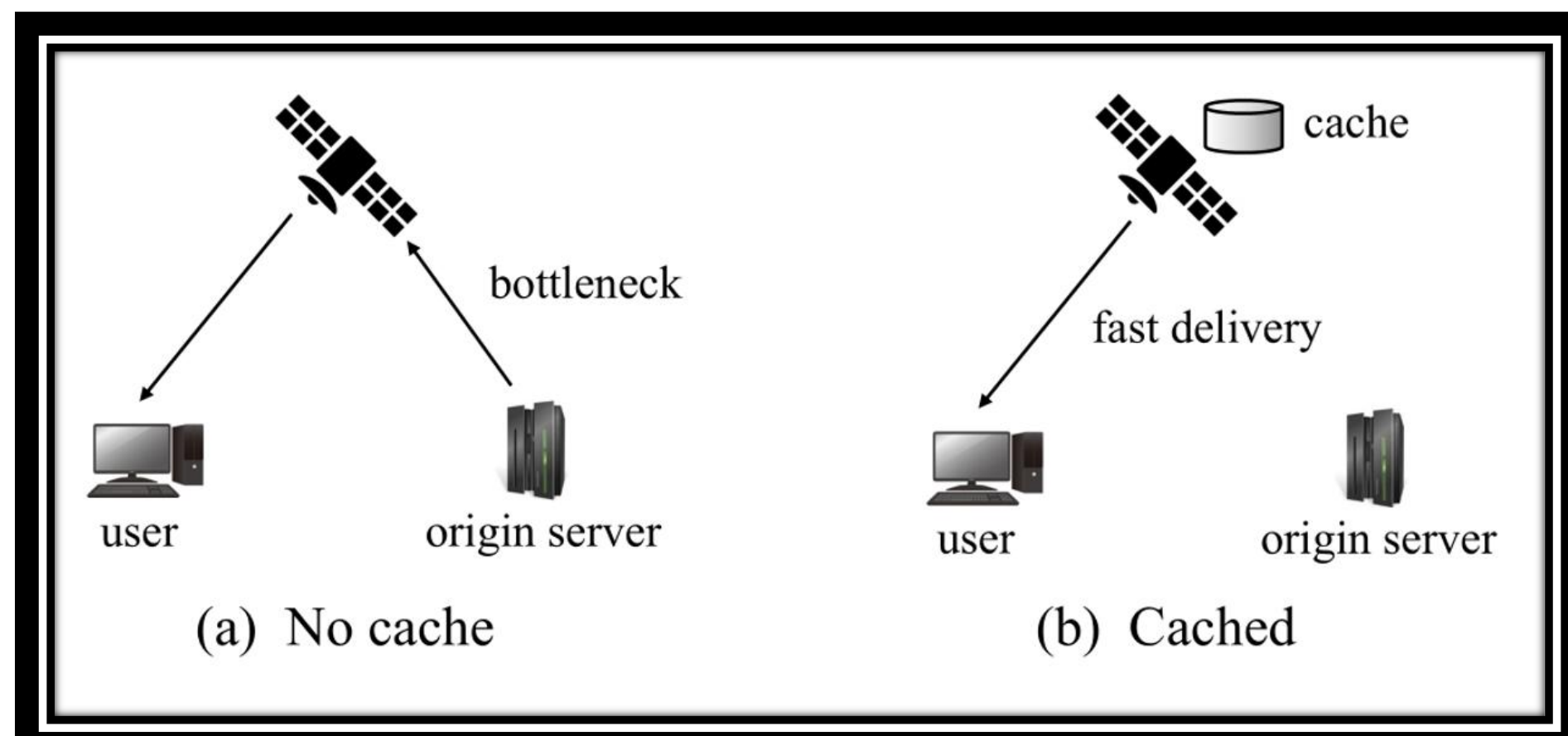
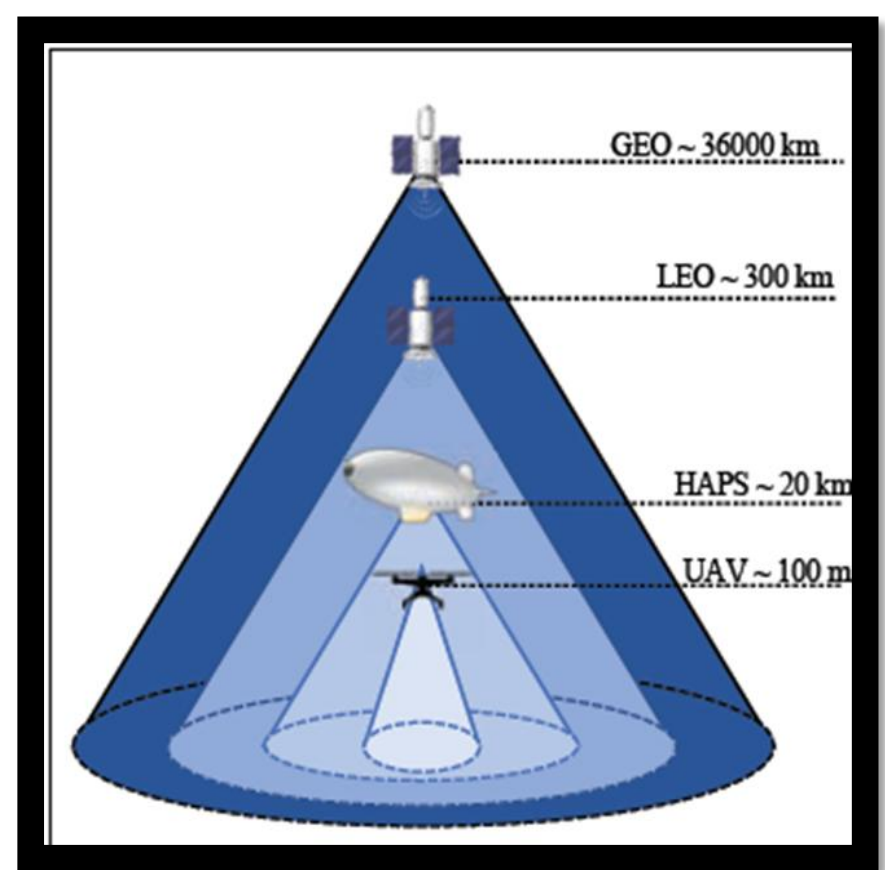
Optimal Content Placement Based on Popularity at Low Earth Orbit Satellites

Haku Nishijima, Noriaki Kamiyama (Ritsumeikan Univ., Japan)

1. INTRODUCTION

LEO satellite network

- LEO satellites orbit below 2,000 km as relay nodes.
- Enable **low power, low latency, and high-capacity** communication.
- **Uplink throughput from ground servers is a bottleneck.**
- Caching on LEO satellites effectively alleviates this issue.



Purpose of research

- LEO caching enables direct delivery and reduces latency.
- LEO satellites serve diverse global regions due to fast orbits.
- Caching globally popular content improves cache hit ratio.
- Inter-satellite links enable content relays when not cached locally.
- Each relay adds delay → More replicas reduce delivery hops.
- We propose a content placement method that:
 - **Optimizes replica count based on global popularity**
 - Improves **cache hit ratio** and reduces **delivery hops**
 - Respects cache capacity constraints
- Placement intervals optimized using **genetic and greedy algorithms.**
- Performance of both methods is compared.

2. PROPOSED METHOD

Placement method

- Proposed placement method relies on **two key principles.**
- Increase cache hit ratio by placing **many highly popular contents.**
- Reduce hop counts by **distributing duplicate content.**
- Proposed scheme distributes content at popularity-adjusted equal intervals.

Optimization methods

- **Optimize placement intervals per content to maximize average cache hit ratio.**
- Two optimization methods, genetic algorithm (GA) and greedy method are used.

3. EVALUATION

- The figures below shows the average results of 10 simulations.

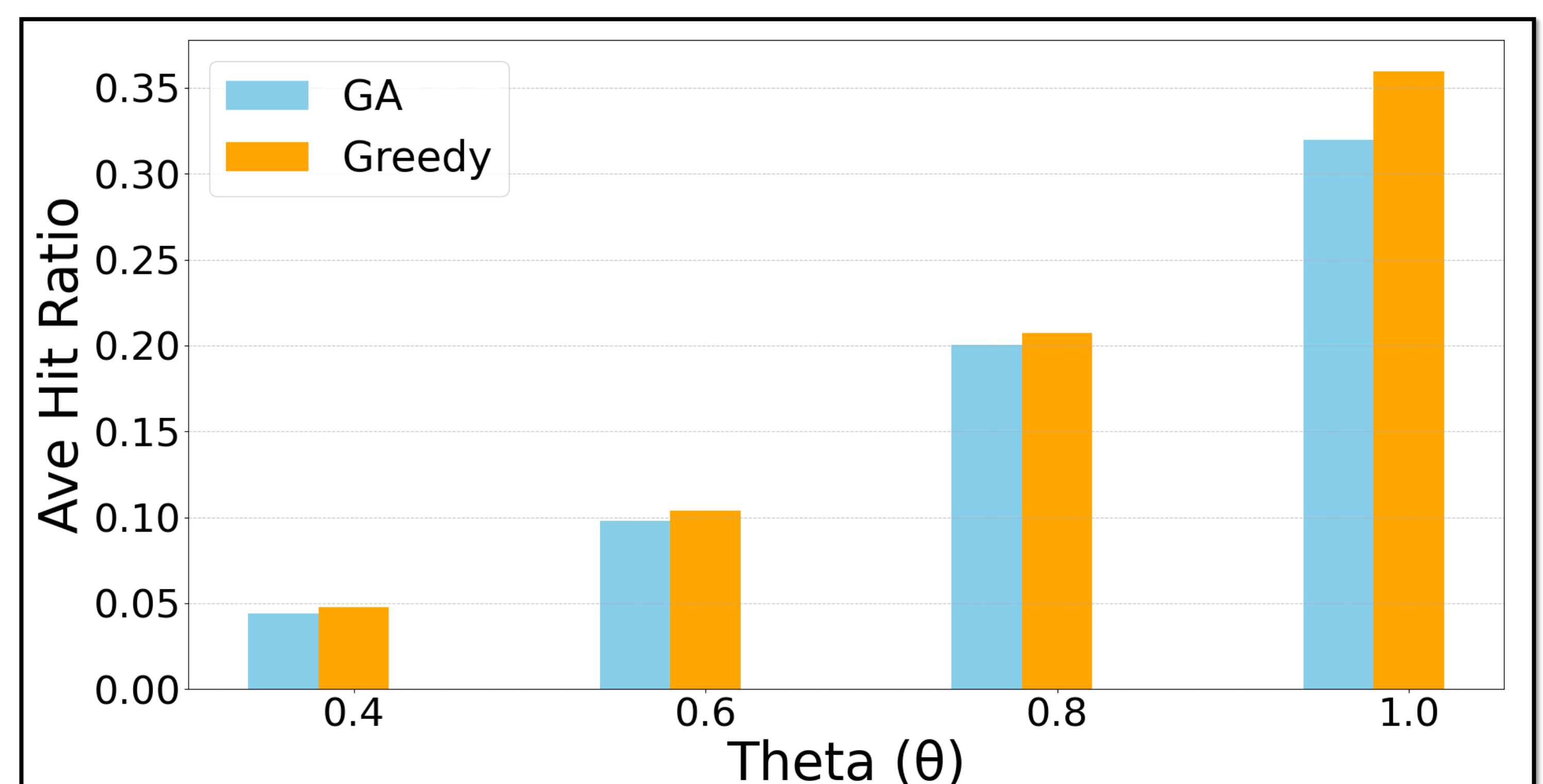


Fig. 1. Average cache hit ratio against Zipf parameter of content popularity

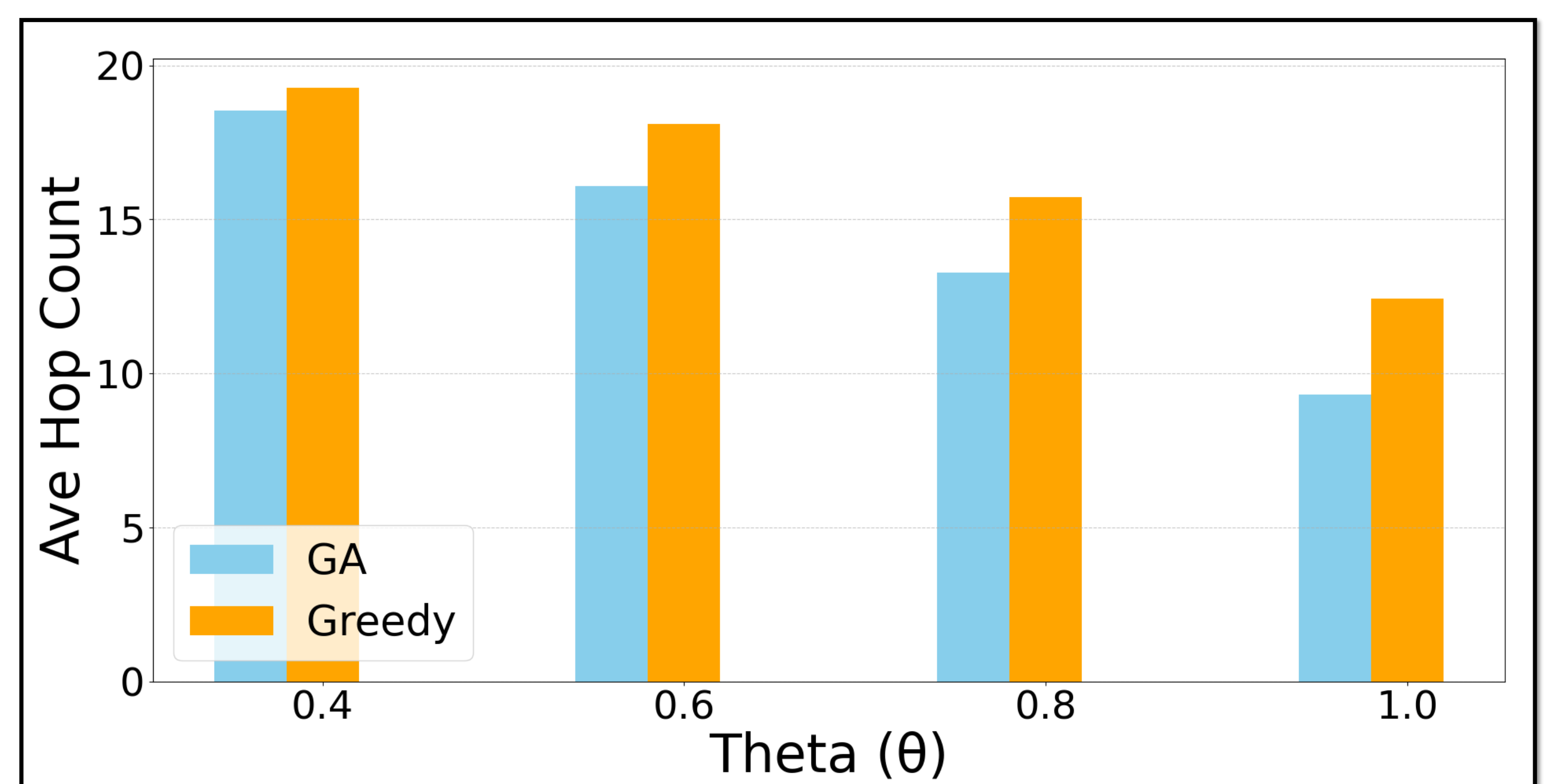


Fig. 2. Average hop length against Zipf parameter of content popularity

- Fig. 1: Average cache hit ratio under varying Zipf biases.
- Greedy placement achieves highest hit ratio, followed by genetic algorithm.
- Fig. 2: Average hops under varying Zipf biases.
- GA placement slightly reduces hops by better distributing medium-popularity content compared to greedy.

Acknowledgment

This presentation is supported by the “Society for the Advancement of Science and Technology at Ritsumeikan”