Learning-based Content Delivery in 5G-enabled Multi-access Edge Computing

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INTRODUCTION

- **Major advantages of caching at 5G-enabled Multi-access Edge Computing (MEC):**
  - alleviates backhaul congestion for massive content delivery
  - meets QoS requirements such as ultra-low latency, ultra-high reliability, and continuous connectivity, while supports various applications for user equipment (UE)
- **Challenges:**
  - uncertainties originating from user mobility in deciding optimal 5G components, representing content routes from Edge Application Servers (EASs) to UEs
- **The objectives of this work are:**
  - to address the optimal 5G component selection to select content routes to minimize latency for the UEs
  - to propose an efficient online learning approach, called Q-CSCD
  - to achieve a bounded performance

OBJECTIVE

Minimizing the overall latency of applications, which is constituted of handover time (migration latency and relocation latency) and content delivery time

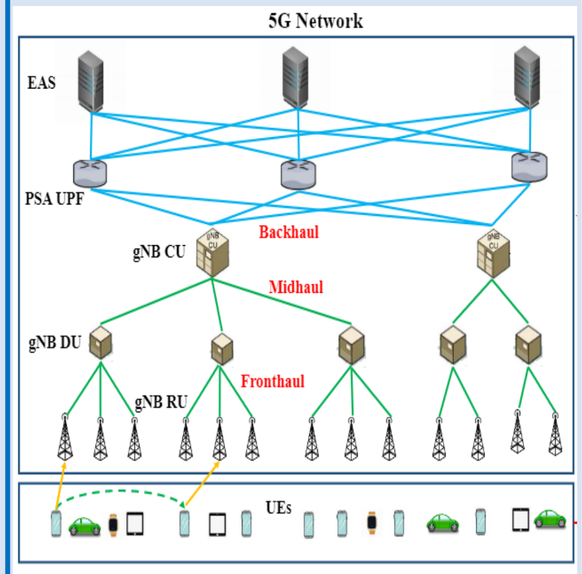
$$\text{Minimize } \mathbf{D} = \sum_{t\in\mathcal{T}}\sum_{n\in\mathcal{N}}\sum_{i\in\mathcal{M}}\sum_{j\in\mathcal{M}}(p^t_{nij}r_{ij} + q^t_{nij}s_{ij}) +$$

$$\sum_{t\in\mathcal{T}}\sum_{n\in\mathcal{N}}\sum_{g\in\mathcal{G}}\sum_{i\in\mathcal{M}}\sum_{j\in\mathcal{M}} k^t_{ngij}c^t_n\left(\frac{1}{d^t_{ng}} + \frac{1}{d_{gd}} + \frac{1}{d_{gc}} + \frac{1}{d_{gi}} + \frac{1}{d_{ij}}\right)$$

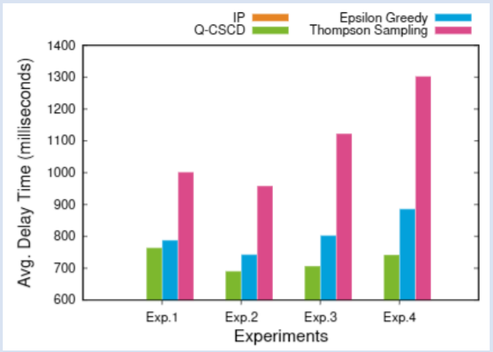
METHOD

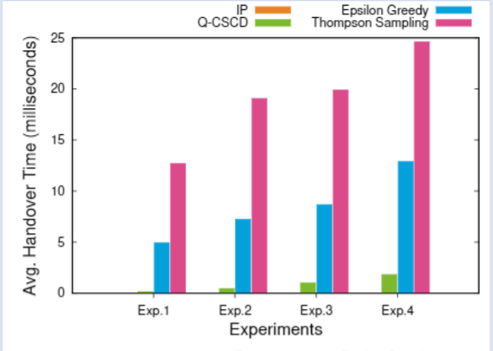
- **Q-CSCD**
  - allows every UE to own only local information (no information about the 5G network status)
  - is an online learning approach based on Multi-armed bandit (MAB) framework to learn the optimal content routes, including selected gNB, PSA UPF, and EAS
  - is adopted from UCB1 strategy
  - sets a tradeoff between exploration and exploitation
  - is inevitable to select suboptimal paths and to have higher radio handover and content migrations between EASs, especially at the beginning of the learning process
  - lowers the complexity of learning by considering just routes that could deliver the UE's content and are in closer proximity

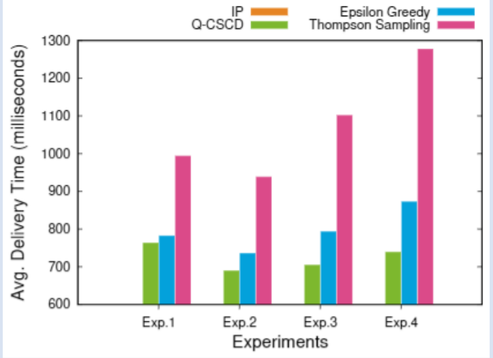
The framework for component selection in 5G-enabled MEC for content delivery for UEs:



RESULTS







EXPERIMENTAL SETUP

- Designing a 5G-enabled MEC environment for content delivery
  - UEs are scattered uniformly
  - all components of a 5G network, including gNBs, PSA UPFs, and EASs, are randomly scattered over the area according to a uniform distribution
  - Using ThousandEyes to model transmission speeds between different links in a 5G network
- Four different-size scenarios:
  - Exp.1: 50 UEs, 7 gNBs, 2 PSA UPFs, and 2 EASs
  - Exp. 2: 100 UEs, 8 gNBs, 3 PSA UPFs, and 3 EASs
  - Exp. 3: 150 UEs, 8 gNBs, 4 PSA UPFs, and 4 EASs
  - Exp. 4: 200 UEs, 10 gNBs, 5 PSA UPFs, and 5 EASs.

CONCLUSION

- 5G-enabled MEC as a solution to alleviate limited backhaul capacity and to ensure QoS for UEs
- Optimal 5G component selection to reduce handover for high mobility UEs and to decrease their observed latency
- We proposed a multi-armed bandit approach called Q-CSCD to learn the optimal 5G components
- Future work plan:
  - to conduct more intensive experiments to compare Q-CSCD with other recent learning-based and prediction-based approaches

ACKNOWLEDGMENT

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