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Caching resource sharing in radio access networks: a game theoretic approach

Key words: Video caching, Oligopoly market, Game theory, Nash equilibrium, Stability analysis

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Motivation

- With the recent proliferation of powerful mobile devices, such as smart phones and tablets, data traffic on mobile network is growing explosively.
- Deployment of caching in wireless networks has been considered an effective method to cope with the challenge brought on by the explosive wireless traffic. Most of the previous works have focused on performance optimization for content caching.
- The problem of caching resource sharing for multiple service provider servers (SPSs) has been largely ignored.

Main idea

- We formulate the caching resource sharing problem as an oligopoly market model. In our oligopoly market, all SPSs compete with each other to share the caching resource provided by the BS, and the goal of all SPSs is to achieve their highest revenue.
- We use a dynamic non-cooperative game to obtain the optimal amount of caching space needed by the SPSs. In the dynamic game, the SPSs gradually and iteratively adjust their strategies based on their previous strategies and the information given by the base station.

Method

1. The caching resource sharing problem is formulated as a dynamic noncooperative Cournot game theory.
2. We propose a Newton-Raphson method based iterative algorithm to obtain the optimal amount of caching space needed by SPSs (i.e., Cournot equilibrium solution). In addition, the *Routh-Hurvitz* stability condition is applied to analyze the stability of the caching space allocation scheme.
3. Carry out various experiments based on the proposed scheme.

Major results

- When the learning rate is set properly, the caching pace demand will converge gradually and finally reach the Nash equilibrium.

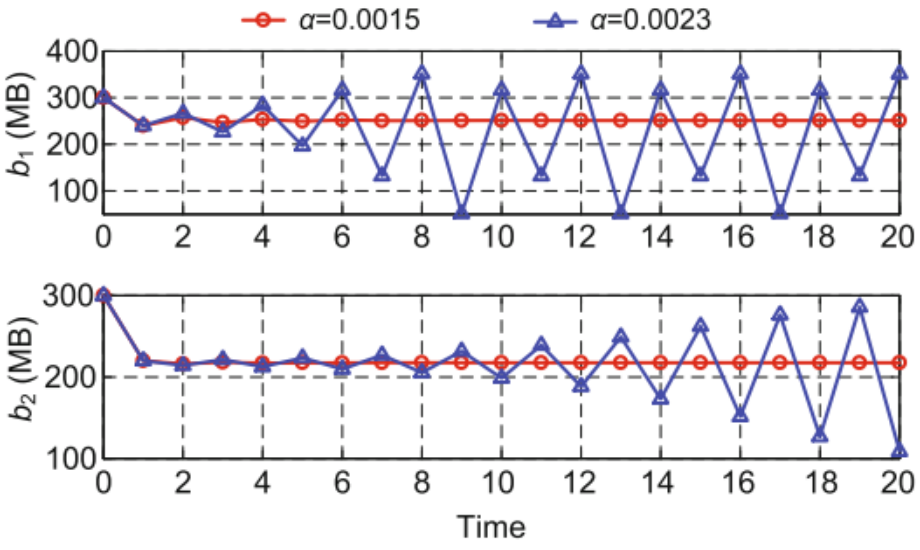


Fig. 7 Dynamic behaviors of stable and unstable cases

Major results (Cont'd)

- Given the initial strategies, our proposed storage resource sharing scheme could converge to Nash equilibrium after several iteration steps.

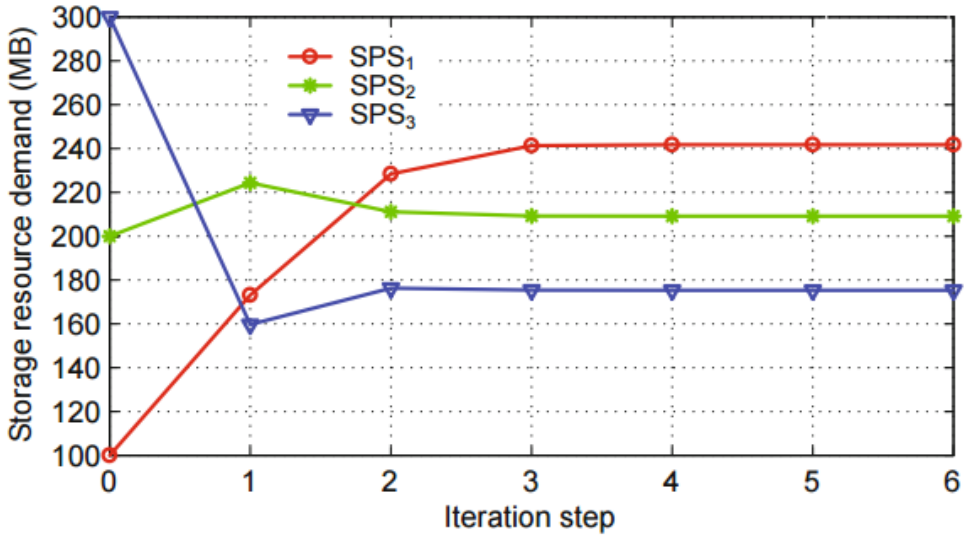


Fig. 8 Convergence of the proposed iteration algorithm based on the Newton-Raphson method

Conclusions

- We focus on the caching resource sharing problem in RANs. The system is modeled as an oligopoly market in which the SPSs compete for the caching resource provided by the BS.
- A Newton-Raphson method based iterative algorithm is proposed to obtain the optimal amount of caching space needed by SPSs.
- We evaluate the performance of the proposed caching resource sharing scheme under different system parameters. Besides, the stability characteristics of the scheme are also analyzed.