UNIVERSITÉ LIBANAISE
Ecole Doctorale
Sciences et Technologie

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES LYON

Wireless caching in realistic mobile networks

Introduction and objectives

The current mobile network generation is expected to cope with the increasing mobile data traffic through new technologies at both the physical and MAC layers. However, these technologies require expensive backhaul links between cells or between cells and the core network. To alleviate network load and increase capacity, the use of inexpensive storage resources within the Radio Access Network (RAN), known as wireless caching, is proposed.

Caching popular content at the edge of the network, such as base stations or user equipment, has been investigated in the literature and is seen as a promising approach for the next mobile network generation. This caching reduces backhaul traffic congestion and latency by serving users directly from the cache without requiring backhaul links. Additionally, optimizing the placement and transmission of content over the network can improve multicast efficiency, reducing network load and access latencies.

The topic of wireless caching in cellular networks has been widely explored, including in macro-cellular networks, small base stations, device-to-device networks, cloud-radio access networks, and fog-radio access networks. Different approaches have focused on content placement and delivery algorithms, as well as joint placement and transmission code design (coded caching).

Contributions

The proposed PhD research topic focuses on finding comprehensive solutions to overcome the challenges associated with the practical implementation of wireless caching in mobile networks. It aims to tackle various aspects, including the variation of content popularities, the integration of caching mechanisms within massive Multiple-Input Multiple-Output (MIMO) systems, and the secure caching-aided coded multicasting transmission.

The second phase of the PhD research involves implementing the proposed solution in CorteXlab, a testbed for radio experimentation located at INSA de Lyon. CorteXlab allows testing user mobility and realistic channel degradation, providing an advantage in incorporating next-generation radio technologies.

The expected contributions are in the context of caching-aided coded multicasting scheme, and they are as follows:

- Propose an innovative caching technique that utilizes Machine Learning solutions to dynamically incorporate user profiles, social behavior, and file popularity into the cache placement phase.

- Develop a novel approach by combining coded caching and MIMO systems to maximize the overall gain and optimize content delivery in mobile networks.

- Introduce a secure delivery scheme specifically tailored for caching-aided coded multicasting, taking into account practical transmission scenarios to ensure secure and efficient data transmission.

Keywords

Coded caching, machine learning, secure wireless transmission

References

[1] Fadlallah, Y., Tulino, A. M., Barone, D., Vettigli, G., Llorca, J., & Gorce, J. M. (2017). Coding for caching in 5G networks. *IEEE Communications Magazine*, *55*(2), 106-113.

[2] Wan, K., Cheng, M., Kobayashi, M., & Caire, G. (2022). On the optimal memory-load tradeoff of coded caching for location-based content. *IEEE Transactions on Communications*, *70*(5), 3047-3062.

[3] Zhang, Z., & Tao, M. (2020). Deep learning for wireless coded caching with unknown and time-variant content popularity. *IEEE Transactions on Wireless Communications*, *20*(2), 1152-1163.

[4] Zhang, C., Wang, S., Aggarwal, V., & Peleato, B. (2022). Coded caching with heterogeneous user profiles. *IEEE Transactions on Information Theory*.

[5] Haidar, M., Fadlallah, Y., Sawaya, H., & Samhat, A. E. (2023, September). Caching-aided coded multicasting in dynamic scenarios. In *2023 IEEE 34th Annual International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC)* (pp. 1-6).

IEEE.

[6] Namboodiri, K. K., & Rajan, B. S. (2021, October). Multi-access coded caching with secure delivery. In *2021 IEEE Information Theory Workshop (ITW)* (pp. 1-6). IEEE.

Contact: Jean-Maries Gorce, email: jean-marie.gorce@insa-lyon.fr
Abdellatif Samhat, email: samhat@ul.edu.lb
Yasser Fadlallah, email: y.fadlallah@usal.edu.lb