



Offre n°2019-01654

Doctorant F/H Dynamic wireless caching solutions for cellular networks

Type de contrat : CDD

Niveau de diplôme exigé : Bac + 5 ou équivalent

Autre diplôme apprécié : Master in telecommunications, signal processing or mathematics

Fonction : Doctorant

Niveau d'expérience souhaité : Jusqu'à 3 ans

A propos du centre ou de la direction fonctionnelle

Le centre de recherche Inria Grenoble Rhône-Alpes regroupe un peu moins de 800 personnes réparties au sein de 35 équipes de recherche et 9 services support à la recherche.

Ses effectifs sont distribués sur 5 campus à Grenoble et à Lyon, en lien étroit avec les laboratoires et les établissements de recherche et d'enseignement supérieur de Grenoble et Lyon, mais aussi avec les acteurs économiques de ces territoires.

Présent dans les domaines du logiciel, du calcul haute performance, de l'internet des objets, de l'image et des données, mais aussi de la simulation en océanographie et en biologie, il participe au meilleur niveau à la vie scientifique internationale par les résultats obtenus et les collaborations tant en Europe que dans le reste du monde.

Contexte et atouts du poste

In the framework of a partnership with Nokia Bell Labs, this PhD proposal addresses an important topic for the optimization of future wireless networks

Current mobile network generations cannot cope with the explosive mobile data traffic growth due to the capacity limitations of radio access, backhaul, and the increasingly on-demand nature of users' demands. Therefore, 5G is expected to support this traffic expansion through new technologies at both Physical and MAC layers. On the other hand, these technologies are in need of an expensive backhaul link between the different cells themselves or between the cells and the core network. In this context, the use of inexpensive storage resources within the RAN is emerging as a promising approach to reduce network load and increase network capacity. Indeed, caching at the edge (i.e. Base Stations or User Equipment) can greatly reduce the backhaul traffic congestion and the time latency, by caching popular contents in some storage or cache memory and serving UEs directly without requiring the backhaul links. Moreover, jointly designing the placement and transmission over the network (e.g. using index coding and transforming the problem to graph coloring algorithms) can significantly increase multicast efficiency, leading to substantial improvements in reducing network load and access latencies.

Mission confiée

The topic of wireless caching in cellular network has been widely investigated recently. Caching techniques and solutions have been applied to different types of networks such as macro-cellular networks, heterogeneous networks with small BSs (SBS), device-to-device (D2D) networks, cloud-radio access network (C-RAN) and fog-radio access network (F-RAN). The solutions have mainly focused on the design of the content placement and delivery algorithms ; i.e. which content to place in which cache, and the way of serving users upon their requests knowing that some content are cached. Other solutions have considered the joint placement and transmission code design and have been known as coded caching. Such solutions have been proposed initially in a shared link caching network topology with one transmitter and K users. However, the implementation of most solutions in practical scenarios still faces significant challenges.

This PhD research proposal aims to address practical coded caching schemes while considering realistic assumptions that helps in implementing coded caching in practice. The aims are, firstly to assume dynamic scenarios with respect to file popularity and number of users. This means that the caching-aided coding design will be adapted to any variation in the file popularity and number of users. Moreover, combining coded caching schemes with MIMO schemes can provide cumulative gain as shown in [7], and since MIMO is one of the essential technologies of 5G system, it is of high interest to consider joint coded caching and MIMO design to achieve an even higher gain. Another aim is also to take into account channel imperfection and tackle the problem of erroneous transmission. This is because assuming an error-free channel is interesting only to derive upper-bounds on the achievable

performance. The objective in the second phase of the PhD will be to implement the proposed solution in CorteXlab, a testbed for cutting edge radio experimentation, composed of a mix of radio nodes and located at INSA de Lyon. CorteXlab will allow properly testing user mobility and realistic channel degradation across wireless endpoints, and will providing a key advantage in order to easily include next generation radio technologies.

The main problem blocking the reach of the objectives mentioned above are:

- Most of existing scenarios are limited to static scenarios with respect to file popularity and number of users. Some recent research work tackled dynamic scenarios such as [8], however, solutions that assumes a caching-aided coded multicasting and count on users to decide how to adapt their caches do not exist.
- MIMO and coded caching have been shown to be complementary and the combination of both provides a scalable solution [7]. However, there is no existing design of such combined scheme.
- Most existing contributions consider an error-free channel, i.e., the message is always successfully delivered from base station to each user. The problem of such an assumption is that it is not clear whether performance of implemented schemes will be similar to theoretical ones.
- Coded caching schemes have not been implemented except in [4] where the goal was to show a proof of concept of some existing coded caching schemes and that the overhead does not degrade the performance gain. However, such a proof of concept does not generalize to more practical conditions such as the ones mentioned above. It would be very interesting to have such a scheme implemented to show it can easily integrate new generation of mobile wireless communications.

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

- Propose an adaptive caching technique that takes into account i) the files popularity, and ii) the number of users that varies continuously since users are expected to leave and join.
- Design a coded caching scheme combined with MIMO systems in order to achieve higher gain.
- Improve the design of the existing scheme by considering erroneous channel where errors will have simultaneous impact on several packets at once since the packets are sent combined together. It is important in this case to theoretically analyze the impact of the erroneous channel on the existing scheme, and then to propose design solutions adapted to erroneous channels.
- Implement the proposed algorithms and designs in CorteXlab, a testbed for cutting edge radio experimentation, composed of a mix of radio nodes and located at INSA de Lyon, which will allow properly testing user mobility and realistic channel degradation across wireless endpoints.

Principales activités

The proposed research program and scientific process derives from the objectives, and it is as follows:

- Development of a decentralized solution for coded caching schemes that takes into the variation of file popularity. By decentralized we mean that the user can decide of what to cache. It is possible to benefit here of the fact that in coded caching scheme as in [4], the users can have access to headers of many transmitted packets in the cell to which it belongs.
- Design of a coded caching scheme combined with MIMO system that significantly improves the data rate performance.
- Analysis of the existing coded caching schemes performance in an erroneous channel, and if necessary design a scheme adapted to this channel imperfection.
- Implementation of the proposed coded caching scheme in CorteXlab.

[1] N. Golrezaei, A. F. Molisch, A. G. Dimakis, and G. Caire, 2013 "Femtocaching and device-to-device collaboration: A new architecture for wireless video distribution," IEEE Communications Magazine, 51(4), 142-149.

[2] Shanmugam, K., Golrezaei, N., Dimakis, A.G., Molisch, A.F. and Caire, G., 2013. "Femtocaching: Wireless content delivery through distributed caching helpers". IEEE Transactions on Information Theory, 59(12), pp.8402-8413.

[3] Ji, M., Tulino, A.M., Llorca, J. and Caire, G., 2017. "Order-optimal rate of caching and coded multicasting with random demands". IEEE Transactions on Information Theory, 63(6), pp.3923-3949.

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

[5] Yang, C., Yao Y., Zhiyong, C., and Bin, X., 2016 "Analysis on cache-enabled wireless heterogeneous networks. IEEE Transactions on Wireless Communications, 15(1), 131-145.

[6] Pedarsani, R., Maddah-Ali, M.A. and Niesen, U., 2016. "Online coded caching." IEEE/ACM Transactions on Networking (TON), 24(2), pp.836-845.

[7] S. Yang, K. Ngo, and M. Kobayashi, "Content Delivery with Coded Caching and Massive MIMO in 5G," Proc. IEEE ISTC, Brest, France, 2016, pp. 370–74.

[8] Sadeghi, A., Sheikholeslami, F. and Giannakis, G.B., 2018, June. Optimal Dynamic Proactive Caching Via Reinforcement Learning. In 2018 IEEE 19th International Workshop on Signal Processing Advances in Wireless Communications (SPAWC)(pp. 1-5). IEEE.

Compétences

The candidate should have an excellent background in digital communication (digital modulation, multiple access technologies, MIMO transmission techniques), strong background in mathematics (linear algebra, probability, and statistics), and good programming skills.

The candidate should be fluent in English. French is optional.

Avantages

- Restauration subventionnée
- Transports publics remboursés partiellement
- Congés: 7 semaines de congés annuels + 10 jours de RTT (base temps plein) + possibilité d'autorisations d'absence exceptionnelle (ex : enfants malades, déménagement)
- Possibilité de télétravail (après 6 mois d'ancienneté) et aménagement du temps de travail
- Équipements professionnels à disposition (visioconférence, prêts de matériels informatiques, etc.)
- Prestations sociales, culturelles et sportives (Association de gestion des œuvres sociales d'Inria)
- Accès à la formation professionnelle
- Sécurité sociale

Rémunération

Salaire brut mensuel : 1982€ la 1ère et 2ème année puis 2085€ la 3è année

Informations générales

- **Thème/Domaine** : Réseaux et télécommunications
Système & réseaux (BAP E)
- **Ville** : Villeurbanne
- **Centre Inria** : [Centre Inria de l'Université Grenoble Alpes](#)
- **Date de prise de fonction souhaitée** : 2019-10-01
- **Durée de contrat** : 3 ans
- **Date limite pour postuler** : 2019-07-12

Contacts

- **Équipe Inria** : [MARACAS](#)
- **Directeur de thèse** :
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A propos d'Inria

Inria est l'institut national de recherche dédié aux sciences et technologies du numérique. Il emploie 2600 personnes. Ses 215 équipes-projets agiles, en général communes avec des partenaires académiques, impliquent plus de 3900 scientifiques pour relever les défis du numérique, souvent à l'interface d'autres disciplines. L'institut fait appel à de nombreux talents dans plus d'une quarantaine de métiers différents. 900 personnels d'appui à la recherche et à l'innovation contribuent à faire émerger et grandir des projets scientifiques ou entrepreneuriaux qui impactent le monde. Inria travaille avec de nombreuses entreprises et a accompagné la création de plus de 200 start-up. L'institut s'efforce ainsi de répondre aux enjeux de la transformation numérique de la science, de la société et de l'économie.

L'essentiel pour réussir

The candidat should present a strong interest for applied science. He should be curious and very adaptative.

He is interested by theoretical research as well as experimental assessment, to address a problem from its modeling up to its validation.

He is positive thinking and enthusiast for new ideas. He likes to share his work and to collaborate with others, irrespective of their culture, gender or origine.

In this project the candidate will interact with many people from Inria, Insa and partners.

This PhD is an ideal step for a future carreer in either the academic or industrial world, at an international level.

Attention: Les candidatures doivent être déposées en ligne sur le site Inria. Le traitement des candidatures adressées par d'autres canaux n'est pas garanti.

Consignes pour postuler

Sécurité défense :

Ce poste est susceptible d'être affecté dans une zone à régime restrictif (ZRR), telle que définie dans le décret n°2011-1425 relatif à la protection du potentiel scientifique et technique de la nation (PPST). L'autorisation d'accès à une zone est délivrée par le chef d'établissement, après avis ministériel favorable, tel que défini dans l'arrêté du 03 juillet 2012, relatif à la PPST. Un avis ministériel défavorable pour un poste affecté dans une ZRR aurait pour conséquence l'annulation du recrutement.

Politique de recrutement :

Dans le cadre de sa politique diversité, tous les postes Inria sont accessibles aux personnes en situation de handicap.