2018-00888 - From finite blocklength information theory to multi-user M2M communication protocols

Type de contrat : CDD de la fonction publique
Niveau de diplôme exigé : Bac + 5 ou équivalent
Autre diplôme apprécié : Master in applied mathematics, signal processing or computer science
Fonction : Doctorant
Niveau d'expérience souhaité : Jeune diplômé

A propos du centre ou de la direction fonctionnelle

Grenoble Rhône-Alpes Research Center groups together a few less than 800 people in 35 research teams and 9 research support departments.

Staff is localized on 5 campuses in Grenoble and Lyon, in close collaboration with labs, research and higher education institutions in Grenoble and Lyon, but also with the economic players in these areas.

Present in the fields of software, high-performance computing, Internet of things, image and data, but also simulation in oceanography and biology, it participates at the best level of international scientific achievements and collaborations in both Europe and the rest of the world.

Contexte et atouts du poste

Within the framework of a partnership (you can choose between

- collaboration between Inria teams SOCRATE (Lyon), AGORA (Lyon), INFINE (Saclay) and EVA (Paris)
- with Nokia Bell Labs through the joint laboratory between Inria and Nokia Bell Labs.

a package/model/prototype/application/interface/infrastructure/other specify ***** more specifically dedicated to *****.

- access to the national FIT/CortexLab experimental testbed (http://www.cortexlab.fr).

Mission confiée

Assignments :
Under the supervision of Prof. Jean-Marie Gorce (INSA Lyon / Inria) and Dr Philippe Jacquet (Nokia / Bell Labs), the recruited candidate will develop a cutting edge research to model, analyze and design new low-layer collaborative protocols for M2M communications.

For a better knowledge of the proposed research subject :
Despite its 60 years of existence, information theory is still a very exciting research domain. The new era of machine to machine (M2M) communications brings to us a new paradigm characterized by three main features:

- information to be exchanged is made of numerous, rare, very small information quantities spread over the network.
- usual signaling techniques (headers, pilots, ... ) play a critical role and may represent the main part of the data flows circulating in the network.
- Ultra Reliable and Low Latency Communications (URLLC) required for haptic services, impose extremely reactive protocols, which require new PHY/MAC designs.

The objective of this PhD is to propose a comprehensive theoretical framework and to develop new collaborative coding techniques adapted to this new paradigm.

Collaboration :
The recruited person will work under the supervision of Prof. Jean-Marie Gorce in the team Socrates of Inria, located at CITI laboratory at INSA Lyon, in strong connection with the Nokia Bell Labs research centre, and in collaboration three other teams of Inria: AGORA, INFINE and EVA.

Principales activités

In the context of the coming fifth generation of wireless networks (5G), and the exponential development of Internet of Things (IoT), the development of new protocols devoted to ultra reliable and low latency communications (URLLC) is mandatory, which change deeply the paradigm of wireless networks. Indeed, current wireless communication protocols have been essentially optimized for high rates data flows under steady-state regime or full buffer conditions. But future IoT networks will be rather transient with bursty communications.

Therefore, our objective is to design on-the-fly protocols allowing any radio node to transmit almost instantaneously a short packet of information in the network, to one or several destinations, avoiding complex synchronization, scheduling and coordination. This kind of communication is a key issue for future 5G (and beyond) communications in order to control vehicles, drones, robots and any other non-human things in real time.

The optimization of URLLC IoT protocols thus requires to reshape almost completely the communication protocol stack to balance latency and reliability with side constraints such as energy efficiency or computational complexity.

The key elements for these communications are to reduce drastically the needs for synchronization,
signalling and detection issues. The packet should be encoded such that all these steps can be performed jointly to avoid costly and long headers to be transmitted.

The proposed approach will rely on estimation theory and hypothesis testing techniques to design new optimal techniques to transmit very short packets (typically less than 100 bits) in a multi-user scenario. The key issue for such problem is to increase diversity at the receiver: multi-antennas reception, opportunistic relaying, joint transmission, multi-user detections are fundamental techniques that have to be reshaped in the context of small packets.

We will take care about the multi-objective framework: increasing reliability should not be done at a high price in terms of complexity or energy efficiency.

The candidate will leverage on recent results in information theory and on hypothesis testing to establish new performance bounds and to derive some fundamental trade-offs (e.g. energy-reliability, latency-reliability, energy-capacity,...), leading to the characterization of optimal multi-user transmission schemes in the Bayesian sense.

This framework will help to design new distributed coding techniques including opportunistic cooperation and relaying. The performance of the proposed algorithms will be confronted to the theory, validated by simulation and experimentally assessed on the platform FIT/CorteXlab.

Some references relative to this topic:

**Compétences**

Technical skills and level required:
- theoretical background: probability and statistics, algebra, functional analysis, optimization theory, signal processing.
- specialization in one of these fields: estimation theory, measure theory, information theory, coding.
- programming: familiar with Matlab, Python or C/C++ languages.
- experience in GNU radio programming is not mandatory but would be appreciated.

Languages:
- English: read/write/speak fluently.
- French is optional.

Relational skills:
- Strong autonomy, innovation, ideas.
- Like to collaborate, to confront ideas.
- Open mind.

**Avantages sociaux**
- Subsidised catering service
- Partially-reimbursed public transport
- Social security
- Paid leave
- Flexible working hours
- Sports facilities

**Rémunération**

Gross income: 1982€ the 1st and 2nd year; 2085€ the 3rd year.