TITRE DE LA THESE :
Deterministic Networking over 5G and Beyond: An End-to-End Connectivity Perspective for Cyber-Physical Systems

Direction de thèse :
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S'agit-il d'une thèse en cotutelle internationale ? Oui
Si oui, organisme avec lequel la cotutelle est envisagée :

Mid Sweden University, Sundsvall, Sweden

Le sujet proposé présente-il un caractère interdisciplinaire ? Non
Si oui, expliquer brièvement pourquoi (2 ou 3 lignes) :

La source du co-financement est-elle identifiée ? Oui
Si oui, préciser quel co-financement est envisagé :

Mid Sweden University will cover the other half of the PhD budget.
Mid Sweden University couvrira l'autre moitié du budget de la thèse.

Autres informations :
Informations utiles que vous souhaiteriez communiquer (si pertinent) :

We have already identified the potential candidate: Juan Cruz Piñero from the University of Buenos Aires, who just completed his six-month internship at IMT Atlantique, campus of Rennes, in the OCIF team, under the supervision of Georgios PAPADOPOULOS. During his internship, he worked on "Modeling and Performance Evaluation of Deterministic Wireless Networks."

Contexte ou état de l'art scientifique :
Décrire en 5 à 10 lignes le contexte de la thèse.

Deterministic end-to-end communications are essential for the real-time interactive monitoring and control of Cyber-Physical Systems (CPS) for industrial automation, transportation, and consumer applications (e.g., gaming). Only a multi-technology infrastructure (e.g., 3GPP 5G, IEEE Time- Sensitive Networking (TSN), IETF DetNet and L4S, cloud/edge computing) can offer end-to-end communications. Even if each technology defines its own solution for deterministic communications, combining them to offer end-to-end guarantees is far from trivial. Many challenges must be solved (from physical to networking/routing layer) for predictable reliability and latency performance guarantees. For instance, how to reliably predict the performance of each individual (wired or wireless) segment and how to combine individual models to obtain end-to-end predictions under uncertainties along the communication path.

Objectifs de la thèse :
Décrire en 10 à 15 lignes les résultats attendus.

Ensuring deterministic end-to-end connectivity over 5G networks requires elemental holistic approaches as each connectivity segment presents its own unique challenges and design space. Therefore, this thesis will focus on designing a solution with the ground-up approach to solving challenges within the 5G Radio Access Network (RAN), the 5G Core Network (CN), and the end-toend deterministic networking solutions, with the following research questions:

1. Statistical and data-driven techniques for link adaptation, grant-free medium access control, and scheduling with reliable-latency guarantees.
2. Packet techniques for macro-diversity enabled reliable-latency medium access under mobility scenarios.
3. Deterministic networking through packet re-ordering function, congestion control, network slicing, etc., in the core-cloud stratum.
4. A unified (involving radio access and core networking solutions developed in 1-3) lowlatency, low-loss connectivity framework for end-to-end deterministic networking aided by cloud/edge computing and intelligence.

Compétences attendues du ou de la candidat·e :
Lister les principales compétences nécessaires pour ce sujet de thèse.

- Statistical tools and methodologies (network calculus, extreme value theory, queuing theory) for identifying and characterizing end-to-end multi-layer potential delays and errors arising from stochastic wireless channel and protocol behaviors.
- Knowledge and/or experience in wireless system modeling, algorithm design, and simulation tools, especially for 3GPP-defined mobile systems, for instance, 5G, LTE, as well as IEEE/IETF specifications on deterministic or time-sensitive networks.
- Strong programming skills in the following programming languages Python, Matlab, C (i.e., write/modify simulators and/or implementation of proposed solutions).