The Networks and IoT Systems research group of CNAM-CEDRIC hires in 2023/2024 from 4 to 7 Ph.D. candidates, postdocs, research engineers in the topics below (detailed description: next pages).

Topics

1. Non-Terrestrial Networks: Routing and Traffic Management
2. Deterministic Combined Wireless and Wired Access Network Technologies
3. Integration of Functions and Algorithms in Programmable Network Cards
4. Collaborative Attack Modeling in Autonomous Vehicles
5. Intent based service fulfillment and assurance in zero touch network management (CIFRE)

Research environment

Team: Networks and IoT Systems (ROC – Réseaux et Objets Connectés; https://roc.cnam.fr)
Computer Science and Communications department (CEDRIC; https://cedric.cnam.fr)

Related research frameworks:

ANR COCO5G: project on 5G network data analytics with Thales, Orange, Inria, IMDEA.
IPCEI ME/CT OpenRAN: project on automation and acceleration for OpenRAN, with Orange.
6G-IA/SNS: European framework for 6G design, WGs on beyond-5G and software networks.
HE AI4CI: European project on Artificial Intelligence for Connected Industries, with UPC, UC3M, ...

Location:

Paris, France - downtown district (le Marais), 3e arrondissement. 2 rue Conté, Paris, France.

Period

The contracts can start from September 2023 to May 2024.
Contract duration: Ph.D. 3 years; Postdoc from 2 to 4 years; Research engineer from 1 to 4 years.

Salary

PhD: about 29 500 € gross/year (about 2 100 € net/month).
Postdoc: 35 000 – 42 000 € gross/year (about 2 500 – 3 000 € net/month) depending on experience.
Engineer: 25 000 – 34 000 € gross/year (about 1600 – 2400 € net/month) depending on experience.

Optional:
- 50% of the public transportation subscription.
- teaching activities in French and/or English for up to 64 h/year, 2 650 € /year, 200 € net/month.

Requirements

Master/PhD degree in computer science, computer engineering, electrical engineering, telecommunications engineering.
Candidates with only a bachelor's degree may be considered for engineer positions at the condition they enroll for a Master or Engineering degree at Cnam (evening classes or apprenticeship).

Application

As soon as possible. Send to perm-roc@cnam.fr your preferred subject(s) and:

- An up-to-date curriculum vitae on maximum 3 pages, including names and contact information of 2 reference persons (professors or industrial tutors).
- University/engineering degree transcripts for the last 3 years.
- All your master/bachelor thesis and/or internship/project report(s).

1 – Non-Terrestrial Networks: Routing and Traffic Management

6G will extend commercial networks to non-terrestrial mobile environment, that is, troposphere networks composed of High-Altitude Plat Form Stations (HAPS), planes, and drones, and low-orbit satellite networks, with evolution of technologies from 5G systems as network slicing and softwarization for such highly mobile and intermittent communication environments.
On the one hand, many low-earth-orbit (LEO) satellites are already operational, with almost 2000 LEO nodes in early 2022, and a new European constellation (IRISS) is being designed for the forthcoming decade. On the other hand, planes, HAPS and drones will form a new mesh to extend terrestrial verticals beyond simple Internet access to non-terrestrial users.

While the geostationary earth orbit satellites latency makes them not attractive for interactive Internet usages, the communication latencies LEO satellites can grant are much shorter making them competitive with respect to terrestrial long-range communications. Nonetheless, switching and network/service functions integration within the satellite payload is strongly constrained by the heating capacity, challenged by the lack of atmosphere. Similar yet less severe limitations do exist in the troposphere as well, where HAPS, plane, drones, also have constrained computing capacity, because of space and power limitations. Nonetheless, these limitations can be compensated by smart node interconnection, adaptive transmission, programmable switching boards and mesh networking. In addition, the combination of wireless-optical interfaces with radio interfaces for NTN network overlays is currently considered for 6G systems.

NTN networking faces therefore new challenges, such as:

- Routing across multiple NTN D2D/mesh, ground-orbit and inter-satellite links.
- Packet/flow multipath scheduling combining multiple paths across NTN nodes and links, and mixing optical and radio interfaces.
- Traffic engineering and dynamic function chaining, as a function of changing propagation physical-layer (wireless optical and radio) conditions.

The research activity in this project can cover (but is not limited to):
(i) extension of the existing satellite network simulator 3 (NSN3) to include NTN links and nodes beyond satellite nodes, and integrate it with an existing physical 5G testbed;
(ii) comparative analysis in terms of achievable latency and bitrates between NTN and terrestrial communications, by Internet routing trace analysis;
(iii) topology design including different NTN features (inter-satellite links, optical interfaces, redundant communications);
(iv) multipath redundant scheduling at TCP, QUIC and IP layers;
(v) design and evaluation of dynamic NTN function chaining and routing architectures.

References

[1] D. Bhattacherjee et al. Gearing up for the 21st century space race. In ACM HotNets, 2018.
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2 – Deterministic Combined Wireless and Wired Access Network Technologies

5G systems are being deployed nowadays mostly in their non-standalone mode that largely leverages on legacy 4G core technologies. Esteemed to still represent only around 1% of the traffic [1], the commercialized services are for conventional mobile broadband services. Expected to reach a 25% traffic portion by 2025 [2], 5G systems will be offering novel and unique services for the IoT and low-latency high-reliability environments.

In particular, URLLC (Ultra-Reliable Low Latency Communication Services) network slices are being designed to be able to deliver near-real-time traffic processing for advanced low-latency services such as augmented reality or smart industries, and that at unexpected availability and reliability guarantees [3]. In the commercial consumer systems, addressing deployment in dense and loosely predictable communication environments, such low-latency high-reliability performance can today be granted only by wireline technologies. Many examples exist, from smart transportation systems with pervasive network control systems [4], to in-flight airplane communications [5] and smart-grid and smart-industry environments.

In this research activity, we aim at:

(i) Integrating network slicing in Cnam 5G platform and demonstrate coexistence between URLLC and mobile-broadband slices.

(ii) Comparing the 5G URLLC access infrastructure to a wireline infrastructure based on deterministic networking technologies such as the DETNET (Deterministic Networking) architecture [6], possibly coupled to TSN (Time Sensitive Networking) IEEE 802.1 systems [7]. The comparison will be made against slice coexistence management.

(iii) Study the possibility to combine 5G access with wireline/V2I technologies in order to further increase access latency and reliability. The usage of recent 5G-WiFi integrated technologies, such as based on multipath TCP, QUIC and VPN aggregators will be considered.

(iv) Investigate cybersecurity threats to the three communication modes (URLLC, wireline/V2I, combined).

Methodologically, the goal is to evaluate the different technology alternatives, also using a private 5G experimental infrastructure operated by the research group at Cnam, making use of customized open-source stacks and software-defined radio systems. The ambition is to enhance the current technologies, defining new access architecture and related scheduling sub-systems in disaggregated softwarized access network platforms.

References

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[3] M.A. Siddiqi et al. 5G Ultra-Reliable Low-Latency Communication Implementation Challenges and Operational Issues with IoT Devices. Electronics 2019, 8, 981.

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3 – Integration of Functions and Algorithms in Programmable Network Cards

Two recent movements in networking research are shaping the design of forthcoming 6G architectures. From the one hand, Open Radio Access Networks (OpenRAN) are breaking the barriers of network programmability, calling for opening also radio-unit and distributed-unit equipment in terms of hardware acceleration management and processing latency control. From the other hand, energy consumption is becoming of paramount importance, so much that standard virtualization systems are being considered not sustainable any longer when micro-services / function-as-a-service (FaaS) approaches are adopted to disaggregate network and service functions.

Indeed, network functions are so being not only decomposed in micro-services, but are also redesigned toward being serverless by design, i.e. the employed micro-services can possibly be dynamically duplicated across the network. Each function so becomes a web of input/output black-box computing nodes, each possibly duplicated across a geographical network. In order for these nodes to meet stringent processing latency constraints while being energy efficient, the offloading of micro-serviced functions to programmable hardware, such as Net-FPGA (Field-Programmable Gate Array) network boards, is being considered in this research activity. FPGA system do have limited computing resources as well, so their programmatic usage for communication system is challenging. Net-FPGA systems are now exiting the pure academic environment they were originally conceived for, to become integral part of the forthcoming 6G ecosystem, possibly replacing legacy switching and routing software and hardware devices for mobile acces and backhauling networks.

The activity is expected to pass through the following steps:

- Use-case design related to network/service function disaggregation using hardware acceleration: RAN function (e.g. LDPC), decentralized network applications (e.g. chat, call systems), embedded queuing and forwarding systems (e.g. corundum, P4-NetFPGA).
- Tackle the FPGA floor planning problem, including its runtime resolution to master the reconfiguration downtime due to local reoptimization as a function of use-cases operations.
- Perform a detailed sustainability assessment of network operations with/without the usage of Net-FPGA devices along the value chain from radio-units to edge application servers, passing through distributed and centralized units.
- Define how radio, computing and link scheduling can be influenced by the online availability of corresponding circuitry and registries at the hardware accelerator level.

The work will be done within a research group of 5 researchers working on hardware acceleration for OpenRAN and beyond-5G systems, and will include the integration of latest NetFPGA boards.

References

[1] Forencich, Alex, et al. "Corundum: An open-source 100-gbps nic." 2020 IEEE 28th Annual International Symposium on Field-Programmable Custom Computing Machines (FCCM). IEEE, 2020.
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[4] Murad Qasaimeh, et al., Comparing Energy Efficiency of CPU, GPU and FPGA Implementations for Vision Kernels, Qasaimeh, Murad, et al. "Comparing energy efficiency of CPU, GPU and FPGA implementations for vision kernels." 2019 IEEE international conference on embedded software and systems (ICESS).

4 – Collaborative Attack Modeling in Autonomous Vehicles

Connected and Automated Mobility (CAM) is considered as a flagship use case for beyond-5G vertical applications. This use-case includes creating complete ecosystems around vehicles, from road-safety or digital rail operations to high-value commercial services for road users and train passengers, e.g. mobile office or infotainment.

Among CAM systems, autonomous vehicles (AV) are viewed as new leveraged transportation means to reduce accidents and to provide a cautious environment for drivers and pedestrians. To build safe and secure systems, AVs can be designed as data-driven vehicles due to their whole amount of data sensors, and are associated with digital twins that will help them to make accurate and real-time decisions.

Our aim, in this research activity, is to investigate security issues specific to CAM environment and their impact on AVs.

The activity is expected to pass through the following steps:

- Design a holistic architecture for security management for autonomous vehicles communications.
- Select appropriate algorithms at the state of the art for attack detection in this context and identify improvement margins.
- Based on graph theory and machine learning, build a solution to identify attack paths and the impacts of these attacks on other components of the AVs to take the accurate decision on time to stop the propagation of such attacks.
- Evaluate the solutions using different criteria.

Candidates should possess good skills in cybersecurity and ML.

References

[1] A. Chowdhury, G. Karmakar, J. Kamruzzaman, A. Jolfaei and R. Das, "Attacks on Self-Driving Cars and Their Countermeasures: A Survey," in IEEE Access, vol. 8, pp. 207308-207342, 2020.
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5 – Intent based service fulfillment and assurance in zero touch network management

Note: this is an industrial Ph.D. in collaboration with Orange (the employer). The first year the salary is equivalent to an academic Ph.D., the third year it increases based on performance.

The goal of the thesis is to design a novel network automation architecture based on the "intent" abstraction for the management of adaptive and automated reorchestration of a network-compute end-to-end stack for 5G slicing and beyond.

Detailed description: https://orange.jobs/jobs/v3/offers/124639?lang=fr

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