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for a greener tomorrow

Ph.D. Research proposal

Access-and-aggregation-network-optimal hardware architectures for optical signal processing

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Job offer reference	GFR_PhD_2020_TelecomParis
Kind of position:	3 years CDD from 01/09/2020 under the French **CIFRE** framework
Research topic:	Fibre optic communications

In recent years, telecommunication operators have been massively rolling out Fiber-to-the-home and similar technologies (FTTx) to support the widespread use of high-speed Internet all the way to end-users [1].

In parallel, the aggregation network segments that allows to efficiently collect and distribute different kinds of traffic and service as mobile backhaul, buisness applications, mutlicast video, etc., is facing increasing stress since the requirements of the existing services are becoming more stringent and since new services as mobile fronthaul or Internet of Things (IoT) are introduced [2,3].

Now, future enhancements of the access and aggregation (A&A) network segments lie in even higher performance in terms of capacity, flexibility and efficiency which requires smarter uses of the installed optical infrastructure. Historically, performance was increased by gradually phasing in high-end components and devices developed for core and metropolitan networks, as their costs were brought down by mass production. Thus, the logical evolution of optical transmission technologies in A&A would be the adoption of the coherent detection, which allows digital signal processing techniques that let core-network systems break the 100-Gbit/s per channel barrier over the past decade[4].

However, the challenges of A&A are not the same as other network segments: operating temperature range is significantly wider; typical distances are shorter but attenuations higher especially in passive-splitting (PON) architectures; new systems must coexist with legacy ones; fine granularity multiplexing is required; and end-user generic best-effort Internet access must share infrastructure with mission-critical industrial connectivity[5,6].

Therefore, a more efficient and less costly optimum may be reachable by designing A&A-specific hardware systems and architectures. They would aim for a performance vs complexity balance that would cover cases such as the near-far effect and high splitting ratios, encountered in A&A but virtually nonexistent in core networks; while neglecting long-range effects such as polarization-mode dispersion, or handling them through system margins or other parameters.

[1] R. Montagne. “FTTH Forecast for Europe”. In: *FTTH Council Europe Conference*. Mar. 2019

[2] J. Segarra, V. Sales, and J. Prat. “Versatile Metro-Access Network Integrating FTTH, Enterprises, IoT and 5G Services”. In: *2019 21st International Conference on Transparent Optical Networks (ICTON)*. 2019, pp. 1–6

[3] J. Terada. “Optical Network Technologies for 5G Mobile Network”. In: *2019 Optical Fiber Communications Conference and Exhibition (OFC)*. 2019, pp. 1–3

[4] G. Wellbrock and T. J. Xia. “The road to 100G deployment [commentary]”. In: 48.3 (2010), S14–S18

[5] Effenberger. “ITU-T Q2 Optical Access Networks”. In: Optical Fiber Communication Conference. IEEE, 2020

[6] *Higher Speed Passive Optical Networks: Requirements*. ITU-T. Nov. 2019

Challenges are twofold: identifying the use cases and relevant constraints actually encountered in A&A; and figuring out the smartest ways to handle them, working on the set of parameters for signal processing, identifying irreductible versus flexible hardware architectures at both analogue and digital levels, selecting existing ones or designing new or advanced ones. This approach will require an acute awareness of the global functionality of the network, across multiple layers of the conventional network paradigm, to design architectures that allow handling complications at the location where the hardware is best suited to them, rather than the obvious brute-force complexification of transmission devices.

1 Research work and roadmap

The work will begin with a bibliographical study of the state of the art in: coherent optical fiber communications, including both transceiver analogue optical front-ends and basic digital signal processing; and architectures and associated photonics devices use cases relevant to A&A networks. The goal of this study is to synthesize a table of channel types, optical signal degrees of freedom, and current associated hardware architectures at both analogue and digital level, by use case.

Then, the most relevant use cases will be selected for further study. Each use case will be studied in simulation using appropriate tools (Matlab, VPI...). In parallel, after an initial familiarization phase, our coherent-transmission platform will be leveraged for experimental validations. Adaptations will be proposed to adapt the platform to selected use cases.

After a sufficiently broad view of the field is acquired, the final phase of the study is the optimal repartition between hardware and network functionalities. Special attention will be focused on the APIs and interfaces required to manage the selected use cases at the network level, and enable optical infrastructure sharing over multiple use cases through network slicing.

The total duration of the Ph. D. is 3 years.

2 Environment

The Ph. D. is to be supervised, on the industry side, by Dr. Gwillerm Froc, Mitsubishi Electric; and on the academic side by Dr. Cédric Ware and Prof. Yves Jaouën, LTCI, Télécom Paris, Institut Polytechnique de Paris. It will be located mainly in Télécom Paris in Palaiseau, France (80 %) and partly in Mitsubishi Electric Research Center (MERCE) in Rennes, France (20 %).

Mitsubishi Electric Corporation is a recognized world leader in the manufacture of consumer electronics, innovative systems and sub-systems for industrial technology, energy, transportation and communication equipment, information processing, space and satellite communication, optical communication for submarine, core, metropolitan networks as well as access networks.

Gwillerm Froc Gwillerm FROC received the Ph. D. degree in Physics from Paris XI University in 1997. He has been researcher at MERCE since 2001. Its main research interests are transport phenomenon, optical and radio components and systems as well as modelling. He is author or co-author of 53 papers or patents.

Télécom Paris is the leading French school in Information and Communication Technology (ICT) and one of France's top 5 graduate engineering schools; **LTCI** is its main research operation in ICT. Among our wide coverage of the ICT field, our Optical Communications Group (GTO) currently numbers 6 faculty and about 20 Ph. D. students, postdocs, research engineer and professor emeritus. Its research topics range from quantum confined photonic devices to ultra-high-bit-rate transmissions on optical fibers, optical information processing, and optical networks. The GTO group has been and is taking part in academic and industrial collaborations all around the globe, from strong partnerships with Nokia Bell Labs and Orange Labs to exchange programs with prestigious universities such as Columbia (New York), UCLA (Los Angeles) and Jiao Tong (Shanghai).

Cédric Ware, Associate Professor, was educated in École Normale Supérieure (Paris), then Télécom Paris, which he joined as faculty in 1998. He holds Ph. D. and Habilitation (HDR) degrees. His research activities have followed the thread of all-optical and opto-electronic functionalities, such as clock recovery, optical CDMA, optical packet switching. He is now transitioning towards optical networking, towards a goal of cross-layer optimization of both performance and energy consumption. Author or co-author of over 90 publications and communications, he has driven and taken part in several French and international projects and collaborations. He lectures on topics ranging from Quantum Mechanics to Optical Networking, and coordinates the M. Sc. on Optical Networking and Photonic Systems.

Yves Jaouën received the Ph. D. degree in Physics from Télécom Paris (then called ENST) in 1993, then his HDR (Research management certificate) in 2003. He had joined ENST in the Communications and Electronics department in 1982 where he is currently a Full Professor and head of the GTO research group. He is lecturing in the domain of electromagnetic fields, optics and optical communications systems. His present researches include high bit rate coherent optical communication systems including digital signal processing aspects, new characterization techniques for advanced photonic devices, high power fiber lasers, fiber optics and remote sensing. He is author or co-author of over 230 papers in journals and communications.

3 Candidate profile

Candidates should hold or be enrolled in a Master of Science or equivalent degree, and have strong knowledge of:

- Physics of optical devices
- Architecture of optical transmissions
- Digital signal processing for communication systems
- Technical English (written and spoken)

Experience in other connected fields are a plus, e.g.:

- Skills in setting up experiments
- Numerical programming (in Matlab or other languages)
- Network virtualization techniques
- Critical thinking, presentation and Communication skills

Interest in French language and culture would help in day-to-day work and life in Paris and Rennes.

Send your CV, cover letter, Master-level academic transcripts and optionally references or other relevant documents in PDF format to:

- Magali Branchereau <jobs@fr.merce.mee.com>