Postdoctoral offer

Actuation of steerable antennas for tracking with optical sensors

Research unit: Laboratoire d'Ingénierie des Systèmes de Versailles (LISV) / Université Paris-Saclay (UVSQ).
Starting date: ASAP.
Localization: Vélizy-Villacoublay, Paris Area (78140 France).
University: Université of Paris-Saclay.
How to apply: Please send your resumes to the contacts listed below.
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1. Context of the project proposal

This postdoctoral position is proposed by the Laboratoire d'Ingénierie des Systèmes de Versailles (LISV), Université Paris-Saclay (UVSQ). The LISV is interested in theoretical and experimental research activities about multidisciplinary purposes (from robotics to mobility), including wireless optical communications. Concerning this specific topic, the laboratory has developed cutting-edge expertise for nearly 15 years. It has been particularly applied in vehicular communication [Béchadergue17] or for indoor network access (a use case also known as LiFi, [Merah19]).

The company **OLEDCOMM**, renowned as a world leader in LiFi, has emerged from the LISV and is still closely linked to it. From a scientific point of view, the LISV recently carried out work on high-speed LiFi links (around 300 Mb/s) with a standard white lighting source [Merah19]. This work has demonstrated the transmission capabilities of a LiFi cell (with an area of about 4m²) towards a maximum of 20 users. However, LISV would be now interested in the optimization of these systems by exploring a new LiFi network topology. To achieve such objectives, this project is granted by the National Research Agency through the **"Steerable Light Antenna for Enhanced QoS Cell-Free LiFi Networks" (SAFELiFi) project**.

2. SAFELiFi project: context and scientific issues

Most academic LiFi products and demonstrators operate standalone and are not interoperable with Radio Frequency (RF) technologies such as WiFi, 4G/5G, etc. More importantly, they are often based on the concept of cells, generated by multiple access points (APs) installed at regular intervals on the ceiling to ensure full room coverage and, as a consequence, continuous connectivity for the user. Such a topology, shown on the left side of Figure 1, requires conventional interference management and handover mechanisms so that all user equipment (UE) are permanently connected to the network.

Although this topology allows for an operational network, it has several limitations. First, it is better to have large enough cells to avoid excessive horizontal handovers, which would reduce the time dedicated to the transmission of traffic and increase signaling transmissions. Next, it is also difficult to provide coverage greater than a few square meters with a conventional light source. The signal-to-noise ratio (SNR), and therefore the QoS, is rapidly degraded when the receiver moves away from the transmission axis. This leads to a low signal transmission at the edge of the cell. Finally, while switching between two cells, there is a short connection loss that contributes to further QoS degradation.

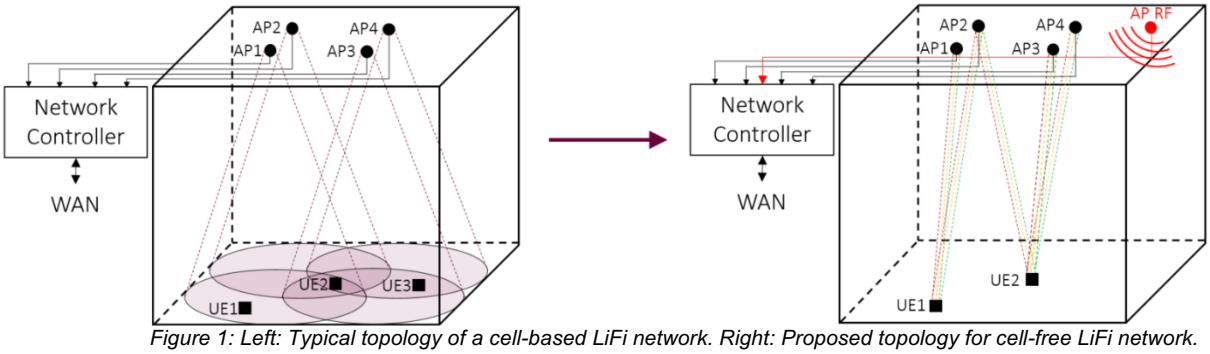

Figure 1: Left: Typical topology of a cell-based LiFi network. Right: Proposed topology for cell-free LiFi network.

3. SAFELiFi project: objectives and possible solutions

To overcome these limitations and ensure optimal quality of service at all times, we propose to develop the **cell-free topology** shown on the right side of Figure 1. According to this topology, each AP would consist of an **optical antenna/steerable receiver** to track one or more users simultaneously (e.g. access point 2) and providing them with a narrow, focused light beam. Such a light beam would thus guarantee a high SNR link that would be difficult to listen to for an attacker who would not be in the line of sight. This topology is possibly more secure than usual cell-based topology. A UE could in turn be served by several APs simultaneously (e.g. AP1 and AP2 for UE1), which would make its connection more robust to obstacles.

During this postdoctoral fellowship, two different use cases will be considered:

- For a first use case, we will assume that **the topology of the targets is known**. Therefore, the candidate will focus on the control of an available mechatronic system to optimize the SNR according to a specific target or a set of targets. It may be, for example, to serve a limited area of the space containing several UEs. Depending on the service needs, **the antenna will automatically switch to the designated UE**, maximizing the optical power of the received signal in real-time. The control laws will probably have to include the results of the communication channel modeling (the team is already actively working about this part).
- For a second use case, a **steerable antenna will be used to serve mobile UEs** (typically for users walking in a room). The control laws used previously require modifications to take into account the constraint due to the mobility of the users (it could be based, for example, on predictions of future positions). This problem is particularly difficult because of the disturbances induced by the users' motions. Moreover, the workspace and the dynamic performances of the steerable system are limited as well as the available optical power. Therefore, the results would definitely need to be extend to the use of several steerable antennas. For this purpose, a smart management of the meshed network is essential to optimize performances. The candidate will clearly formulate the limits of the system and propose alternative solutions for a densified network of APs and UEs.

For these two use cases, simulations will have to be carried out. The success criteria will depend on telecom performances metrics (however, we do not expect the candidate to be a specialist in telecom). On the other hand, he/she must be of some help to implement the control laws on the demonstrators available in the laboratory.

4. Scientific and technical skills

We are looking for a candidate with a mechatronic / automatic background. Some knowledge about communication would be appreciated but it is not an obstacle to conduct the project. The simulations have been running with Matlab so far. Experience with this software seems important to us. Any knowledge about development boards with microcontrollers would be appreciated for the practical implementation. Publications

in international journals will be strongly encouraged and should be facilitated by the novelty and the ambitious nature of this project.

Bibliography

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