ELIoT: Enhance lighting for the internet of things

Dr.-Ing. Christoph Kottke

The project ELIoT (Enhance Lighting for the Internet of Things) targets the development of mass-market internet of things (IoT) solutions with next-generation wireless communications networks, light fidelity (LiFi), travelling over light instead of radio waves.

The future IoT will place much higher demand and emphasis on the data rate, reliability and latency of wireless connections. If many IoT devices communicate in a confined space, the demand for radio frequencies will increase much faster than previously expected. With LiFi, the ELIoT consortium explores a networked wireless communication technology operating in the previously unused light spectrum, besides Wi-Fi and cellular radio.

LiFi has many use cases for commercial, industrial or outdoor applications. It could function well in environments where certain radio frequencies are not possible or allowed. For outdoor usage, it could offer high bandwidth point-to-point links from rooftops, between streetlights or to consumers’ homes for our next-generation networks. Higher network demands might come from software-controlled production, virtual and augmented reality and autonomous driving, where LiFi could prove useful.

ELIoT integrated the lighting infrastructure with LiFi, added positioning, multicast communications and enhanced security. ELIoT demonstrated these features and a new infrastructure in real environments (e.g. industry, the office and the outdoors) to address multiple LiFi use cases. Moreover, one project goal was to provide an open reference architecture for the support of IoT in the lighting infrastructure, to build consensus reflecting the best architectural choices, to contribute to the standardisation of lighting and telecom infrastructures in IEEE and ITU-T and to provide a roadmap for IoT until 2022 and beyond.

ELIoT demonstrates that LiFi is an interesting solution for industry, consumer, commercial, office and outdoor application scenarios. In the following, you can find the highlight of these demonstrations.

Industry

The industry scenario targets reliable wireless network connections between end-user devices and an application server. Important objectives are the combination of LiFi with 5G radio technology to reach flexibility, reliability,
Besides the Teams call, seamless handover to 5G took place. In case the line of sight was broken, LiFi was available, and LiFi was used; in densely occupied offices. A typical office was equipped with a LiFi-multiplex-input-multiple-output (MIMO) system, providing two or more optical frontends on both the user and ceiling sides. By deploying MIMO, we could prove that LiFi can be made robust against line-of-sight blockage. Despite the reduced throughput when a line of sight is lost, providing sufficient bandwidth for typical office applications is still possible. Horizontal (cell-to-cell) handover is required to support user mobility in a LiFi-equipped space. ELIoT analysed various technology options and showed the feasibility of smooth horizontal handover using distributed MIMO.

**Office**

With the growing bandwidth requirements of modern applications, such as video conferencing, LiFi can play a significant role by augmenting congested Wi-Fi networks, especially in densely occupied offices. A typical office was equipped with a LiFi-multiplex-input-multiple-output (MIMO) system, providing two or more optical frontends on both the user and ceiling sides. By deploying MIMO, we could prove that LiFi can be made robust against line-of-sight blockage. Despite the reduced throughput when a line of sight is lost, providing sufficient bandwidth for typical office applications is still possible. Horizontal (cell-to-cell) handover is required to support user mobility in a LiFi-equipped space. ELIoT analysed various technology options and showed the feasibility of smooth horizontal handover using distributed MIMO.

**Positioning**

Indoor positioning is a key aspect of many IoT services, and current radio-based techniques, like GPS, are often not accurate enough or not feasible at all. However, a light-based system as developed in ELIoT can solve these issues. LiFi-based positioning is especially interesting in an industrial environment, like for autonomous guided vehicles to transport material. Such a positioning system needs to localise and track a moving object on a shop floor with centimetre accuracy. ELIoT’s localisation approach is directly based on the ITU-T G.9991 standard for optical wireless communication, which means that the same system can be used for communication and positioning. In ELIoT, we have set up a LiFi cell in a factory hall with multiple optical frontends (Tx) and a mobile unit (Rx). We achieved an accuracy inside the LiFi cell of about 3 cm and could track any movement. Additionally, transmission rates beyond 500 Mbit/s have been measured within the same system.

**Consumer**

LiFi technology can be an enabler of connectivity for the consumer market. It is standard for a household to have a Wi-Fi access point, often provided by the internet service provider. However, the coverage and stability of a single Wi-Fi access point is often not good enough for the whole house. LiFi could be an attractive addition to a Wi-Fi-only network solution by adding LiFi hotspots at key locations in the home. Our demonstrator shows two important aspects of such a system. First, a vertical handover between LiFi and Wi-Fi allows mobility without the loss of connectivity inside the house; second, local high data rate LiFi links to ease the load on Wi-Fi, e.g. to connect the TV or the laptop. The implemented handover allowed a nearly seamless video call while moving out of the LiFi cell, and the installed LiFi hot spot could achieve up to 800 Mbit/s.
Fixed wireless access

It is widely accepted that optical fibre is the best choice for high-speed fixed broadband access deployments. However, the installation of optical fibres is very expensive, and the deployment and planning process takes a long time. A possible solution is the so-called fixed wireless access (FWA) with LiFi, where the last couple of metres are realised with an optical link from the street directly into the building window. In ELIoT, we demonstrated such a link and achieved around 1000 Mbit/s of transmission rate over a distance of 20 m. Additional long-term tests of our links have shown high robustness against bad weather conditions such as snow or rain. This is based on a flexible modulation scheme, which is automatically adapted to the link quality. An even higher resilience is possible by combining the LiFi link with a 60 GHz link in parallel.

PROJECT LEAD PROFILE

After studying electrical engineering, Christoph Kottke completed his PhD at the Technische Universität Berlin in 2019. Since 2015, he has been working at Fraunhofer HHI in Berlin, where he is involved in optical wireless communications and optical access network infrastructures.

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