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.

Figure 1: LiFi use cases investigated in ELIoT.

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,

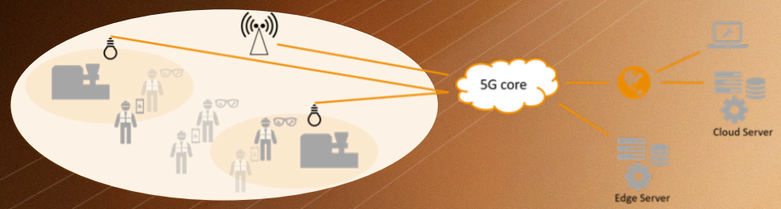

Figure 2: Architecture of the demonstrator with 5G radio access network and two LiFi APs with cabled backhaul: staff equipped with, for example, smart glasses for teaching tasks can move between LiFi cells without the loss of connectivity.

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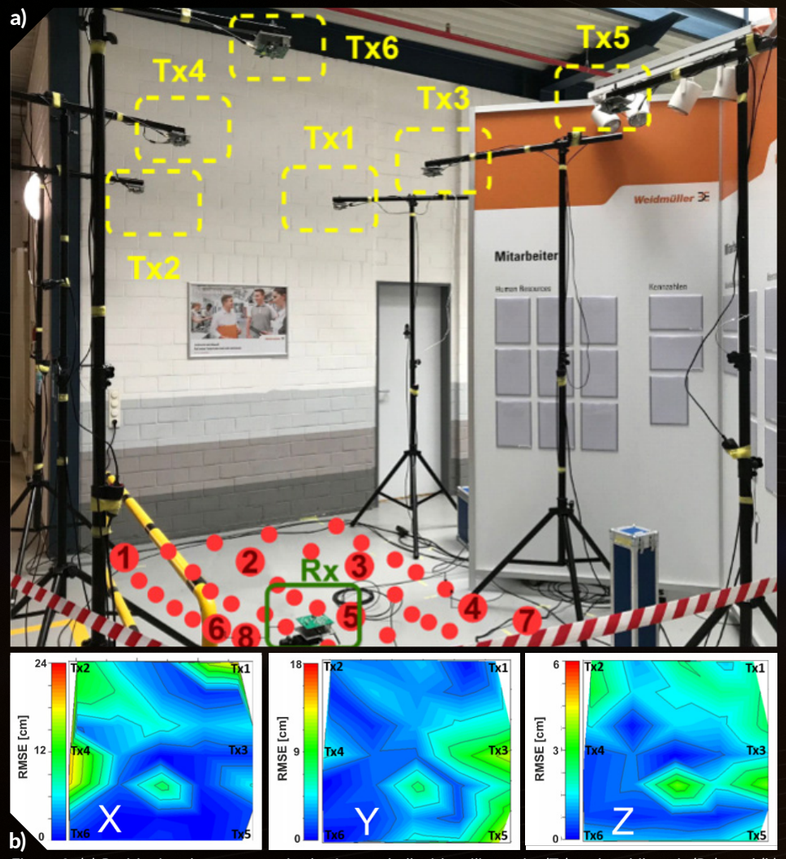


Figure 3: (a) Positioning demonstrator in the factory hall with ceiling units (Tx) and mobile unit (Rx); and (b) Measurement results for positioning error, root mean square error (RMSE), in x,y and z direction.

coverage and high throughput for fixed and mobile devices on the factory shop floor as well as coverage of machines with LiFi. In such a scenario, optical wireless communication is implemented as complementary communication technology to 5G in smart factories. To demonstrate this, ELIoT has set up a LiFi cell, i.e. LiFi access point (AP), and implemented the vertical handover to 5G with the help of a non-3GPP Inter-Working Function. This function manages the networks and handover aspects. A Microsoft HoloLens was connected to the network by LiFi and acted as an end-user device for a Microsoft Teams call. The HoloLens sends and receives video material, e.g. for teaching or maintenance tasks. If LiFi was available, then LiFi was used; in case the line of sight was broken, a seamless handover to 5G took place. Besides the Teams call, transmission measurements of the LiFi link showed data rates up to 550 Mbit/s in a coverage area of 5m².

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 materials. 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.

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-multiple-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.

The current ceiling fronthaul infrastructure for carrying data between the MIMO modem and optical frontends is based on CAT5 copper cables. Although copper cables are acceptable from a bandwidth point of view, the possibility of cost and electromagnetic interference reduction via wave-division-multiplexing over plastic optical fibres (WDM-over-POF) technology has been investigated. An optical device with combined multiplexor (MUX) and de-multiplexor (DeMUX) functionalities has been developed and tested with satisfactory results. Adopting WDM allows sharing a single POF among multiple ceiling optical frontends. Future investigations in this direction can address the manufacturability of the MUX/DeMUX device and the inclusion of more than two colours.

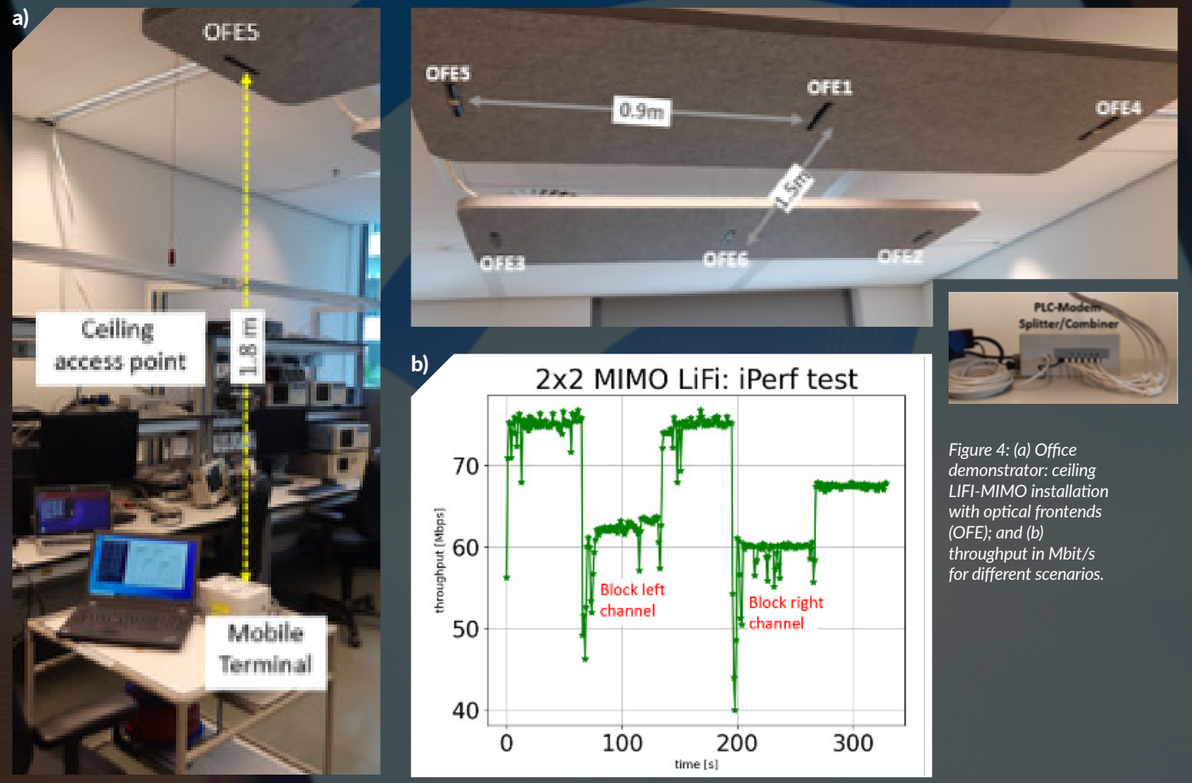


Figure 4: (a) Office demonstrator: ceiling LIFI-MIMO installation with optical frontends (OFE); and (b) throughput in Mbit/s for different scenarios.

Consumer

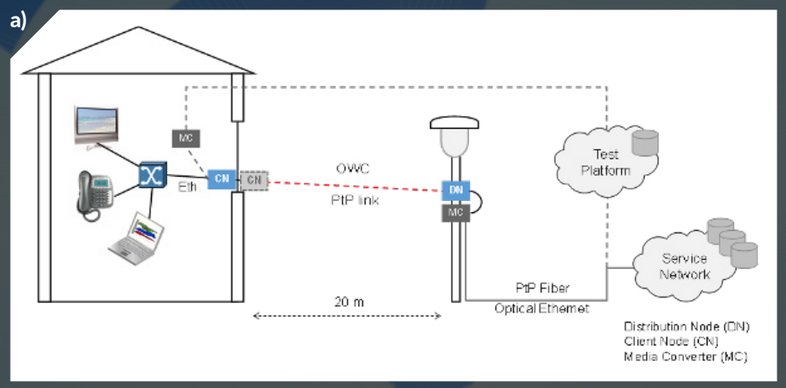
LiFi technology can be an enabler of connectivity for the consumer market. It is standard for a household to have a Wi-Fi access point, often provided by the internet service provider. However, the coverage and stability of a single Wi-Fi access point is often not good enough for the whole house. LiFi could be an attractive addition to a Wi-Fi-only network solution by adding LiFi hot spots 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.

Figure 5: In-home demonstrator with LiFi access points at the TV and over the sitting areas (red circles).

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.

a)



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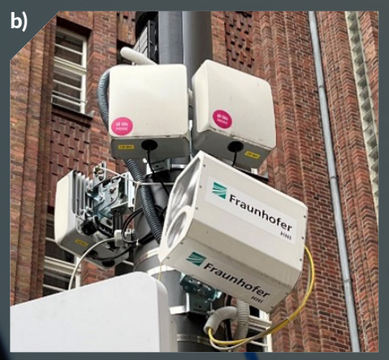

Figure 6: (a) Fixed wireless access demonstrator; and (b) LiFi frontend mounted at a streetlight.

PROJECT NAME

Enhance Lighting for the Internet of Things (ELIoT)

PROJECT SUMMARY

Project ELIoT targets the development of mass-market internet of things (IoT) solutions with a next-generation wireless communications network, light fidelity (LiFi), travelling over light instead of radio waves.

PROJECT PARTNERS

Fraunhofer HHI, Fraunhofer FOKUS, Signify, MaxLinear, Nokia, Weidmüller, Deutsche Telekom, Royal KPN B.V. LightBee, University of Oxford, Technical University Eindhoven.

PROJECT LEAD PROFILE

After studying electrical engineering, Christoph Kottke completed his PhD at the Technische Universität Berlin in 2019. Since 2018, he has been working at Fraunhofer HHI in Berlin, where he is involved in optical wireless communications and optical access network infrastructures.

PROJECT CONTACTS

Dr-Ing. Christoph Kottke
christoph.kottke@hhi.fraunhofer.de
Fraunhofer Heinrich Hertz Institute,
10587 Berlin, Germany.

www.eliot-h2020.eu
/eliot-h2020
www.youtube.com/channel/UCLyEHg5jBQb5u1IfZmkJeLg
https://cordis.europa.eu/project/id/825651

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Have your voice heard: Commission launches Horizon Europe strategic planning process 2025-2027

On 28 September 2022, Commissioner for Innovation, Research, Culture, Education and Youth Mariya Gabriel officially launched the 2025-2027 strategic planning process for Horizon Europe during the conclusion of day one of the European Research and Innovation Days.

Horizon Europe's Strategic Planning is a tool which will guide the work programmes and topics for the programme in the coming years. Like its predecessor, the Strategic Plan 2025-2027 will be co-designed with citizens and stakeholders.

Commissioner Gabriel said: "Today marks an important milestone in the Horizon Europe strategic planning process. It will ensure that research and innovation funded by the EU generates maximum impact on the key challenges faced by all Europeans."

Next steps

The Strategic Plan will be covered in the largest ever public consultation of research and innovation stakeholders undertaken within Horizon Europe. Due to be published in November on the Have Your Say portal,Search for available translations of the preceding link the consultation will also feature questions on the past and current research and innovation programmes (Horizon 2020 ex post evaluation and Horizon Europe interim evaluation). The consultation will remain open for 12 weeks, and a dedicated workshop for citizens is planned to take place in December.

Background

Horizon Europe is the key EU funding programme for research and innovation, with a budget of €95.5 billionSearch for available translations of the preceding link.. It tackles climate change, helps to achieve the UN's Sustainable Development Goals and boosts the EU's competitiveness and growth.

The Strategic Plan is a novelty in Horizon Europe and sets the strategic orientations of the programme and outlines the contributions of its various parts. By establishing a strategic research and innovation agenda, it takes an important step towards the work programmes. It ensures that EU research and innovation actions contribute to EU prioritiesSearch for available translations of the preceding link, including a climate-neutral and green Europe, a Europe fit for the digital age, and an economy that works for people.

Citizen and stakeholder involvement was a key feature in the preparations for the Strategic Plan 2021-2024. It is estimated that in total, more than 6000 respondents contributed to these preparations; ensuring that citizens' and stakeholders' views were integrated in the research and innovation efforts from the start.

More information

Horizon Europe Strategic Plan
Factsheet: Horizon Europe Strategic Plan 2021-2024
Horizon EuropeSearch
Have your say portal
European Research and Innovation Days

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Source: The European Commission
https://research-and-innovation.ec.europa.eu/news/all-research-and-innovation-news/have-your-voice-heard-commission-launches-horizon-europe-strategic-planning-process-2025-2027-2022-09-28_en