LCA | LIGHT COMMUNICATION ALLIANCE

2023 LCA Annual Public Report

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Welcome to 2023’s LCA annual report

Marc Fleschen

ceo

Zero 1

It's that time of year when we reflect on last year's achievements and assess our goals. In 2023, we experienced significant international growth exposure and successfully increased our objectives. Firstly, this was achieved through our participation in numerous new conferences worldwide, spanning from the United States to Asia.

Secondly, we expanded our reach by welcoming a new member from the Middle East. We are pleased to welcome TII (Technology Innovation Institute) from Abu Dhabi, United Arab Emirates.

We further enhanced our impact by participating in exhibitions for the first time, showcasing our standalone Light Communication Alliance. At ECOC, with the presence of our Vice Chairman Nikola Serafimovski, we introduced our alliance to the wider ecosystem. The exposure was undoubtedly a great success, and we plan to participate in more exhibitions alongside our members, aiming to reach new audiences and expand our alliance's presence, including returning to ECOC and exploring other exhibition opportunities.

Our annual LiFi conference in June welcomed numerous new companies, presenting their latest research, projects, or products. It was a significant moment for all our members to come together with a unified goal of making LiFi mainstream. Across various conferences, we discussed use cases, energy savings, integration, and commercialization.

Every year, it's with emotion and passion that we witness the growth of our alliance and, more importantly, the ecosystem surrounding light communications. This response clearly indicates that light communications are attracting larger industries, reaffirming that this technology is and will continue to be a game-changer in how we utilize wireless technologies for years to come.

We also bid farewell to one of our executive board members, our Treasurer and Secretary, who has transitioned to new professional opportunities. We thank Hannah Brown for her dedication to the Light Communication Alliance. Without further delay, I am excited to invite you to read our newly published 2023 annual report.

Before we proceed, I would like to express my heartfelt gratitude to each and every one of our members for their time, dedication, and invaluable contributions. Your efforts are instrumental in propelling light communication technology to new heights every day.

Thank you sincerely on behalf of the Executive Board,
Nikola, Dominique, and Marc"

Executive summary

This 2023 annual report aims to review the critical information for the Light Communications Alliance (LCA), summarizing the 2023 activities and provide guidance for the plans in 2023.

After an introduction describing the history, the operational structure of the LCA, this report lists the members of the LCA, and provides a description of each member. The description of the Alliance is completed with its eco-system.

In another chapter, a description of the 2023 activity is summarized. After the detailed description of the budget used for the LCA in 2023, for each working group, a brief description of the tasks is made as well as new actions launched in 2023 to improve the visibility of the LCA. A particular focus is made on the close work realized with Genoa Black to reinforce the marketing part and the LCA visibility. Beyond key performance indicators identified to follow the evolution of the LCA, a benchmarking with other Alliance made in 2023 will drive new actions for 2023 to increase the visibility of the LCA on the international scene.

The last part of this report proposes directions for 2023 as well as a projected 2023 budget validated by the board of directors. This chapter includes also some elements for an analysis of strategic directions to put in place in 2023 to reinforce its scope and its impact.

Different annexes give access to key documents, in particular, the administrative documents of the LCA, the document for new members, and the messages of the LCA.

LCA

History and missions of the LCA

Using light to communicate information has been around since the earliest civilizations, whether it was the Egyptians and Chinese that used signal fires to communicate incoming attacks, the Romans who developed a battlefield communication system using fires on opposing sides of the battlefield, the Native Americans who used smoke signals or the photophone from Alexander Graham Bell that modulated sunlight to communicate voice over a distance. In recent history, light communication (LC) has seen an increased use, whether to communicate between ships at sea, between buildings to remove the need for cabling or between your remote control to the TV in the home. More recently and with the development of more sophisticated radio frequency (RF) communication systems and the increased need for more secure wireless communications, the industry started to consider additional use-cases that light communications could satisfy.

The inaugural talk by Professor Harald Haas, from the University of Edinburgh, during TED Global in 2011 with the introduction of light as a mean to complement other RF systems for last meter connectivity created an impetus for accelerated development and deployment of various LC-based communications solutions. As is typical at the start of a new industry, the term “LiFi” became associated with a wide range of use-cases that had completely different requirements. Unfortunately, this led to a good degree of confusion in the market with customers unsure what technology was right for their use-case and this lack of clarity slowed market adoption.

Micheline Perrufel, working for Orange was investigating the use and value of LC for the telecom giant. Realizing the market confusion Micheline and Sylvain Leroux from Orange organized the first LiFi Forum in November 2017 in Paris. The aim of the show was to provide an industry-wide snapshot of LC, demonstrate the various technologies and encourage mobile device manufacturers to include LC capabilities in their devices. The meeting, however, also served as a basis for the initial vision to agree on the need and value of a unified messaging platform and language across the LC industry.

The first meeting of what would become the Light Communications Alliance was hosted in December 2017 in the Edinburgh offices of pureLiFi.

It was during this early period that LC use-cases and technology was defined into three distinct sections:

- Optical Camera Communications (OCC) – a broadcast unidirectional technology that uses a modified LED lighting driver to modulate the light emitted from the luminaire that can be demodulated through the use of a smartphone camera.
- LiFi – high-speed, bidirectional and networked optical wireless communications exploiting the visible and/or the Infra-red light, offering a substantially similar user experience as Wi-Fi.
- Free Space Optics (FSO) – point-to-point communication systems that are typically deployed in outdoor environments as a replacement for laying cabling for backhauling, but that can be also used for in-door and short reach applications.

The initial idea of the role that LiFi could play in the future of wireless communications as developed in the very first white-paper in May 2018.

The LCA was officially launched in June 2019 and the website providing an overall review of LC. The kick-off meeting of the LCA was held at the European Parliament Building in Luxembourg in December 2019.

Main historical dates of the LCA in a nutshell:

- November 2017: First LiFi forum on the LiFi technology organized by Orange in France.
- December 2017: Kick off meeting at pureLiFi, in Edinburgh, for the creation period of the LCA.
- May 2018: White paper: “Light Communications for Wireless Local Area Networking”.
- June 2019: Press releases to announce the official creation of the LCA
- December 2019: Kick-off meeting of the LCA in Luxembourg.

Creation of the LCA

The head office of the LCA

ZERO1, headquartered in Luxembourg, was approached by the Luxembourg government in 2018 to participate in various events to present OCC and LiFi technologies. Marc Fleschen also joined the Luxembourg working group on 5G.

The prospect of LCA as a new international organisation bringing together major players in technology and industry has convinced government authorities to support the LCA.

Mr. Eric Krier, Minister of State in charge of media and communication of the Grand Duchy of Luxembourg, actively participated from the first founding work of the Alliance and provided a letter of support from Prime Minister Mr. Xavier Bettel (Annex V.1).

The choice of LCA's headquarters was also motivated by Luxembourg's position and its proximity to European authorities.

Registration of the LCA

The LCA is registered under RCS: F12764 of 04/10/2019 as a non-profit association for an unlimited period.

Marc Fleschen was appointed Chairman, and Nikola Serafimovski and Dominique Chiaroni were both appointed Vice-Chairman.

Bank account

The account was opened at “Banque Internationale du Luxembourg”.

Dr. Enrique Poves is acting treasurer of the LCA.

Bylaws

The Bylaws document defines the statutes of the LCA which contains in particular, the main operating and organizational rules of the LCA. Each LCA member reviews and signs the LCA bylaws to be an effective member of the LCA. This ensures their acceptance of the LCA rules (Annex V.1). The latest version of the document has only regular members. It means that founding members or strategic members from the past remain only historical titles of the LCA.

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Objectives of the LCA

The objectives and the role of the LCA can be summarized through the three following actions:

- Motivations: Delivering the benefits of ubiquitous Light Communications to serve people & technologies, requires a far-reaching & coherent ecosystem working at a determined pace

- Missions: Driving a consistent, focused & concise approach to market education that will highlight the benefits, use cases & timelines for Light Communications.

- How? By aligning leaders across every industry to develop or envisage business models using Light Communication systems & technologies by defining a standard of education in an efficient communication & co-operation frame.

LCA members and partners in a nutshell

LCA members in a nutshell

The membership is opened to any company having an interest in Light Communication technologies. A member can be an industrial company (operators, equipment vendor, technology and chipsets developer, software vendors, …) or a research institute/university.

The members are asked to provide consistent messaging of the LCA and contribute during the regular meetings to provide inputs. In return, the members can find a support of the LCA to provide them a higher visibility in different events, find new opportunities of collaboration between the LCA members, or to participate to an Alliance strategy for the benefit of all the LCA members. The inclusion model is strongly motivated to orient this technology in the right direction, and aligned with the big evolutions of the ICT, or anticipating new needs for vertical segments.

For the second year, 21 companies are members of the LCA and are split into six categories:

1. LiFi key players
2. Applications
3. Operators
4. Equipment vendors
5. Networking and security
6. University/Research institute

LiFi/OCC key players

Lucibel
NavTech
OLEDCOMM
PureLiFi
Signify
Velmenni
Zero 1

Applications

Crantec
OLEDCOMM
Signify
Zero1

Operators

Emirates Integrated Telecommunications Company (EITC)
Liberty Global
Orange
Post Luxembourg

Equipement vendors

BKS Digital Connectivity Solutions
GETAC
MinebeaMitsumi
Nokia
Signify
VIAVI

Networking and security

BKS
Crantec
MinebeaMitsumi
Nokia
Orange
Post Luxembourg
QRCrypto

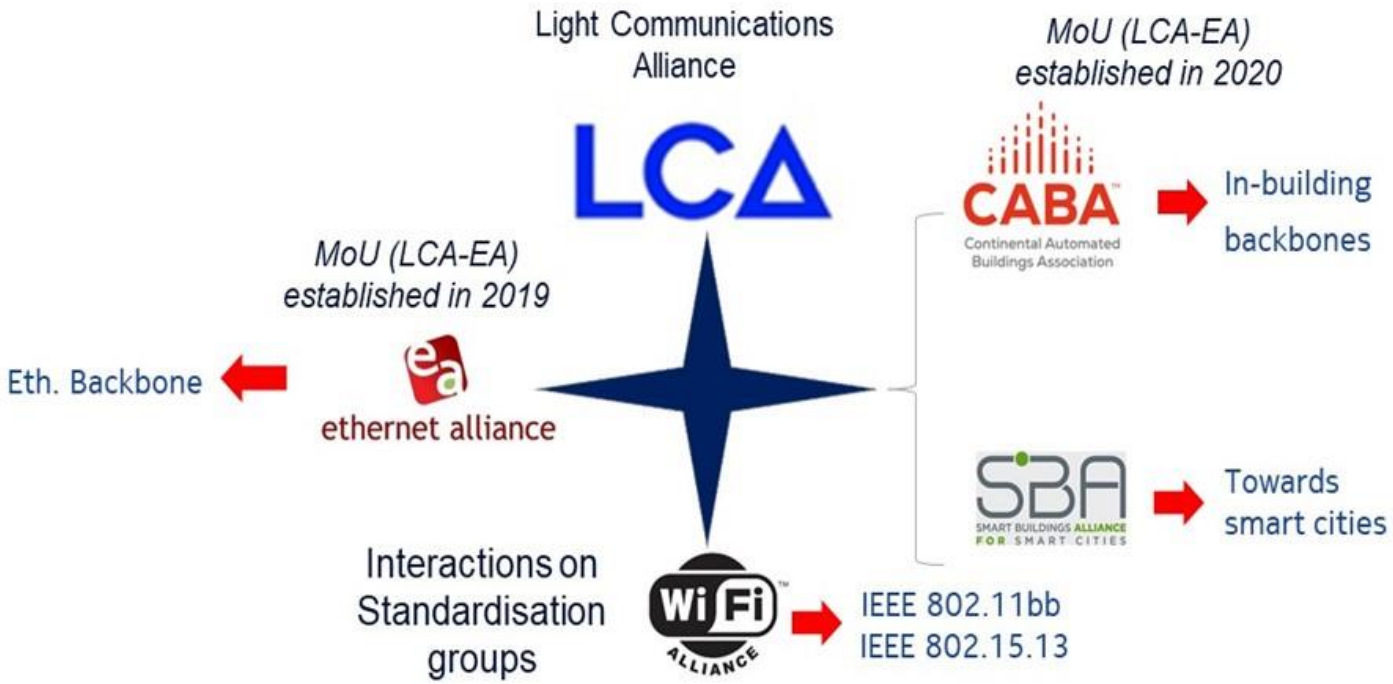
University/Research Institute

CEA
University of Strathclyde
Institut Mines Telecom

LCA Member logos

The Light Communications Alliance has created links with other Alliances (fig. 3). These Alliances are:

- The Wi-Fi Alliance, for discussions on the standards.
- The Ethernet Alliance to interact with them on the Ethernet Backbone, like Power over ethernet technologies.
- The CABA Alliance, focused on the in-building topics
- The Smart building Alliance targeting the identification of relevant solutions for Smart Cities.

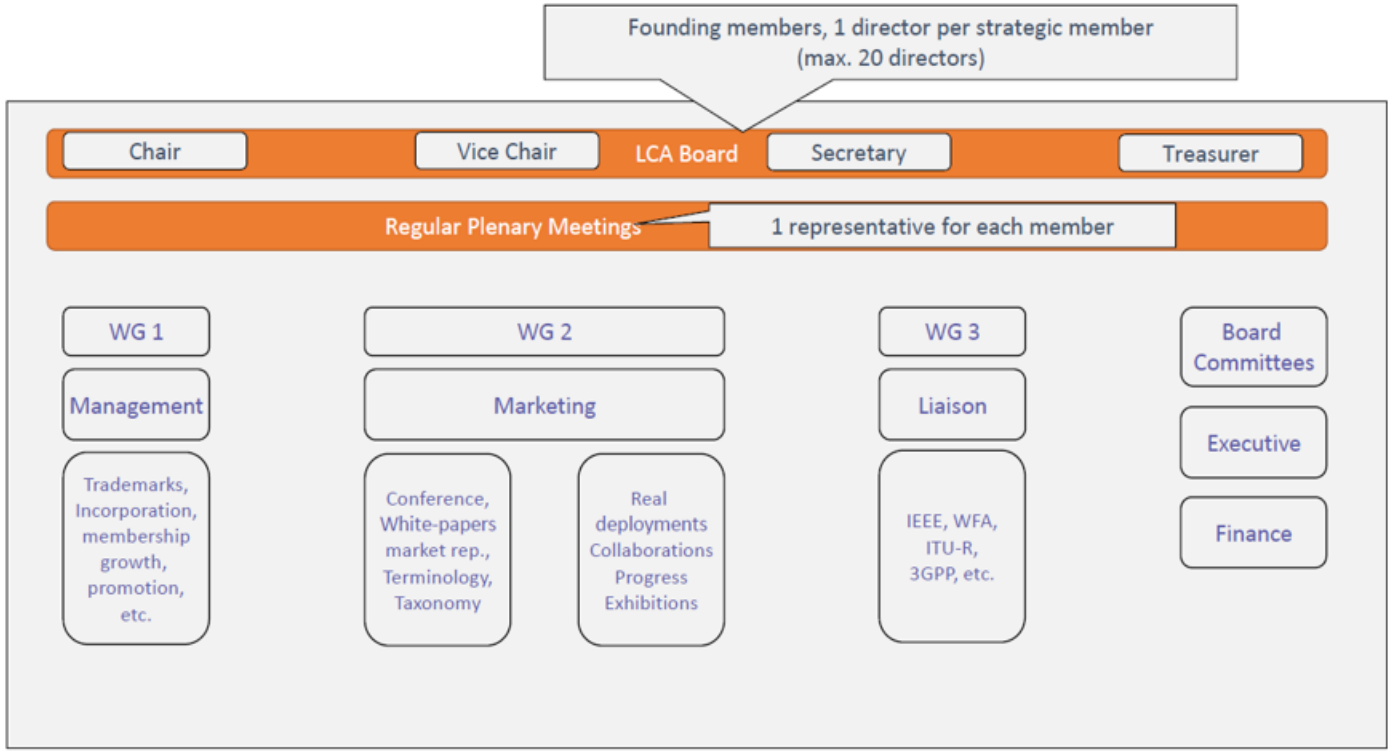


Operational structure of the LCA

The LCA operation structure is illustrated in the figure.

The LCA has one chairman, two vice-chairs, and one secretary/treasurer.

Monthly plenary meetings are organized to address first the general information, and secondly to address specific aspects or topics.



- For the key messaging, two steps have been identified, taking into account the 2022 experience.
- The need for aligning the messages on the original taxonomy and directions adopted during the LCA creation period. The objective for 2023 was to recall the key messages of the LCA, with a validation of the founding members to have a reference document.
  - A word document listing the position of the LCA, and
  - A slideware available for any external presentation.
- Organize periodic workshops on this specific aspect, to reconsider the original messaging, and make new proposals that will be then voted and adopted by the LCA board.
- LCA is an association of founding, strategic or regular members having one common goal: align the global messages, deliver messages to the global scientist community through publications, white papers or contributions in standardization bodies, being facilitator for local initiatives through collaborations or projects. We notice that in 2024 the LCA will be association of regular members only.

Key events in 2023

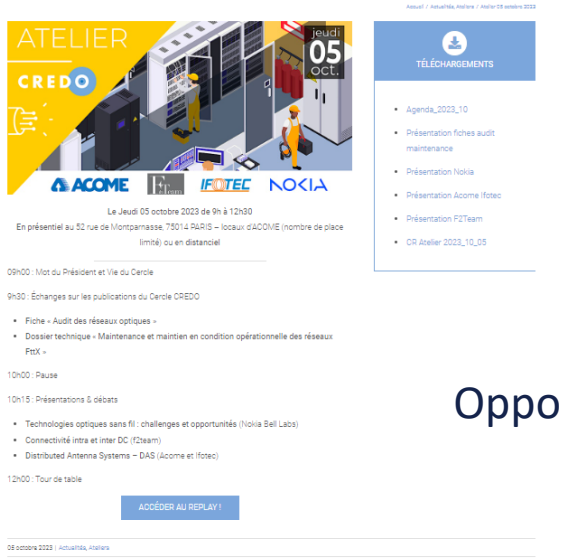
2023 was in the continuity of 2022 concerning the participation in events.

Several participation to events :

1. Feb. 2022: participation to an ISA conference organised by China
2. June 2022: Sponsor and participation at the 2023 LiFi conference (3 members of the LCA participated)
3. October 2023: GITEX event
4. October 2023 : Presentation of LC and of the LCA to a circle of experts in France (in the frame of the CREDO).
5. December 2022: 2023 Optical Wireless Communication Conference. Participation of one LCA member.

China

Europ



France

Opportunities offered

Paper “Terabit Indoor Laser-Based Wireless Communications: LiFi 2.0. for 6G

Accepted for publication at the IEEE Wireless Communications in February 2023.

Terabit Indoor Laser-Based Wireless Communications: LiFi 2.0 for 6G

[1]Mohammad Dehghani Soltani, [2]Hossein Kazemi, [2]Elham Sarbazi, [3]Ahmad Adnan Qidan, [3]Barzan Yosuf, [3]Sanaa Mohamed, [4,6]Ravinder Singh, [7]Bela Berde, [7]Dominique Chiaroni, [8]Bastien Béchadergue, [9]Fathi Abdeldayem, [10]Hardik Soni, [11]Jose Tabu, [12]Micheline Perrufel, [13]Nikola Serafimovski, [3]Taisir E. H. El-Gorashi, [3]Jaafar Elmirghani, [4]Richard Penty, [4,5]Ian H. White, [2]Harald Haas and [1]Majid Safari

[1]The University of Edinburgh, [2]University of Strathclyde, [3]University of Leeds, [4]University of Cambridge, [5]University of Bath, [6]Toshiba Europe Limited, [7]Nokia Bell Labs, [8]Oledcomm, [9]Du AUE, [10]Nav Wireless Technologies Pvt Ltd, [11]Crantec, [12]Orange, and [13]pureLiFi Limited

This paper provides a summary of available technologies required for implementing indoor laser-based wireless networks capable of achieving aggregate data-rates of terabits per second as widely accepted as a sixth generation (6G) key performance indicator. The main focus of this paper is on the technologies supporting the near infrared region of the optical spectrum. The main challenges in the design of the transmitter and receiver systems and communication/networking schemes are identified and new insights are provided. This paper also covers the previous and recent standards as well as industrial applications for optical wireless communications (OWC) and LiFi.

Introduction

The number of wireless communication devices and their associated services are increasing rapidly requiring substantial improvements in data density measured in bits per second per square metre (bps/m^2). Key new applications will center on the cyber-physical continuum or metaverse including the convergence of sensing, communications, computing/artificial intelligence (AI) and robotics/control. It is generally accepted that in order to enable this vision, new spectrum beyond the classic radio frequency (RF) spectrum is required [1].

OWC is a viable solution to achieve the ambitious key performance indicators (KPIs) of 6G in terms of data density, peak data-rates, latency, energy efficiency and security. OWC enables the creation of ultra-small cells in a cellular network design. This is vital to unlock the path to exponential capacity growth for indoor scenarios and to achieve step-change improvements in data density. Furthermore, OWC can offload traffic from congested RF wireless networks, thereby providing extra capacity which can be traded off for a reduction in latency for time critical Internet of Things (IoT) applications. OWC will co-exist with current and future RF wireless communication systems to combat issues such as blockage (e.g., when an OWC-enabled smartphone is in user's pocket). Nevertheless, the availability of three orders of magnitude unregulated spectrum (close to 589 THz for VLC and IR) compared with the entire RF spectrum (close to 300 GHz) and using technologies that underpin optical fiber communication, OWC will significanty augment the RF communications. Because of the directionality of light and significant link quality degradations in a non-line-of-sight scenario, OWC has primarily been used for intentional communications in the past such as fixed point-to-point communications. IBM research in 1980 developed the first OWC networks between static computers using infrared (IR) light [2]. In the last two decades, however, OWC networks supporting user mobility have been developed where mostly visible light is used for both illumination and downlink communication while infrared light is used for uplink communication. The simultaneous function of illumination and downlink communication was motivated by the replacement of incandescent light bulbs with light emitting diode (LED) light fixtures. LEDs can achieve up to gigabit per second (Gbps) transmission speeds while user mobility is enabled by a careful integration of link diversity techniques, both at the access point and the mobile device. Mobile OWC networks are also referred to as LiFi networks [3].

A limitation of LEDs is their limited electrical bandwidth. In contrast, laser diodes achieve significantly higher bandwidth, but eye safety limits their output power. However, recent work has shown that vertical-cavity surface emitting laser (VCSEL) can be used to achieve tens of Gbps transmission speeds while maintaining eye-safety limits. When combining this capability with the directionality of light, it has been shown that it is possible to build LiFi access points that can achieve aggregate data rates of greater than 1 Tbps in line with 6G KPIs [4]. VCSELs exhibit advantageous features such as high-speed direct modulation (ten's of GHz bandwidth – a single VCSEL could have as much bandwidth as 1/6 of the entire RF spectrum), high power conversion efficiency, low cost, long lifetime and possibility to manufacture highly integrated VCSEL arrays. These attributes make VCSELs very attractive for use in many applications, particularly for high-speed indoor networks.

- One the basic on the work made for the LCA white paper on “Energy and LC technologies”, a public white paper is envisaged for 2024.

- Why this paper is arriving at the good moment?
  - The energy is becoming more and more critical and certifications are under study to classify products.
  - Some countries like Denmark have launched national initiatives like the GreenCOM project
  - The EC is pushing for a sustainable 6G. IT is then important to position the LC technology as a key enabler of a sustainable 6G.

- Projects and collaborations between partners are active

- Topics investigated in 2023:
  - LC for software training rooms
  - LC for railways
  - LC for more security

- In the frame of the public position paper on Energy and LC
  - Collaboration of several members of the LCA

- New initiatives started:
  - Towards a new Green Meter to link KPIs to KVIs and be able to identify rapidly energy efficient end-to-end solutions. This Green Meter could be very important to position the LC technology wr to a RF technology.
  - LC and FC technologies positioned as a strategic technology for a sustainable 6G technology.

- Mounting of one LCA booth in two conferences

- LiFi conference in June 2023
  - Booth, with booklets, pens, USB memory keys including key LCA doc.
  - Live presentation with a timer to be bel to read the main messages
  - Participants of the conference have visited the booth
  - Dominique Chiaroni

- ECOC conference in October 2023
  - Nikola Serafimovski

- Thanks to Genoa Black, Hannah and Pieter Hermans for being facilitators

- 2022 Annual reports
  - Internal Annual Report
  - Public Annual Report
  - Description of the LCA members
- Reporting on key events to the LCA members:
  - Summary of :
    - The ISA conference in 2023
    - The LiFi conference in 2023
- Proposition for a new strategy to increase the visibility

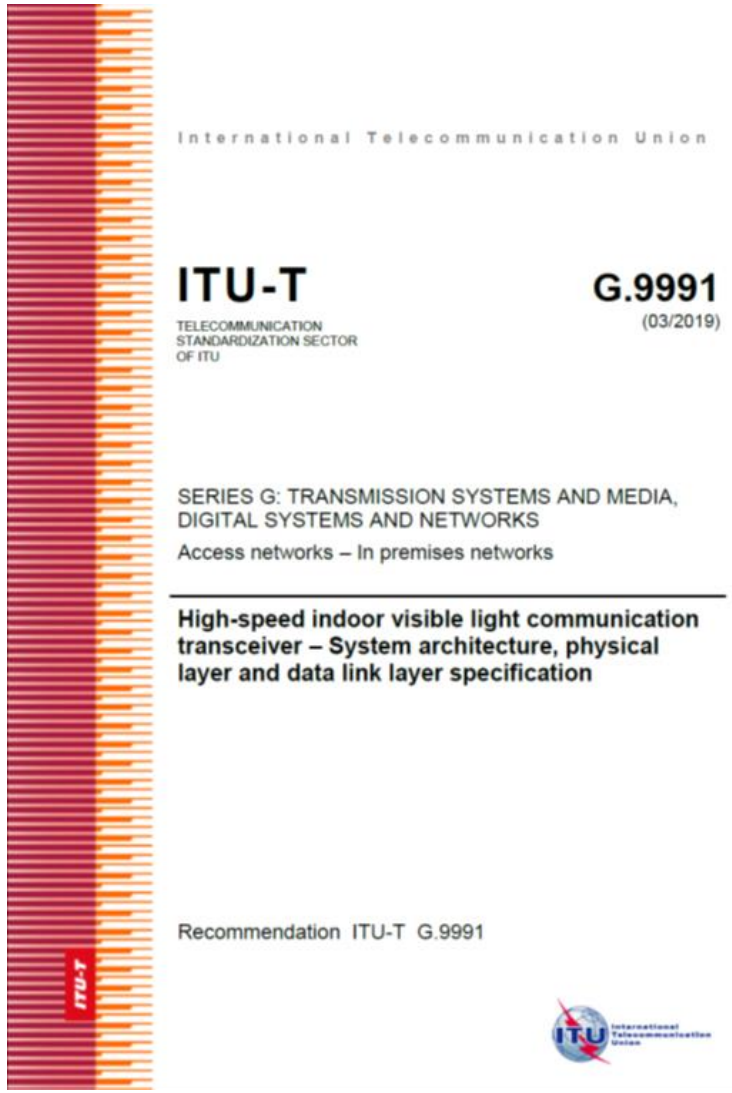
Standardisation and partners

Standardisation status

ITU-T G.9961 (G.hn) is the leading standard for powerline communications and various other last mile connectivity Millions of units shipped globally across a range of verticals Established market and open standards have created a competitive ecosystem of devices.

G.9991 (G.vlc) systems leverage existing G.hn chipsets to extract maximum performance from the optical link with existing systems

G.9991 chipsets offer a straight-forward integration route with the opportunity to easily connect various devices



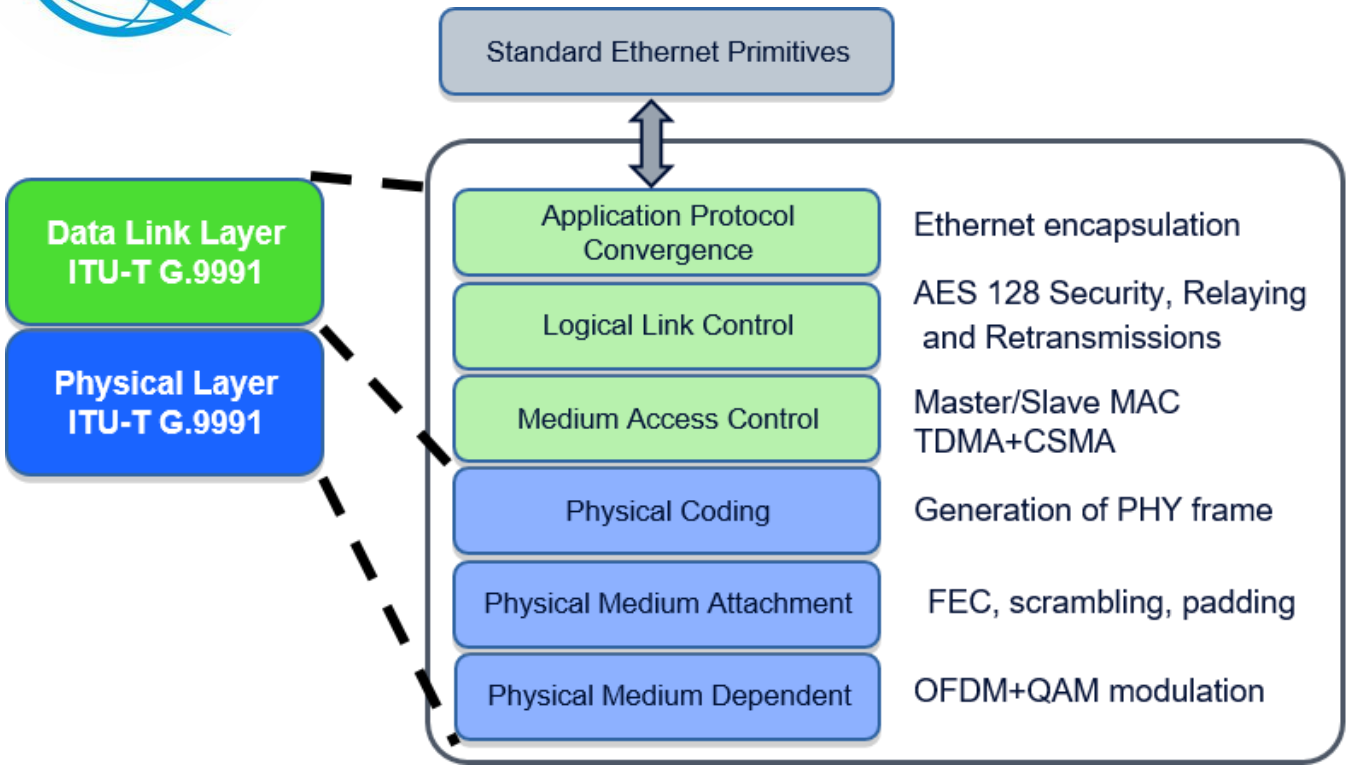
ITU-T G.9991 Key parameters

Layer	Area	Value	Notes
Physical Layer	Line code	OFDM	Configurable OFDM parameters (cyclic prefix, per-subcarrier PSD, etc)
	Max modulation	12 bits/subcarrier	Each sub-carrier is modulated with a different QAM, depending on SNR
	FEC	LDPC	Multiple FEC rates (1/2, 2/3, 5/6, 16/18, 20/21) dynamically selected
	Spectrum	5-200 MHz (VLC)	Individual sub-carriers can be notched to coexist with other services
	Subcarrier spacing	195 kHz (VLC)	Sub-carrier spacing optimized for the expected delay spread in each medium
Data Link Layer	Logical topology	P2P, P2MP	Support for multiple topologies to support both access/in-home services
	MAC protocol	TDMA	TDMA ensures no-collisions, while enabling CSMA slots for registration CSMA is also described in the standard but not used for other purposes than registration
	Retransmission protocol	Yes	Retransmission protocol provides zero-loss operation and flow-control
	Encryption	AES-128	Standard enables each node in the network to use different AES keys
	QoS	8-levels	8-level prioritization to support voice, video, data, control messages, etc
	Multicast & Broadcast	Native Multicast & Broadcast support	Including reliable multicast with Rx acknowledgement
	Bandwidth Allocation	Per user & per direction	Supports different service tiers on the same network

LCA

ITU

ITU-T G.9991 ('G.vlc')

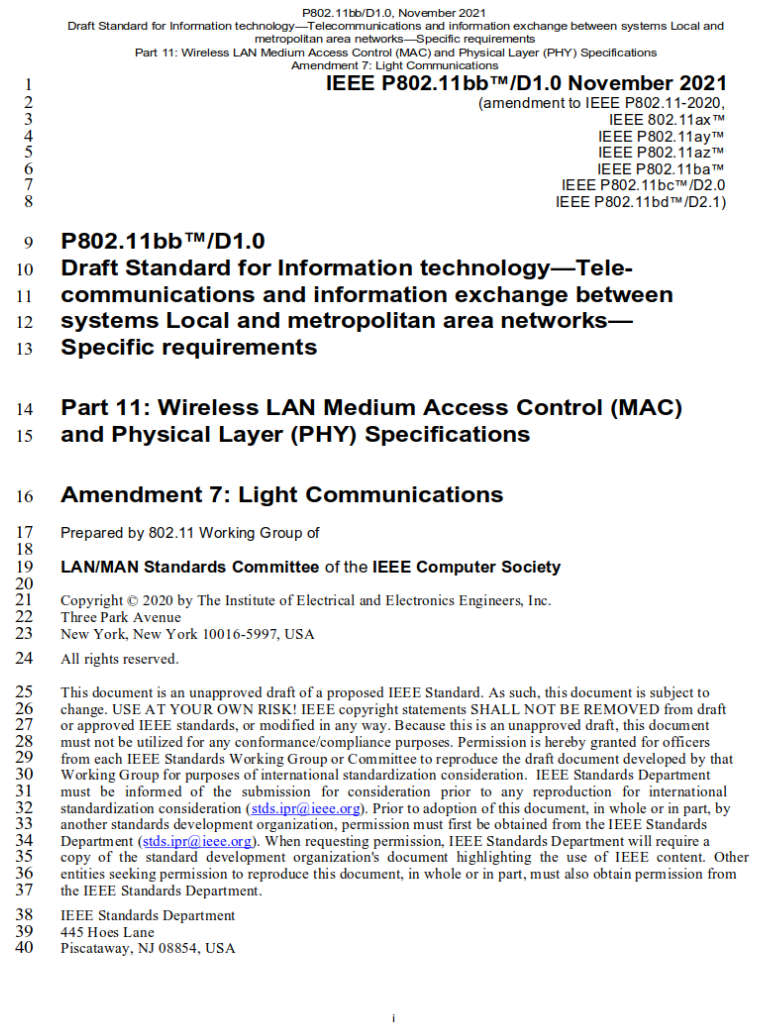


- Based largely on G.9960/61 (aka G.hn)
- Objective: Leverage the highly flexible OFDM engine provided by G.hn
  - Part of ITU-T G.999x series (optical transmission)
    - LC = VLC + IR
- Developed by ITU-T SG 15 (Q18/15 In-premises networking)
  - Started 2H2015, first approval 2019-04-01
  - Revised through 2 amendments and a corrigendum
  - Latest release: April 2021
- 2 PHYs on common MAC
  - PHY 1: G.9960 (DCO-OFDM)
    - Performance oriented, up to 2 Gbps
  - PHY 2: ACO-OFDM
    - More flexible, e.g. in case of dimming
  - MAC: G.hn MAC + additions (FD-prepared)
- Topologies: P2P & P2MP

Motivation for IEEE 802.11bb

IEEE 802.11 bb is the world's most common communications standard

- Over 3.8 billion Wi-Fi chipsets were shipped globally in 2021 in everything from smartphones, TVs, CCTV cameras, baby monitors, etc.
- The large established market and open standards have created a highly competitive, vibrant ecosystem of devices, testing facilities, etc.
- Deploying LiFi on a global scale requires reducing the barrier to entry for anyone looking to produce interoperable systems.
- IEEE 802.11 offers the simplest integration route with the highest number of possible device integration options



P802.11bb/D1.0, November 2021
Draft Standard for Information technology—Telecommunications and information exchange between systems Local and metropolitan area networks—Specific requirements
Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications
Amendment 7: Light Communications

IEEE P802.11bb™/D1.0 November 2021
(amendment to IEEE P802.11-2020,
IEEE 802.11ax™
IEEE P802.11ay™
IEEE P802.11az™
IEEE P802.11ba™
IEEE P802.11bc™/D2.0
IEEE P802.11bd™/D2.1)

P802.11bb™/D1.0
Draft Standard for Information technology—Telecommunications and information exchange between systems Local and metropolitan area networks—Specific requirements

Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications

Amendment 7: Light Communications

Prepared by 802.11 Working Group of

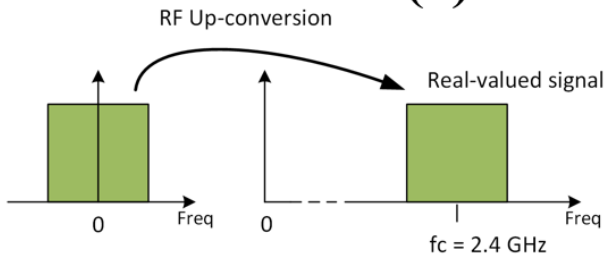
LAN/MAN Standards Committee of the **IEEE Computer Society**

Operational Concept for IEEE 802.11bb

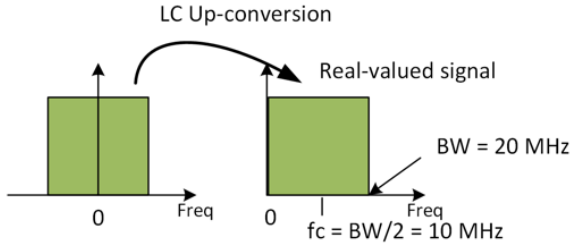
- Existing chip sets can easily be extended to operate in the light spectrum.

Using existing 802.11 PHYs for LC (2)

- RF frontend up-converts baseband signals onto e.g. f_c=2.4 GHz.

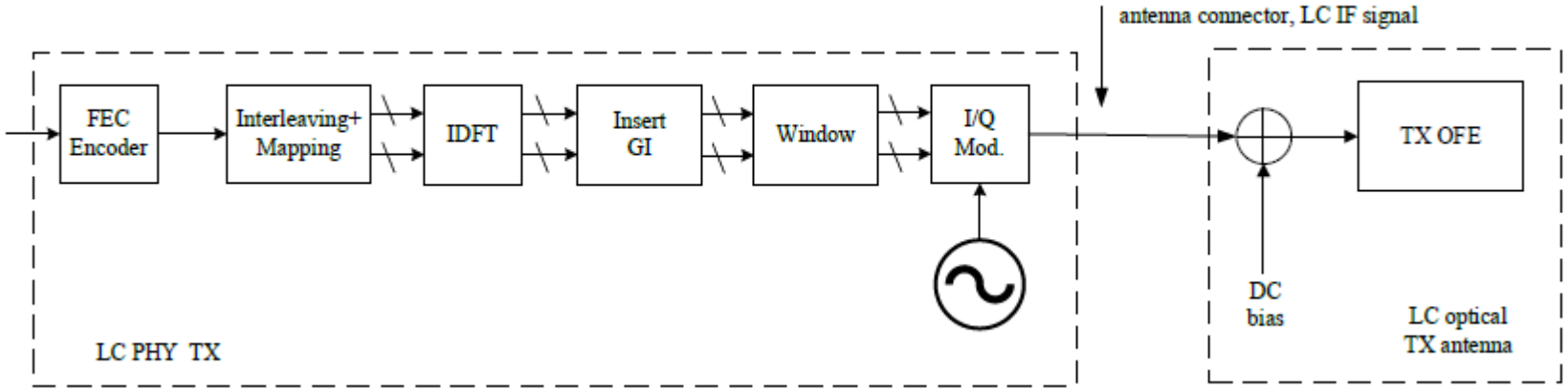


- LC frontend up-converts baseband onto low IF e.g. f_c=BW/2 + Δ.
  - Δ is to be agreed depending on signal mask design.



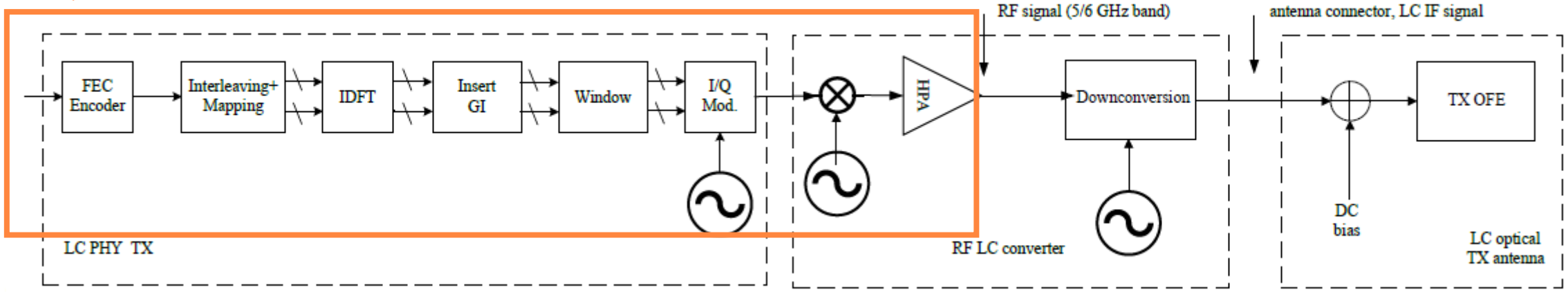
- This way, any complex-valued baseband signal (i.e. any existing IEEE 802.11 PHY) can be used to facilitate LC.

Implementation options for IEEE 802.11bb



Existing Wi-Fi Chipsets

Direct Conversion



The Light communication technologies could:

- provide new added values in different segments.
- become key technologies to reduce the energy consumption since:
- The critical energy consumption is mainly generated at the periphery of the network
- The LC technologies are energy efficient when increasing the bit rate

The complementarity wr to 5G or Wi-Fi seems relevant for different use cases.
This technology could then a catalyst for the 5G deployment in some sensitive use cases:

- Hospitals to have a wireless technology when a RF technology is not possible, In planes to avoid interferences with sensitive equipments or to find some weight gains,
- At home to reinforce the security and minimize the power consumption,
- In the Industry 4.0 to guarantee a data communication continuity or to offer ultra high bit rates with a reinforced security,
- In commercial centres to take advantage of already existing LEDs in the ceiling.
- LC has also a strong potential to reach the 6G requirements

Perspectives for 2024

Budget

Follow the member registration, Budget for the president, Budget for missions, Budget for events

Short and medium term vision

Revisit the Use cases
Propose a product road map
White papers on a product vision

Standardisation

Participation and reporting about standards évolutions
Propose a LCA vision
Certification strategy

Long term vision

White papers to position the LC technology
Roadmap and vision
LC and the 6G era

Communication

Annual report
Organisation of industrial events and LCA booth at events
Participation in seminars, webinars, workshops, symposium and conferences
Website

01

Always increase the number of members :

--> business manager to develop partnerships and memberships.

Strengthen the presence of members during Meetings.
A minimum of 1 per quarter to be able to make your contribution, value....

Open discussion on fees - (Dominique Chiaroni)

02

Improve tools for members

- Provide a compatible logo for insertion on partner websites.
- Creation and administration of a blog on the LCA website
- Creation of a member area
- Creating a YTUBE channel

03

Annual report

Like every year - setting up of a working group from the beginning of 2024 for distribution of the report on April 24

04

White paper in progress

At the request of several members: a public version of “energy savings” no later than the end of June 24

Thank you