IEEE P802.11
Wireless LANs

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| A CSD Proposal for Light Communications (LC) |
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Abstract

This is the IEEE 802.11 Light Communications (LC) SG proposed CSD.

# 1. IEEE 802 criteria for standards development (CSD)

The CSD documents an agreement between the WG and the Sponsor that provides a description of the project and the Sponsor's requirements more detailed than required in the PAR. The CSD consists of the project process requirements, 1.1, and the 5C requirements, 1.2.

## 1.1 Project process requirements

### 1.1.1 Managed objects

Describe the plan for developing a definition of managed objects. The plan shall specify one of the following:

1. The definitions will be part of this project. **YES**
2. The definitions will be part of a different project and provide the plan for that project or anticipated future project.
3. The definitions will not be developed and explain why such definitions are not needed.

### 1.1.2 Coexistence

A WG proposing a wireless project shall demonstrate coexistence through the preparation of a Coexistence Assurance (CA) document unless it is not applicable.

1. Will the WG create a CA document as part of the WG balloting process as described in Clause 13? **YES**
2. If not, explain why the CA document is not applicable.

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## 1.2 5C requirements

## 1.2.1 Broad Market Potential

Each proposed IEEE 802 LMSC standard shall have broad market potential. At a minimum, address the following areas:

a) Broad sets of applicability.

We live in an increasingly connected world. The demand for mobile wireless communications is increasing at nearly 50% per year according to the Cisco Visual Networking Index. Three numbers explicit the global ever-accelerating need for bandwidth and wireless: by 2021 more than half of 17 billion connected devices will be mobile, 65% of the IP traffic will be from mobile devices, 80% of the internet traffic will be video requiring high speed wireless.

There are multiple solutions that can provide an increase in the available spectrum and increase the spectrum reuse in a given area, as well as increased speed. WiGig solutions, defined in IEEE 802.11ad, .11mc, .11aj and 802.11ay are such examples. However, the continued deployment and growth of 802.11 technology relies on new technologies progressively being implemented to address a continued increase in capacity of wireless networks, and the availability of additional unlicensed spectrum, such as the visible and IR light frequency range. Additionally, non- RF based solutions may be preferred for multiple complementary use-cases, like environments where traditional RF solutions are not allowed due to safety and or securityEMI sensitive equipments, underwater communications, M2M or when security considerations prevents their use for example in banks and defense industry.

The light spectrum, for the most part, has been underutilised for free space communication. The visible light and near IR spectrum alone stretches from approximately 250 THz to 800 THz, which means that there is potentially more than 1000 times the bandwidth of the entire RF spectrum of approx. 300 GHz. Both the visible light spectrum and the infrared spectrum are unlicensed.

The key difference between the potential LC standard and the former IR standard within 802.11 is that the potential LC standard would be looking at providing complementary capabilities created by the introduction and large scale deployment of solid state light sources (LED, OLED and laser diodes) and appropriate PHY and MAC technologies that can help 802.11 address existing use-cases with enhanced performances as well as additional use-cases. In addition, the pervasiveness of LEDs, technological maturity and the increasing demand for wireless capacity, low latency and high speed all play a significant role in the motivation for creating an LC standard within 802.11.

LC has been a subject of intense research & development for more than 15 years with steady improvements in performance, cost, reliability and components' compactness. While many applications have been imagined, it is the exponential development of LED Lighting that is shaping the LC market. LED lighting in 2016 accounted for <10% of the over 45 billion lighting sockets available. Yet, LED lighting accounted for more than 50% of the revenue for the lighting industry in 2016 and are fast replacing traditional light sources. It is anticipated that LED will replace over 70% of the current incandescent and fluorescent lighting by 2020. LC offers significant market growth potential with over 550 million LED lights sold annually globally for a global $100bn general lighting market [1].

The LC technology uses unregulated spectrum of visible light that does not need licensing. It is exhibiting a low latency ideal for applications such as AR/VR and robotics and the high frequency modulation of LED and laser diodes gives access to the 1 to 10+ Gbps range [ ]. The intrinsically very small cells generated by LC access points allow for a high density of point-to-multipoint communications. respect norms and standards of the lighting industry so that they don’t represent don’t

LC are a powerful complement or alternative to RF, in environments where data exchange should be perfectly secure (banks, R\&D centers, defense, …), radio waves are not permitted or restricted (hospitals, pre-K schools, EMI sensitive industrial facilities such as natural gas compression stations) or connectivity should be guaranteed (conference rooms, hotels). The selection of use cases is driven by the facts that, on the one hand, the visible light frequency range is interference free and not regulated and, on the other hand, light communications happen in the cone of light. Obvious limitations of the technology, such as the fact that light has to be switched on, have to be acknowledged and constitute simply boundary conditions in the immense space of the use cases.

With increasing performances in terms of bandwidth, distance etc… many new use cases are unlocked: multi-person video calls, AR/VR, M2M communications, robotic telepresence, real time gaming ….

With people in industrialized nations spending more than 90% of their time indoors, lighting is poised to be a communications infrastructure of choice.

b) Multiple vendors and numerous users.

A wide variety of Light Communications (LC) vendors currently build various, non standardized, products for many use-cases [4].

As a consequence of the demonstration of the value of LC for these various use cases, the demand for LC is growing. The LC market size is forecast to be worth $15 billion by 2022 according to Markets and Markets [2].

Standardization is seen by the industry as a key element to the technology’s ability to address the mass market. Vendors include chip makers to deliver PHY & MAC sub-systems, system integrators, Tier 1 telecoms, ISPs, lighting companies, emerging IoT companies, large industrial manufacturers, etc. It is anticipated that the majority of those vendors, and others, will participate in the standards development process and subsequent commercialization activities.

## 1.2.2 Compatibility

Each proposed IEEE 802 LMSC standard should be in conformance with IEEE Std 802, IEEE 802.1AC, and IEEE 802.1Q. If any variances in conformance emerge, they shall be thoroughly disclosed and reviewed with IEEE 802.1 WG prior to submitting a PAR to the Sponsor.

1. Will the proposed standard comply with IEEE Std 802, IEEE Std 802.1AC and IEEE Std 802.1Q? **YES**
2. If the answer to a) is no, supply the response from the IEEE 802.1 WG.

The review and response is not required if the proposed standard is an amendment or revision to an existing standard for which it has been previously determined that compliance with the above IEEE 802 standards is not possible. In this case, the CSD statement shall state that this is the case.

## 1.2.3 Distinct Identity

Each proposed IEEE 802 LMSC standard shall provide evidence of a distinct identity. Identify standards and standards projects with similar scopes and for each one describe why the proposed project is substantially different.

The project will have a narrow focus on the definition of the PHY and part of the MAC layers to enable the use of the light spectrum for wireless communicate using intensity modulation and direct detection.

The difference between LC and the existing 802 light communications standards is the use of the 802.11 MAC and associated services that are focused on local wireless area networks relative to the existing (802.15.7m and 802.15.13) efforts that are focusing on deploying the technology for wireless specialty networks. In addition, the coexistence and hand-over with other 802.11 PHY types creates a unique market capability for LC as part of 802.11. Similar to the differences between the 60 GHz work done within 802.15 and within 802.11, the use of the light spectrum with 802.11 technologies can uniquely address existing use-cases potentially covered by 802.15.13 as well as novel use-cases. The decision on the technical specifications of any 802.11 PHY would be determined by the eventual LC TG.

## 1.2.4 Technical Feasibility

Each proposed IEEE 802 LMSC standard shall provide evidence that the project is technically feasible within the time frame of the project. At a minimum, address the following items to demonstrate technical feasibility:

a) Demonstrated system feasibility.

There are many publications demonstrating the hardware feasibility of LC. Greater detail on the technical feasibility of LC, including refreences for the demonstrated systems can be found here:

<https://mentor.ieee.org/802.11/dcn/17/11-17-0023-09-00lc-lc-tig-draft-report-outline.docx>

b) Proven similar technology via testing, modeling, simulation, etc.

IEEE 802.11 is a mature technology which has a variety of legacy devices and a proven track record, with several billions of deices shipping eachyear. The increased capabilities envisioned with LC for IEEE 802.11 are in line with the current progress in technology and not expected to impinge testability.

The amendment will use modeling and simulation as a tool for evaluating performance metrics.

**1.2.5 Economic Feasibility**

Each proposed IEEE 802 LMSC standard shall provide evidence of economic feasibility. Demonstrate, as far as can reasonably be estimated, the economic feasibility of the proposed project for its intended applications. Among the areas that may be addressed in the cost for performance analysis are the following:

a) Balanced costs (infrastructure versus attached stations).

The infrastructure costs are expected to be similar to the installation of traditional lighting or Ethernet based networks. In other words, very reasonable in terms of the delivered functionality.

1. b) Known cost factors.

LC technology is well characterized in terms of cost and is tended for devices, such as fixed assets and mobile devices, which are also well known and characterized in terms of cost. The addition of a LC chipset that is based substantially on existing 802.11 technology in LED lights creates a very good estimate for the infrastructure costs. Similarly, the presence of optical modules and communications modules in mobile devices allows for a very good estimate of the expected/potential impact on device costs.

c) Consideration of installation costs.

These are substantially similar to current installations for lighting and the market forces are driving demand independent of LC, in particular for Power over Ethernet solutions suitable for smart buildings.

d) Consideration of operational costs (e.g., energy consumption).

The added energy cost to support LC is minimal since the energy that is used for illumination may also be used to provide wireless communications. LEDs are being used for illumination and communications, removing constraints on the transmit power for the downlink.

Using LC for uplink can be more power consuming. However, as discussed in [3] (“how does uplink of LC-systems work”), when power consumption is an issue, the uplink could use infrared radiation or RF for uplink with similar level of power consumption as current 802.11 devices.

e) Other areas, as appropriate.

The light spectrum (100 nm – 10000 nm) is already considred licensed-exempt by some government regulators and falls outside of the remit of most other government regulators including outside of the regulatory authorities in Australia, Canada, China, India, Japan, Europe, South Korea and the USA.**References:**

1. Nikola Serafimovski, Christophe Jurczak, “IEEE 802.11-17/0803r1 Economic Considerations for Light Communications”
2. Global Market Insights, “Free Space Optics (FSO) and Visible Light Communication (VLC)”, available at http://www.marketsandmarkets.com/Market-Reports/visible-light-communication-market-946.html
3. Nikola Serafimovski et al. “IEEE 802.11-17/1048r0 Light Communications for 802.11”
4. Christophe Jurczak, “IEEE 802.11-17/1500r1 Light Communications Experience of a Lighting Systems Manufacturer”