No One Cares About Light – A Reflection on Lighting in the Smart Home Market

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Abstract

Both LED technology and the Internet of Things provide the basis for innovations in the lighting market. In the context of Smart Homes, connected LED light bulbs are perceived as game changer for the industry by many players. However, a long-term business model as well as long-term customer satisfaction have not been realized by today's market offering. Our article addresses this gap and develops the vision of lighting as a sensor platform in the smart home context. It shows (1) a disinterest of customers towards pure lighting-based use cases and (2) the technical suitability of lighting installations to serve as sensor platform. It then (3) introduces business model innovation as a mean for industry players to profit from light's enhanced role. (4) We conclude by presenting our answer to the above mentioned shortfalls: Our startup project "Comfy"[1].

Introduction

Lighting in the Smart Home is influenced by two major trends: LEDs and the Internet of Things (IoT). Through LED the light industry is changing radically, as it allows for easy-to-produce and dimmable lighting solutions with an unprecedented color spectrum. This opens up a wide field of possibilities for new products, consumer-centric services and novel business models. On the other hand, the Internet of Things is commonly recognized as the “next big thing”. E.g. Cisco predicts 50 Billion internet-connected devices by 2020 [1], with significant effects for the lighting industries across all sectors.

Up to now, the lighting industry delivered one pathbreaking product for the smart home market in the form of a remotely controllable LED bulb. The basic concept is to connect LED light bulbs with the web and make them controllable via mobile applications or other smart home devices. First players in the market are the Philips Hue and the crowdfunded startup LIFX. Due to the significant market potential, incumbents such as OSRAM, Samsung, LG, Belkin, General Electric are following with products of the same type[2]. However, these offers are not able to inspire long term usage.

Our research and startup project addresses this gap. This article as an excerpt presents our vision for smart home lighting beyond remotely controllable LED bulbs. First, it outlines identified consumer needs in the smart home context with a focus on lighting. Second, it analyzes the technical features of lighting installations. Third, it provides an overview on business model innovation with attention to the

[1] Preliminary project name
[2] Light and Building 2014

lighting industry. Finally, our project "Comfy" is outlined, which we build upon both fact-based and theory-driven insights.

Smart Home Lighting – A Study of Customer Requirements

In a dedicated study we are analyzing consumer needs in the Smart Home context with a focus on lighting. In detail, we compare three groups of use cases: light-driven, sensor-driven and actor-driven use cases. Light-driven use cases are enabled by available, remotely controllable LED bulbs. Sensor-driven use cases are characterized by the installation of additional sensors in the customer's home. Actor-driven use cases are realized by additional actors enhancing the controllable LED bulbs.

Study design: We acquired 250 participants via Amazon Mechanical Turk [2] for a small monetary compensation. To allow study participants the evaluating of abstract use case groups, each of the three use case groups was depicted by seven use cases, i.e. in total 21 use cases. Each participant was asked to evaluate 10 out the 21 use cases one by one. Each use case was described in 25 to 50 words. The evaluation criteria comprised four different items and were measured by a seven-level Likert scale. Three of these items studied the intention to use according to Davis [3] (“I would use such a product.”, “I would consider buying such a product.”, and “I would recommend this product to other colleagues.”). A fourth item focused on the general interest towards the product (“This product fascinates me. It is really new.“). In order to avoid interference effects, we randomized the order of the use cases.

Study findings: The test persons' general interest in the product provides first insights into customer requirements. The visualization (see Fig 1.) shows two essential aspects: First, survey participants perceived lighting-based use cases in general less interesting then sensor-based or actor-based use cases. Second, considering the lighting use cases, ambient lighting and presence simulation lighting are perceived most valuable. In contrast, automatic lighting, lighting notifications and emotional lighting are notably less appreciated by the study participants.

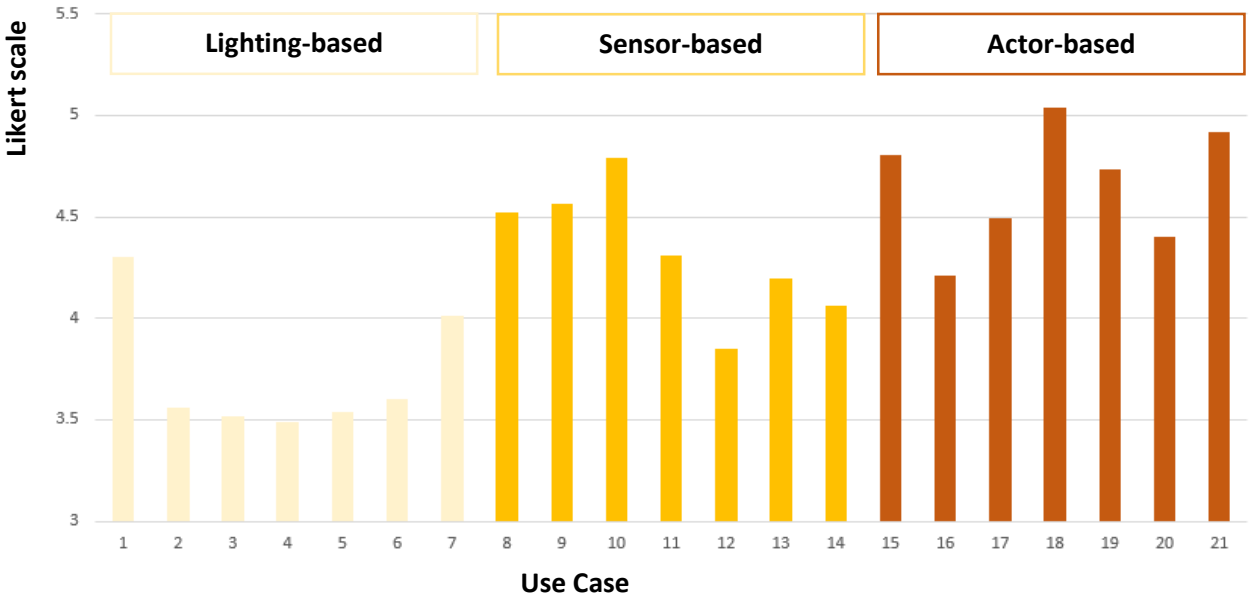

Fig. 1. General average interest (“This product fascinates me. It is really new.”) per use case (see Tab. 1 for use case description).

Use Case Group	Use Case	Intention to use			
		Average	Standard deviation	Group min.	Group max.
Lighting-based	1. Ambient TV Lighting	4.28	1.93	3.39	4.42
	2. Romantic Lighting	3.39	1.87		
	3. Automatic Lighting Kitchen	3.87	1.95		
	4. Automatic Lighting Toilet	3.64	1.92		
	5. Automatic Lighting Living Room	4.03	1.83		
	6. Preventive Security	4.42	1.85		
	7. Light Notifications	3.41	1.85		
Sensor-based	8. Thing Finder	4.66	1.79	3.95	5.04
	9. Ubiquitous music	4.75	1.82		
	10. Smoke detector +	5.04	1.59		
	11. Family presence	4.06	2.05		
	12. Room climate monitoring	4.06	1.53		
	13. Intrusion detection	4.67	1.70		
	14. Health tracker	3.95	1.89		
Actor-based	15. Urban farming	4.64	1.89	3.76	5.01
	16. Intelligent hoover	5.01	1.57		
	17. Automatic shopping	4.50	1.83		
	18. Smart kitchen	4.73	1.83		
	19. Ubiquitous entertainment	4.56	1.80		
	20. Smart wardrobe	3.76	2.12		
	21. Smart lock	4.88	1.77		

Tab. 1. Intention to use per use case group: average values, standard deviation, minimum/maximum.

Our hypothesis, that pure lighting use cases are not the most sought after ones, is supported by an in-depth analysis of the intention to use. We conducted a t-test to compare the average of the three measurement items (cp. Tab. 1). The intention to use lighting-based use cases is significant lower than for sensor-based use cases ($t(1682)=-6.388$; $p<.001$). Likewise, the intention to use lighting-based use cases is significantly lower than the intention to use actor-based use cases ($t(1703)=-7.519$; $p<.001$). To our surprise, actor-based use cases do not stimulate a higher intention to use then purely sensor-based use cases ($t(1730)=-1.236$; $p=.108$).

In conclusion, the study reveals a generally lower interest of customers in purely lighting-based use cases, although two use cases are a notable exception: Both ambient lighting and security related lighting feature above average rankings. A potential limitation of the study design may be an inhomogeneity of the use case groups, which is suggested to be analyzed by future research.

The Value of Lighting Installations in Smart Homes

A wide range of relevant use cases for a Smart Homes exist that are purely based on occupancy data. Smart heating and room climate monitoring systems offer the possibility to save up to 15% of the building energy consumption as well as increasing comfort [4]. Ambient assistant living allows elderly people to stay independent by the automatic detection of critical situations [5]. Smart security systems detect intruders and enable the owner to timely react.

Different approaches for occupancy detection exist [6]. The spectrum of possible sensors comprises wearable inertial sensors, cameras, pressure pads, motion sensors, electric field sensors, and microwave sensors. They can be classified according to their energy requirements, their requirement

to be attached to humans, or their sensitivity. In contrast to their technological maturity, the most relevant question remains unclear: How can customers easily install a network of sensors in their home to profit from the before mentioned use cases?

Light bulbs are one possible approach to solve the sensor distribution problem. A broad installed base exists due to the need of light in every room and standardized fixtures. Light bulbs are usually positioned at a central location in the room, and: They are a source of power. Moreover, LED bulbs provide idle space inside due to the reduced space requirements of LEDs, and possibly can take on additional sensors and connectivity modules.

Business Models in the Smart Home

Business Model Innovation has advanced into a buzzword in recent years. According to a recent study by the Economist Intelligence Unit, Business Model Innovation is thought of as key lever of competitive advantage for companies across branches – superior to technological and process innovation [7]. In a nutshell, a business model (see Fig. 2) describes the overarching logic of how businesses works and features following four dimensions [8]:

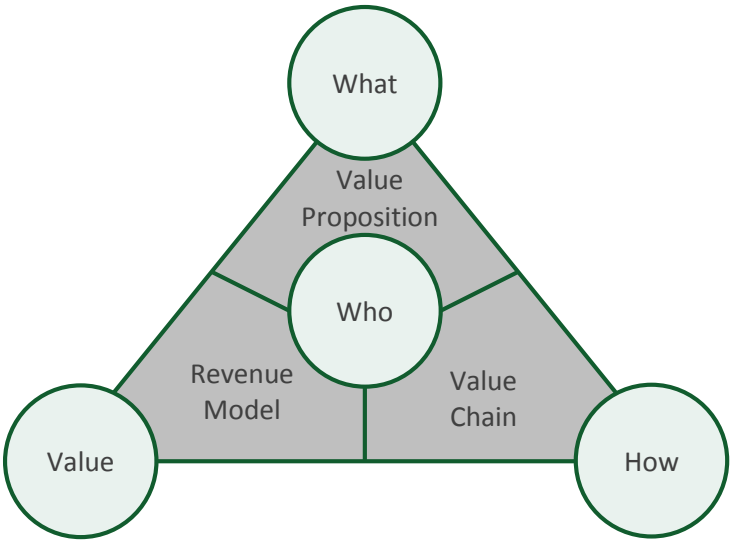

Fig 2. Business model definition: The magic triangle. [9]

- **Who** is the target customer (segment)?
- **What** is the specific value proposition to the customer?
- **How** is value **created**? By what competences and resources? How is it delivered?
- How is **value** captured? By what revenue model?

The relevance of business models proliferated with the diffusion of the Internet since the 1990s. Information and communication technology allowed to change the four dimensions of business models – Who, What, How, Value - and triggered numerous variants of e-business: Different business model patterns emerged [9]. One example is the long-tail business model of online stores like amazon that allowed to address an unprecedented diversity of customer needs, compared to traditional book stores.

Another wave of business model innovation will be triggered by the Internet of Things. With the integration of connectivity and sensors, data come into play and new ways of interaction with the customer are facilitated. This builds the basis for novel services and applications. The customer advances into a "producer" of data and becomes co-creator of value. In this light, a smart home device is no longer a commodity product, yet advances into a platform for data and a growing number of unforeseen services to be leveraged by an ecosystem of partners [10, 11].

Project Comfy

Our project Comfy (see Fig. 3) realizes the idea of an internet-connected LED bulb with embedded sensors. Comfy contains a presence recognition sensor, a brightness sensor, and a connectivity module. This imparts two properties to the bulb: (1) The bulb is able to capture real time presence data about its surroundings and (2) it can be controlled remotely via a smartphone app. Compared to existing solutions, especially the first property lays the foundation for novel services – beyond “just light”. Comfy addresses both light use cases and security use cases.

Comfy is the first home security device which offers triple security functions with following core: preventive, detective and reactive: While the user is absent, Comfy makes him/her feel secure about his home, as it deters would-be intruders by presence simulation. Therefore it switches the lights on and off based on historical presence information. In case of an intrusion, comfy detects unexpected presence at home and notifies you via push message to take immediate action. Like traditional alarm systems, it also bothers the intruder by flashing lights. This combination provides advantages to both traditional security systems and available Smart Home security systems.

One major advantage to existing security systems is its usefulness while the user is at home. Here Comfy provides comfort and convenience through adjustable light on a par with existing remotely controllable LED bulbs. It also provides automatic light based on presence data. The combination of these features is currently evaluated in field tests. First patents are in place.

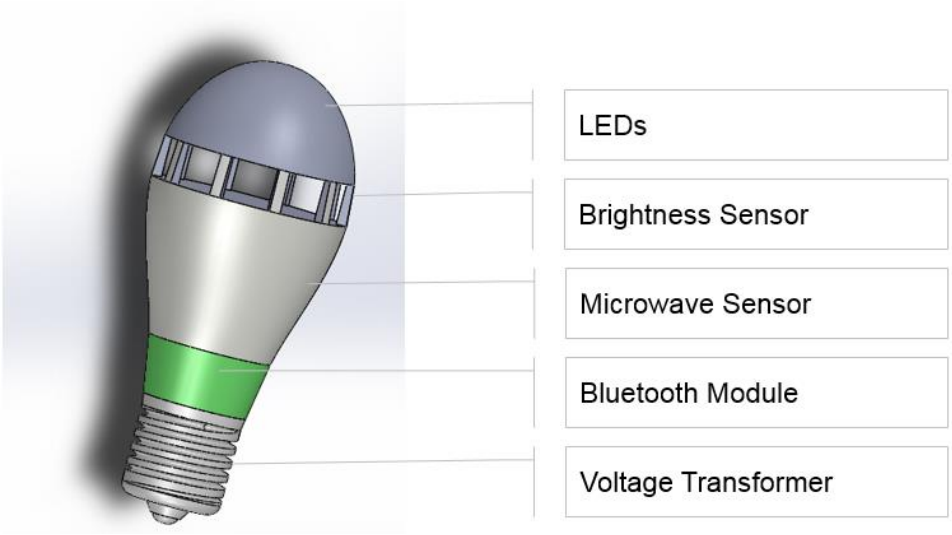

Fig. 3: Technical plan of the Comfy device.

Conclusion

What is the role of lighting installations in a Smart Home? This article develops the concept of lighting installations as a sensor platform in three steps: First, it presents a disinterest of customers towards pure lighting-based use cases. Second, it highlights the relevance of a sensor platform in the Smart Home context and the potential of the lighting infrastructure to take the lead in providing this platform. Third, it introduces business model innovation as lever to profit from "light as platform".

How realistic is the concept of lighting installations as a sensor platform? We cannot predict the future, but certainly influence it: Our project Comfy is a first step towards an evaluation. We look forward to discussing our ideas with interested readers, experts and potential partners.

Acknowledgement

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