Service Design Based on Smart Urban Lighting

Abstract

The lighting industry is in transition from a hardware only industry to a full solution and services industry. With the growing availability of all kinds of data on the one hand, and flexible lighting systems (with sensors and controls) on the other there are many opportunities for new business with services in lighting. It also creates opportunities for new professions, such as in the design of lighting services and in the development of software applications for smart solutions: professions that are new and require different skills than the traditional ones in the hardware related industry.

Introduction

Last year, in the Open Innovation Yearbook 2013, we presented the case of participative innovation in smart urban lighting, with a vision on the future of urban lighting and its transition towards a focus to improve quality of life in cities. In the past months various projects have been initiated to make this vision a reality. All of these projects build on the enabling technologies that led-lighting and ICT solutions provide and seek for meaningful services. In these projects various public and private organisations collaborate to explore new venues. A reflection on these projects shows that new skills are required compared to the traditional professions in the public lighting domain. We will first explain the context of smart urban lighting, and then we will show practical examples of two cases, before reflecting on the consequences for jobs in this field.

Innovative Lighting Solutions

Public Lighting and Public Lighting Infrastructure can play a significant role in achieving ambitions of cities in making the city an attractive place to live. Technological developments include an upgrade of the public lighting infrastructure and system by connecting to ICT solutions. This enables cities to offer a wide range of intelligent and integrated services benefitting society and individual citizens and bringing cities closer to the ambition of becoming smart cities. This integrated lighting- and ICT solution can best be explained by describing 4 levels of the system (see also Figure 1):

- **Infrastructure**
  The level of the infrastructure can be seen as the 'road' that enables all 'traffic'. Traditionally for public lighting this meant the underground wiring for power. Nowadays it also includes Internet connectivity as well as wireless solutions. In the coming years, the infrastructure will become a dense network to enable the connection of all kinds of devices and communicate all kinds of data.
- **Devices**
  The number of devices is growing rapidly. Traditionally, devices in public lighting contain public lighting luminaires and traffic lights. This is gradually expanding with other types of sensors and actuators, either with low bandwidth, such as timers, light intensity sensors, microphones, movement sensors, fine-dust sensors or high bandwidth for example camera's, interactive displays, touch screens, and smart phones. Many devices collect or use data and are therefore connected (the Internet of things).
- **ICT**
  On the ICT level the connection is made with data and software applications. The data that is collected through different devices contains e.g. time, people counting or proximity measurements, weather information, movements, energy consumption, camera data, etc. Mashups and data analytics will lead to insight in emerging patterns or correlations that can be used for various software applications.
- **Services**
  At this level meaningful services are developed that provide value for the relevant stakeholders. In urban lighting there are often different stakeholders that use the area, with different needs and wishes. The ultimate goal of urban lighting solutions is to create value for societal stakeholders by creating a healthy and liveable city. Smart lighting can offer valuable services for different stakeholders using the ICT based lighting platform.

In this four level model, technology is considered an enabler. Technological developments create new opportunities for applications. These applications become meaningful when they address relevant societal needs.

In the coming years innovation will take place at all four levels. Businesses will drive technology developments, securing intellectual property and providing hardware to the market. This hardware will become mainstream, easier to produce in low-cost countries and will create little jobs in Western Europe. However, in the field of meaningful applications designed to address societal needs there are more opportunities for new jobs, especially in the domain of developing new services with lighting. The type of jobs is shifting from hardware related jobs towards the design of lighting services as well is to the development of software applications for smart lighting solutions: jobs that are new and require different skills than the traditional jobs in the hardware related industry.

Figure 1: Levels in the system architecture of intelligent lighting solutions

The development of meaningful applications requires a changing attitude interconnecting the different levels:

1. Open platforms, open data and open knowledge make new connections possible. By linking data and integrating various perspectives new solutions for societal needs emerge. Data analytics becomes an important element to identify emerging patterns and spot new opportunities. It also enables to determine the impact of solutions. The technical challenge lies in the selection of the required devices to efficiently and effectively collect data and integrate all data into a total system.
2. Innovation driven by societal needs requires the active involvement of all stakeholders to find solutions that cater for their different needs. Stakeholders turn from objects to active participants, being involved in all stages, including very early ideation and prototyping. The active involvement of stakeholders is also needed to develop new revenue models that enable the continuous innovation and further development of the services. Municipalities may be able to provide basic infrastructures in public lighting, but due to budget restrictions it is not realistic to expect that all investments will be done from the public domain. By understanding the potential value of innovations for the different stakeholders, also opportunities for co-investment arise.

A Changing Business Environment

Meaningful applications in public lighting are based on societal needs and use the enabling technology in lighting and ICT to provide solutions that address the needs of the stakeholders. Different areas in cities have different stakeholders with different needs. The solutions will need tailoring to the specific situation. For example, an entertainment district in a city has different stakeholders with different needs than a residential area or an area around a school. For each project it is therefore important to start with an inventory of the specific stakeholders of the area and their needs. Based on these needs a creative process starts to define a proposition for an urban lighting solution. With intelligent lighting solutions it is often possible to address different needs with one technical platform as long as the platform is able to offer this flexibility. To illustrate this process we give the example of two projects that are currently in development.

Increasing the Hospitality in a Public Square

One of the projects the TU/e Intelligent Lighting Institute is involved in is the Amsterdam Smart Lighting project. In this project a smart lighting solution is being developed for Hoekenrodeplein, a square in Amsterdam. This project is a collaboration between the city of Amsterdam, Philips Lighting, Cisco Systems, Alliander and the Intelligent Lighting Institute. All partners invest in this pilot with the ambition to create a showcase for smart lighting solutions. Hoekenrodeplein is situated in the surrounding areas of the Amsterdam ArenA where frequent soccer matches and various events take place; the Heineken Music Hall and Ziggo Dome, both hosting large scale music events; the Arena Boulevard, with various shops; the Bijlmer ArenA train station; and Reigersbos, a residential area. So although it is very close to lively areas, the square itself is mainly used by commuters just passing it on the way to their destinations. In the redevelopment of the area an investigation was made of the main stakeholders in the area and their needs. These needs were defined as:

- **Sustainability**
  The city of Amsterdam has the ambition to reduce energy consumption and lower the carbon footprint and therefore would like to use led-based solutions. Furthermore the idea is

to only provide light when needed, and dim the lighting when possible. This is also preferred to reduce the level of light pollution.

- **Safety**
  The reputation of the area is not as good as the city would like. Improvement of the safety is needed for crime prevention and will improve the image of the area. Lighting is seen as a good way to support this need. Furthermore, a specific element in this area is the need for crowd management solutions when events are taking place and large numbers of people visit the area. Smart lighting solutions might also help to manage these crowds.
- **Hospitality**
  Various stakeholders wish to improve the hospitality of the area to attract people and to make them stay in the square for leisure activities. This will also increase the social safety and social cohesion in the area. Smart lighting solutions would potentially have an impact on the hospitality.

Because of these needs, propositions were developed for a smart lighting solution with the ambition to cater for as many needs as possible. The proposed solution is an adaptive lighting solution that creates an attractive atmosphere in any circumstance. It adapts to the use of the square: commuting or leisure. The solution exists of a set of dimmable led lights that reduce energy consumption. The system uses people counting sensors to be able to dim the lights when there is nobody around, but that also gear up when light is needed. Because the square is quite large it also makes use of the fact that the same light level might not be needed everywhere at the same time: by lighting up areas of the square where people are present, a pleasant atmosphere can be provided when it is not so busy, thus create an inviting atmosphere that attracts more people to stay and stay longer. When it becomes busier more lights are turned on, creating a larger area that is attractive to spend time. Furthermore, to increase safety when it is very busy, the system can be geared up to calamity lighting, enabling surveillance and emergency officials to keep an eye on the crowd or provide help when needed. A side effect might be that when these high light levels are applied, some people will find the place less attractive and will leave. Once the amount of people is down to a certain level, the lighting will change again to create a cosier atmosphere.

Technically, the system needed to create these light-on-demand settings involves just lights, people count sensors and an application to design and trigger lighting scenarios. When looking further in the needs identified by the stakeholders, an opportunity was found in using the same technical system to increase a 'virtual stage'. Dedicated spot lights can create a stage for (music) performers and local talents. People can book airtime on the stage through an app. or portal. The performance can be recorded or streamed to the web by the video camera that is normally used for people. This virtual stage can be promoted in connection to events in the area and might make the square more attractive to visit and create a prolonged stay of people before or after events in e.g. the ArenA, Heineken Music Hall or Ziggo Dome. It is even possible to charge a fee for the booking of the virtual stage, thereby creating a revenue model to earn back the investments for the development of the app. and for new investments in the smart lighting system and related apps in the area.

This case shows that the technical system enables the creation of various services for different stakeholder needs. The challenge lies not so much in the technology (although a good system integration of various existing building blocks can still be a challenge in itself), but more in the development of meaningful services that make sense in this specific area. The type of people needed to perform such projects is not the traditional lighting designers that are used to make a lighting plan based on uniform distribution of a sufficient lighting level. In this case the challenge is to creatively design services using the available technology and integrate the different needs into one solution. Furthermore, more dynamic lighting scenarios need to be designed, that address issues as atmosphere creation and changing the behaviour of people (in this case to invite them to stay in the square they otherwise only pass by). This will not be just a one-time design, but regular new lighting scenarios are needed to keep the square attractive over longer time for returning visitors. The hardware infrastructure allows for such flexibility.

Increasing Safety in an Entertainment District

The city of Eindhoven is currently implementing its vision and roadmap for urban lighting. This involves the set-up of various living labs in the city to explore the opportunities of innovative lighting solutions to increase the quality of life in the city. One of the living labs is related to the project Stratumseind 2.0. Stratumseind is the entertainment area in Eindhoven, a street of approximately 400 metres long with around 50 pubs, attracting over 20 000 young people every weekend. As in many entertainment districts, incidents happen. Moreover, the businesses in the area are suffering from reduced turnover. This was the reason to start collaboration between the entrepreneurs, breweries, property owners, police and city council and set up the living lab to explore

the possibilities to structurally improve and increase the economic and social activities on Stratumseind. The main needs identified in this case are:

- **Safety**
  The ambition is to reduce the amount of incidents. Stratumseind is also a very well-known area for specific events such as the celebration of national holidays and victories of the Eindhoven soccer team PSV. At times it can be really busy, and crowd management becomes an issue.
- **Liveability**
  Improving the liveability for the neighbouring residents. Some residents are living directly above the pubs and others live in adjacent streets and experience the area as being very noisy at times.
- **Attractiveness**
  The area is well visited in the weekends, but mostly late at night. There is a need to extend the liveliness for a longer time by attracting more people during daytime and early evening.

One of the propositions being explored at Stratumseind is the ability to influence mood and stress levels of the visitors of the street. For this purpose a research project 'De-Escalate' was defined that got awarded with a national subsidy in the Netherlands. Partners from various organisations also invest in the project, including the municipality of Eindhoven, Polyground, the Dutch Institute for Technology Security and Safety, the association CrimiNee, Philips Lighting, ViNotion and the TU/e Intelligent Lighting Institute.

The idea is to install a lighting system that enables different atmospheres through dynamic lighting scenes. The existing public lighting will be replaced by led, where not only warm white and cool white light, but also red, blue and green leds are integrated in a fixture. The led's can be controlled individually, allowing the creation of a very wide range of colours and intensity levels, as well as dynamic patterns. In this way different scenarios can be created that respond to triggers in the street and aim to diffuse escalating behaviour. For this system to work it is important to establish whether there is a risk for escalating behaviour.

In the living lab a 'base camp' has been opened recently where data from various sources is collected and combined to determine the real time level of the risk of escalation. OpenRemote provides an open platform that integrates different devices and provides a user interface for the control of the lights. The data that is collected contains a number of real time measurements such as: 3D sound measurements to identify noise levels and the direction of the noise, social media watching to identify how Stratumseind is being mentioned, and counting people entering and leaving the area to establish the bustle. Other data is collected with a delay, such as: police reports on incidents, determination of origin and counting of mobile devices to establish where groups of people come from, litres of beverages consumed by collecting data from the breweries or amount of waste thrown in the street measured by the cleaning service. Correlating the data on the incidents to specific parameters is done to predict when there is a higher risk for escalation. Historical data from past incidents is now used to find such correlations. Based on the determined risk level, lighting scenarios are activated. For this purpose different lighting scenarios will be designed that aim to diffuse the escalation and in the living lab their effectiveness will be researched.

Also in this case the technological infrastructure provides opportunities to address also other needs. An example here is that when the 3D sound sensors were installed, it suddenly appeared that during the weekend there was no block of 3 hours that the residents in the area could sleep well. After the closing of the pubs, late in the night, it was quiet for a while, but very early in the morning the cleaning cars caused high noise levels again, followed by the ringing of the bells of the nearby church. By changing the time of the cleaning to coincide with the church bells, the liveability of the area was significantly improved. Another example is the use of the lighting system not just to diffuse escalation, but also to create a more attractive atmosphere in the early evening to invite people to come earlier or attract other people at different times of the evening.

The challenge in this case lies much more in the integration of all the information collected by the sensors and other systems. The analysis of data of different nature and combining patterns to create new insights is a key element in this case. This requires new skills for data scientists. With these insights lighting scenarios can be designed and tested on their impact on the mood and behaviour of people.

New Professions

Looking at the two cases presented above we can see a shift in the type of skills required from the more hardware related to new ones that focus more on the ICT and services part. We would especially want to highlight two professions that are new in the domain of urban lighting: the data scientist and the dynamic lighting service designer.

Data Scientists

Data scientists know how to gather data with the Internet of Things. They know what combination of

sensors and data gathering is required to obtain relevant data and how to register the data. They also know to apply the various models, theories and tools to add and extract value from sets of the gathered heterogeneous data. They turn data into information. What is also relevant in the context of smart urban lighting is to use this information to understand and influence human behaviour. The data scientists bridge the technical competences and the social sciences.

Dynamic lighting service designers
These designers need to be able to empathise with the different stakeholders. In comparison with traditional designers, who focus mainly on users, they need to extend their scope and research the needs of a wider range of stakeholders. This will provide them with insights as input for various use scenarios. With the help of these scenarios they can search for creative ways to apply new technologies to alleviate the needs and provide new services for the different stakeholders. Next to these skills, they also need to understand the impact of lighting on people's mood and behaviour to be able to create desired atmospheres and experiences. In comparison to traditional lighting design, this also requires the application of dynamic and interactive lighting scenarios. Moreover, these designers need to be very aware of the ethical impact of their designs. This is particularly important for public spaces.

Both professions are needed on recurring basis; therefore more work is being created than one might think at first sight. The renewal rate of the infrastructure is relatively low: once broadband and sustainable energy provision is secured there is no need to change the infrastructure on short term again. The renewal rate for devices is slightly higher, because of the limited technical lifetime (such as electronics), and with new and better technology being introduced they may have an even shorter economical lifetime. The renewal rate for the software and applications is even shorter. The data scientist might find new emerging patterns that spark the development of new applications. New applications are launched daily in the smart phone business. Similar renewal rates may apply for software applications build on open platforms in the field of smart urban lighting. Also the renewal rate of services will be relatively high. New applications will give rise to the need for new lighting scenarios. Moreover, even when there are no innovations on the other levels in the system, regular new lighting scenarios will be needed to keep an area interesting and inspiring. On top of that changes in weather, seasons, type of festivities etc. might call for adapted lighting scenarios. So both professions are not just needed in the design and implementation phase of projects, but will be needed over the lifetime of the system to adapt the system to keep the city an attractive place to live.

Contact

The projects mentioned are done in collaboration with various partners. If you are interested, please contact us through: www.ili-lighthouse.nl or www.tue.nl/ili.

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