The architecture behind networked lighting

Johan Lukkien interviewed by Michiel de Boer of Moesasji

Turning a switch may soon be obsolete. Lighting systems are rapidly transforming into networked systems, offering a complete range of new functionalities. Lighting can become adaptive, invigorating and even healing. However, with the growing number of components and the increase of wireless connectivity and complexity, the system architecture behind lighting systems needs to evolve to keep up with the pace of development. We asked Prof. Dr. Johan Lukkien, chair System Architecture and Networking (SAN) at the TU/e Department of Mathematics and Computer Science and a thought leader of the ILI Bright Environments program, about their work intelligent networked lighting systems.

"We are looking into networked and embedded system architectures in a broad sense. With lighting becoming a networked system, we aim to contribute to the reliable, safe and cost-effective architectures for such systems. We bring a technological perspective to ILI. A lot of our effort goes into designing proper resource management in the system architecture. By this, we mean balancing budgets in terms of money, time, memory, processor capacity, seamless communication protocols and energy usage."

Golden formula?

By replacing mechanical parts in systems with hardware and software components, we rely increasingly on embedded computing power. With the progress of technology, we need systems that can perform in an ever faster and yet reliable way.

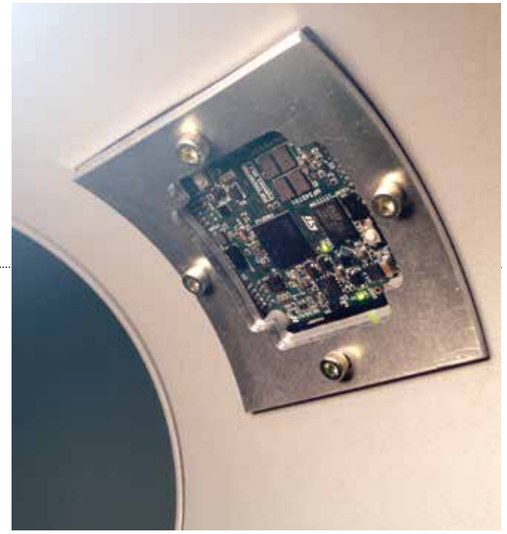
"The average car, for example, already contains up to 100 processors. By connecting these in a (networked) system you can do wonderful things, however, it comes with challenges as well. While the intelligence of our systems increases, we produce heavy amounts of data and are at the same time trying to decrease the processing loop times. Since processors and memory storage have their limits, we create systems in which data is distributed to multiple processing and storage units, thus increasing complexity. Furthermore, the growth of the software part in systems is just as much an asset as a problem. It is harder to maintain the software, difficult to detect errors and complicated to keep it predictable. There is no golden formula in system architecture: the problem domain defines what is the most dominant and thus which route can lead to a solution."

Stakeholder concerns

"Next to technical restraints, we increasingly encounter stakeholder concerns in the development of system architectures. Interconnectivity brings new questions to the table. Examples are transparency, privacy, safety and governance. The connected vehicle, for instance, places governments in a new position.

"Within a European project together with Philips Lighting, we aim for an open standard in connected lighting systems."

Possibly, they will need to get out of their chair of regulators and act as data managers as well. Also manufacturers need to reconsider their approach. Maybe they should not build the applications themselves, but allow external developers to build them on top of their frameworks, that is, like Apple did with the developer framework for iOS-apps. The iPhone and the iPad would never have been such great systems without the opening of the platform."



This leads to the conclusion that connected lighting systems could benefit from open structures for the development of network components and applications. Open systems allow all parties to contribute and innovate.

"You can solve nearly any technical problem if you have enough time and money. However, **solving it cost effectively is a challenge**. The Internet of Things (IoT) boosts progression in technology and the IoT movement shows more and more conversion towards cost-effective standardized protocols and frameworks we can all benefit from."

Connected lighting

How do these developments relate to lighting?

“Connected lighting takes on the characteristics of similar networked systems. There is, for instance, a tendency towards wirelessly communicating components for the ease of instalment and remote control. However, wireless lighting systems need a cascaded structure. Their radius is limited to a few tens of meters. This means they need to work together to get the information across which causes all kinds of issues in synchronization, detection and communication. Compare it to a crowd at a festival. Sending everybody an alert on their smartphones at the exact same time is no use. The alerts would be lost in interference. The same applies to all wireless networked systems; you will have to balance data volume and distribution speed. We are currently looking into smart protocols to cascade communication towards system endpoints fast and efficiently. Together with Philips, NXP, Zumtobel, ARM, Johnson Controls, Imtech, Tridonic and TNO we aim for an open standard in connected lighting systems in the European H2020 project called Open Architectures for Intelligent Solid State Lighting Systems (OpenAIS).”

Achtse Barrier experiment

“In the past years, we ran an experiment with adaptive street lighting in the Achtse Barrier (residential area in Eindhoven) with several groups in ILI. This produced a lot of interesting results. Things we expected, but also surprises. The first conclusion is: dynamic street lighting is relevant from an environment perspective but hardly cost-efficient, in spite of what newspapers tell you. Energy cost of a lamppost is very low – almost free. Switching street lighting to LED means a huge saving in energy usage. An average lamppost consumes 300 kWh a year, which equals 30 Euros. Switching to LED brings it down to 15 Euros a year, while further dynamicy saves another 2 or 3 Euros per year. That means you have only 3 Euros per lamppost to add some kind of intelligence. Second is the perception of the adaptive street lighting. People like it. The adaptivity makes them feel someone is watching over them. We do conclude, however, that the system has to be very transparent. People don’t like unexpected changes in lighting and need to get used to the way the system functions. When a cat crosses the street and the lights go on, people want to know what’s happening. Third is that the extra use cases of a networked lighting system are interesting. Since you have a network structure available, you can also equip some of your lampposts with sensors to detect air quality for example, or put in cameras for safety-monitoring.”

Bridging disciplines

“ILI is a beautiful scientific institute. I find working together with different groups and disciplines enlightening. It allows me to expand my horizon beyond my primary source of research and touch parts of psychology, physics and chemistry as well. After all, connected lighting is a technical system, but the impact lies in the experience and health benefits it brings. This context is important because the lighting systems of the future are built around the needs and desires of humans (they may even be self-learning) and, therefore, feature a seamless integration of diverse technologies. That is also what I aim to teach my students. I want to help them to understand the properties that do not directly relate to the functioning of the system. I want to increase awareness about what they create: ‘If I change this, privacy is no longer guaranteed, or safety is at stake’. I think the **Bright Environments** research program enhances this contextual thinking and builds bridges between disciplines.”