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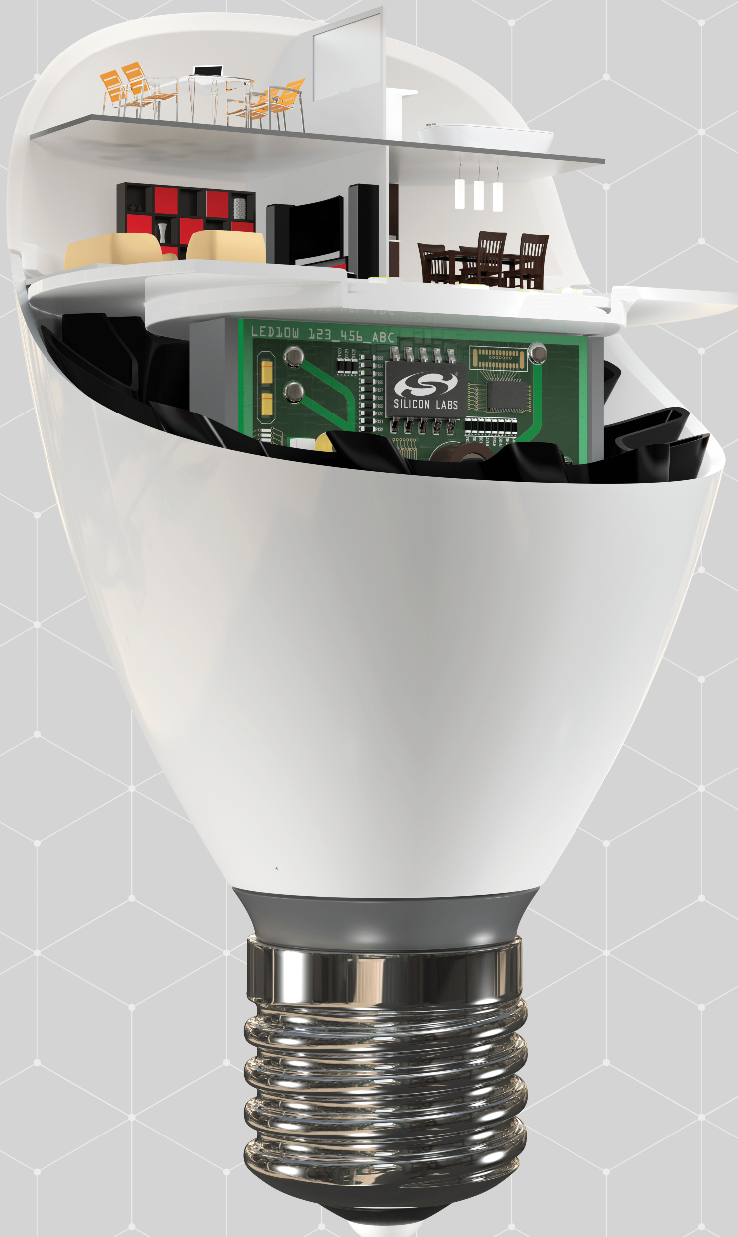
Flipping the Switch on Smart Connected Lighting



Flipping the Switch on Smart Connected Lighting

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In this whitepaper, we explore the rapidly maturing smart lighting market and examine some of the motivations driving consumers toward home automation. We'll also take a look at the specific design challenges that come with wireless lighting connectivity and how developers are addressing growing demand with the latest technology.

Reimagining the Light Bulb

It's been nearly 140 years since Thomas Edison filed his first patent for "Improvement in Electric Lights," which described using a carbon filament as an incandescent conductor to limit the heat so light could be sustained for extended periods of time. From those days, when a chief design concern was not having your prototype burst into flames, to today, when lighting is virtually taken for granted, clearly much has changed.

One of the most disruptive advances in lighting in the 14 decades since Edison's breakthrough has been the invention of the LED. Today's LEDs, connected LEDs in particular, bring with them some added functionality like color options. They also offer significant energy savings as well by emitting more lumens per watt than traditional incandescent bulbs. Plus, the energy efficiency of LEDs is not impeded by size. But all of this control comes with a whole new layer of complexity for users thanks to the required connectivity.

Imagine coming home from work and the lights come on before you walk through the door. Or bedroom lighting that slowly wakes you up in the morning over the course of an hour by gradually adjusting the color and brightness of your bedside lamp.

Today, LED lighting is a $30 billion global industry, but it still hasn't quite crossed the chasm into mainstream adoption. Currently, colored connected bulbs cost around $50 each, and the average US home has 40 sockets. Spending nearly $2,000 on bulbs isn't going to accelerate adoption for anyone, save for maybe the most dedicated early adopters.

But prices are coming down. Standard LED bulbs were $25 each in 2014, and today they're $2. This price settlement is creating an opportunity for vendors to get serious about differentiation.

The Advantages of Connected Lighting

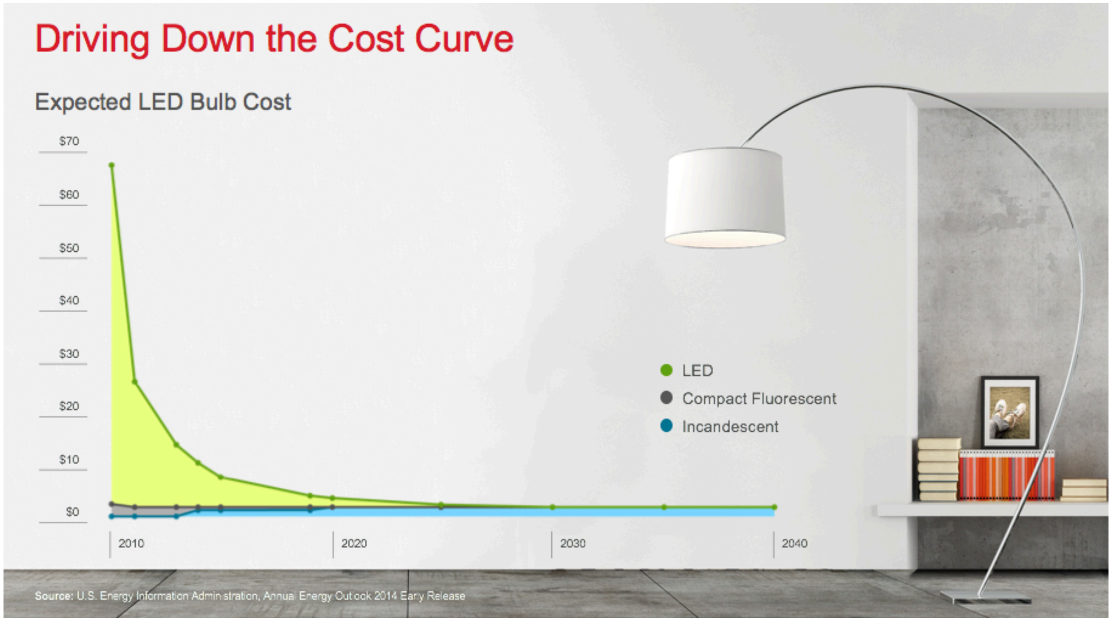
As we mentioned earlier, there are three primary benefits that are driving the adoption of connected lighting: convenience, intelligence, and data analytics. Lighting is a powerful environmental factor, heavily influencing how we go about our daily lives. In an office environment, for example, lighting is typically static so it doesn't change. The light is either on or off. And when it's on, it floods the room in fluorescent light. This works well for reading a book, but it's not very good for staring at a computer monitor. If you could adjust the ambient lighting accordingly, you now have the ability to tailor the lighting to fit the task. Smart lighting, and its use of intelligence and sensors, also opens up opportunities for users to gain insight on things like occupancy data or monitoring the conditions in a room, temperature, or even traffic patterns. Finally, smart LEDs can provide analytics related to location and space utilization. For example, LEDs can be used to determine when areas of a building are most utilized or provide feedback on how efficiently warehouse space is being used.

The average home in the US has 40 sockets, and connected, color bulbs cost around $50 each.

Most people will ease into smart lighting by installing a few connected LEDs at home. Besides changing the nature of the output, smart lighting and the connectivity that comes with it brings a host of benefits to residences. The ability to wirelessly monitor and control will empower users to take control of energy usage wherever they are. The added value of intelligence and data analytics also gives consumers a real-time view into their energy consumption, the ability to control their smart things from a mobile device, and add more sophisticated features like occupancy and ambient condition sensors so an environment can respond without any action from the user. Occupancy, ambient light, even temperature sensors can all play a part in being able to control the lights more intelligently. Turning off the lights when no one is in the room is truly just the tip of the iceberg.

Location-based lighting is also an emerging convenience. This is the idea of using lights to determine the location or occupancy of the people. Light suggests activities and people gather where lights are. Since lights are immobile, typically spaced out evenly in industrial, commercial, and even some outdoor locations like parking lots and city centers, they provide the perfect bearing to people's location. There are many use cases for integrating location-based capabilities in a light. In the simplest form, combining the health status and the location of a light, one can preventively determine when to service the light, saving time and money. Using technologies like sensors, or Bluetooth® beaconing, one can accurately determine the location of a single person.

Aggregating the data over time and space, the information can then be used to determine the space utilization efficiency of a warehouse, a super market, or even a parking lot. Another use case of this data could be for retailers to selectively promote their products based on the location of the shopper.



In 2014, standard (non-connected) LED bulbs cost $25 each, and today the price has dropped to around $2 each.

Emerging Market Trends

Security, is becoming an issue for IoT devices in general, and lighting is no exception. A system is only as good as its weakest link. But whose job is it to make the system secure? Security should not be seen as a feature that can be enabled at the end of the development cycle, but rather a process.

These wireless systems are complicated, and as an engineer the focus is on making something work. It's easy to become single-minded in that pursuit at the expense of other considerations. A strong, systematic approach can mitigate these dangers and allow teams to focus on their area of expertise.

The good news is that the tools exist today to greatly enhance the security of smart lighting systems.

Rather than innovating, the challenge is to learn to use technology in the correct way. For example, turning off the security features in Bluetooth or ZigBee chips can simplify development and ease debugging. This may also result in a less expensive part, so there may be some financial incentives to disable security. Another common mistake is not closing the debugging interface when a chip goes into production. If an end user connects a debugger, the chip becomes fully transparent. Removing security might have short term benefits, but has long term costs that far exceeds those benefits.

Everyone serving the smart lighting market – from chip designers to consumer device manufacturers – need to shoulder the responsibility together. Currently there are no real incentives for anyone to take on more than what they perceive as their share of the load. When high profile attacks happen, the fallout goes far beyond the loss of revenue or damage to a single brand. The loss of consumer trust can reduce the market for a long time. As with any technology, user experience is critical and the more insecure consumers feel as a result of these isolated, but highly publicized failures, the more hesitant people will be to adopt. Longer term insecure devices might trigger regulation or certification of the industry.

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Design Requirements and Flavors of Multiprotocol Connectivity

When looking at smart lighting systems, we believe these are the key high-level requirements:

Low Cost	***Small Size***	***Long Product Life***
Strict Regulatory Requirements	***High Operating Temp. (125° C)***	***Flexible Connectivity (Multiprotocol)***
Secure	***Future Proof (Over-the-Air Updates)***	

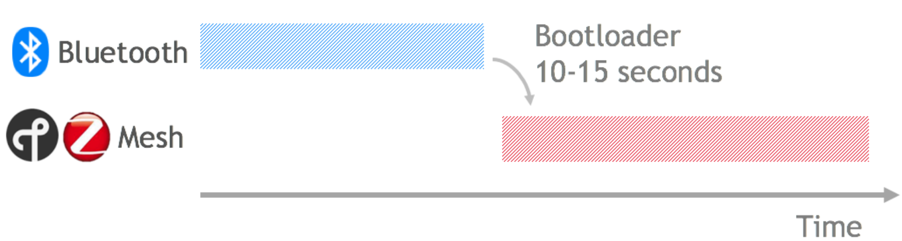
The flexibility and ease of use of multiprotocol compatibility is becoming a differentiator to provide better user experience and enhanced uses cases. This can be around simply doing Bluetooth commissioning for ZigBee, or it can be about running both ZigBee or Thread and Bluetooth at the same time.

Programmable Multiprotocol

The most basic multiprotocol support entails having a chipset that, when programmed with the right software stack, can run any number of wireless protocols. Being able to program a chip in production to support Bluetooth Smart or ZigBee or Thread or some proprietary protocol means that a manufacturer can streamline their hardware design and quickly address different markets. A chip platform that supports multiple protocols via different software images is a fundamental prerequisite for all other multiprotocol use cases.

Switched Multiprotocol

The next step forward for any multiprotocol platform is to be able to change which wireless protocol is supported by bootloading a new firmware image when the device is already deployed in the field. As we will see, this requires some fundamental building blocks to be in place, but opens up a lot of opportunity for future-proofing existing products, including making use of smartphone connectivity to simplify and secure commissioning devices onto ZigBee, Thread, and other wireless networks.

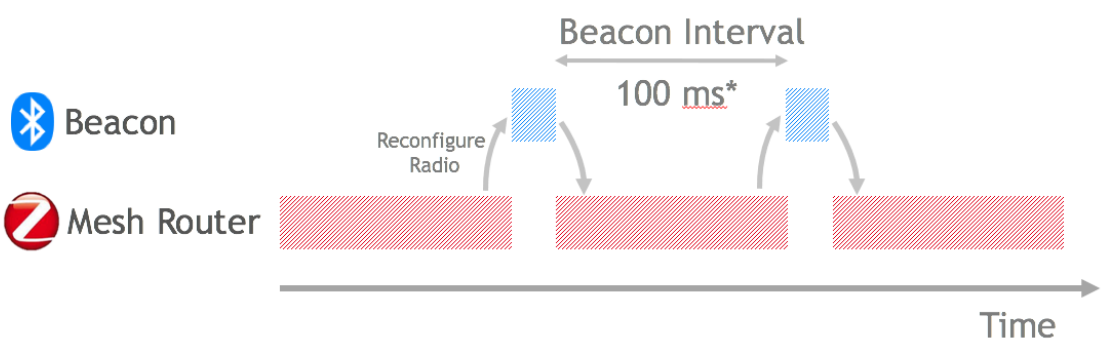


Dynamic Multiprotocol

Ultimately, any multiprotocol solution must address the possibility of running multiple wireless protocols together on one chip, using a time-slicing mechanism to share the radio between protocols. This opens up even more use cases, especially when combining Bluetooth Smart with other wireless protocols. The simplest of these use cases involves the periodic use of Bluetooth beacons from a device that normally operates on ZigBee, Thread, or some other wireless protocol.

An example of this at work is the use of Bluetooth beacons to enable proximity-aware applications alongside a mesh network, such as a retail lighting network. If a retail store is equipped with a ZigBee-controlled lighting system, the ZigBee-enabled lighting fixtures could also be made to transmit a Bluetooth beacon periodically. Lighting in a store is an ideal way of not only determining location as lights tend to be spaced evenly and throughout the area but also transmit information to devices based on those locations.

A Bluetooth beacon is used to advertise the device's presence and services. By using received signal strength (RSSI) measurements on periodic received packets, it is possible for a mobile device to determine how close it is to any given beacon and whether it is moving closer to it or further away. Monitoring multiple beacons can provide quite an accurate understanding of where the mobile device is in the store. In this example of a retail store environment, Bluetooth beacons can be used to deliver coupons and tailored offerings relevant to where you are in the store. The store would provide shoppers with a smartphone app, and by monitoring the beacons emanating from lighting fixtures located around the store, the app can provide location-specific information and create an interactive user experience based on nearby products and services.



Concurrent Multiprotocol

This is essentially a special type of Dynamic multiprotocol. For wireless protocols that share the same MAC and PHY, there is an opportunity to avoid switching the radio between different PHYs or modulations. In particular, with ZigBee and Thread both residing on an IEEE 802.15.4 2.4GHz MAC/PHY, there is an opportunity to share that PHY and run both stacks on one device, effectively running both simultaneously because the radio is always available to both. Routing between ZigBee and Thread in the same network could be a very interesting prospect.

The difference between this use case and other dynamic use cases is that because there is no changing of radio protocols or parameters, there is no loss of packets while you are off the network, although of course with 2 networks/protocols sharing the bandwidth, you still cannot receive a ZigBee packet and a Thread packet simultaneously but normal CCA mechanisms apply to avoid collisions.

Simultaneous Multiprotocol

True simultaneous operation, especially where different radio frequencies are used by different protocols, really requires two radios. There is a lot of value in an application and networking stack that can operate across two radios that perhaps even utilize two completely different frequency ranges. One example of this is Smart Metering in Great Britain, where the government will deploy dual PHY ZigBee communications hubs in 30 million premises through 2020. This effort is to enable a Home Area Network that contains both 2.4GHz ZigBee devices and sub-GHz ZigBee devices (operating at 863-876, 915-921MHz), maintained on the same logical PAN with the communications hub routing traffic between devices on different radio frequencies.

Application Areas

There are several areas where smart lighting is beginning to generate serious momentum. We've talked about the consumer market and the importance of usability there. We're also seeing accelerated adoption in commercial applications like retail and healthcare, as well as municipal use like streetlights. Each of these application areas carry unique design challenges and requirements. We'll be exploring each of these area in more detail within three forthcoming whitepapers:

The Smart Home

In the next part of this series, we'll take a look at some of the automated and smart lighting solutions entering the consumer market and how you can get to market faster by bringing the latest low-power MCUs, wireless technologies, and mesh networking standards (including ZigBee and Thread) to your connected home applications. We'll look at the advantages offered by having the right wireless stacks, certified modules, and reference designs as well.

The Smart Building

We'll also take a look at smart buildings and factories, where connected, energy-efficient LED lighting can generate substantial energy savings, help personalize work spaces, and optimize manufacturing by leveraging the right multiple wireless protocols, including ZigBee, Thread, and Bluetooth with SoCs and certified wireless stacks.

The Smart City

Smart lighting can help make municipalities safer, reduce energy costs, and encourage community engagement. While the Smart City includes Smart Buildings, it is much more then that. It brings together the complexity of not only sheer size, but also multiple vendors that must be managed effectively and efficiently.