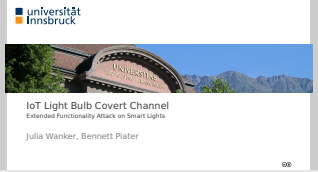
universität
innsbruck

IoT Light Bulb Covert Channel

Extended Functionality Attack on Smart Lights

Julia Wanker, Bennett Piater



IoT Security in General

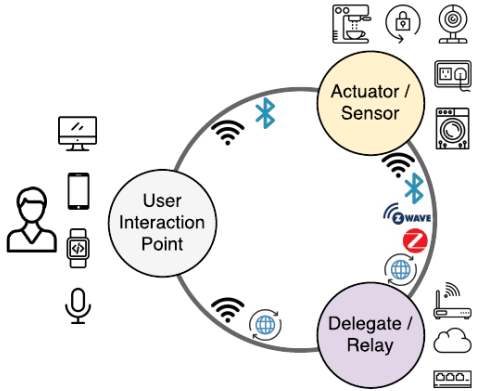
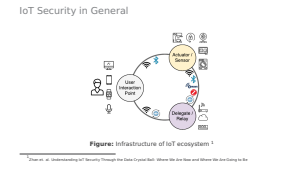


Figure: Infrastructure of IoT ecosystem [1]

[1] Zhan et. al. Understanding IoT Security Through the Data Crystal Ball: Where We Are Now and Where We Are Going to Be



IoT Security in General

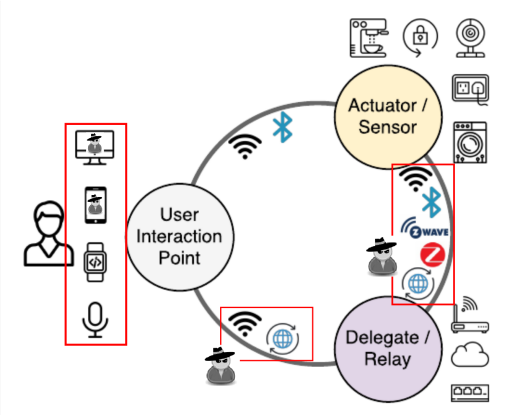
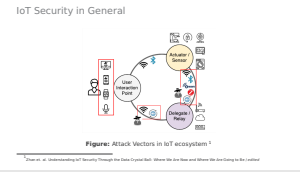


Figure: Attack Vectors in IoT ecosystem [1]

[1] Zhan et. al. Understanding IoT Security Through the Data Crystal Ball: Where We Are Now and Where We Are Going to Be / *edited*



Smart Light Security

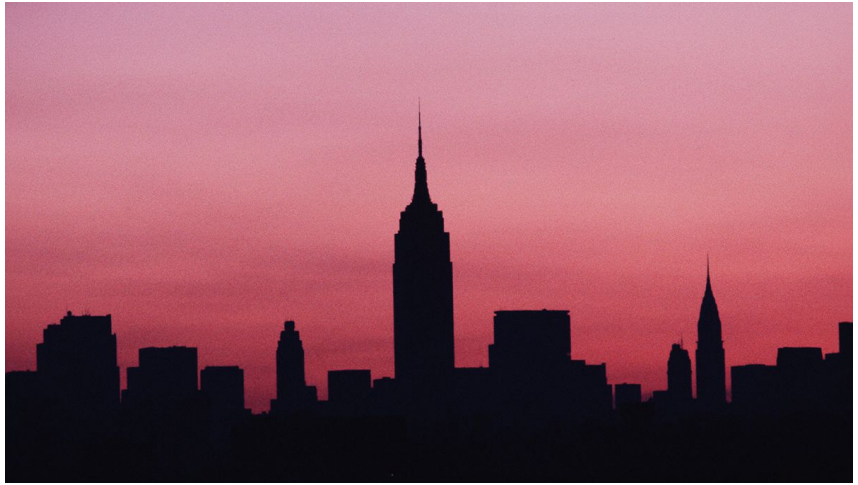
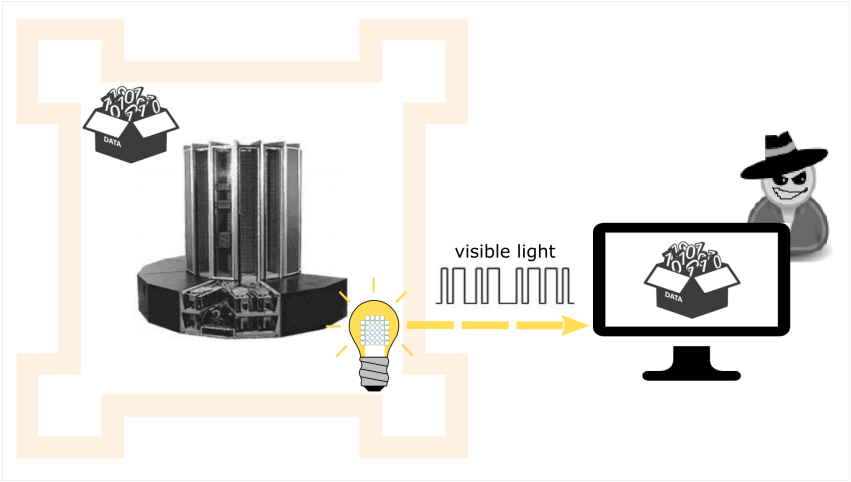


Figure: NYC Blackout of 1977 (Allan Tannenbaum/Getty Images)

Smart Light Security

Figure: NYC Blackout of 1977 (Allan Tannenbaum/Getty Images)

Extending Functionality

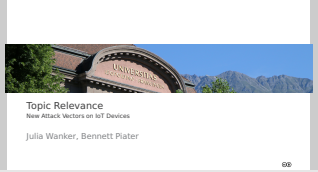


Extending Functionality

Topic Relevance

New Attack Vectors on IoT Devices

Julia Wanker, Bennett Piater



Communication With Lights

General Light Communication

- Change PWM signal
- **Off** period represents logical **0**
- **On** period represents logical **1**

Smart Light Communication

- Send close brightness change commands
- **Lower leve** represents logical **0**
- **Higher level** represents logical **1**

(Covert) Communication With Lights

Covertness

- Flicker at a rate above 60 Hz or use close brightness commands
- Detectable by sensor but not seen by human eye

(Covert) Communication With Lights
Covertness
* Flicker at a rate above 60 Hz or use close brightness commands
* Detectable by sensor but not seen by human eye

Smart Light Systems

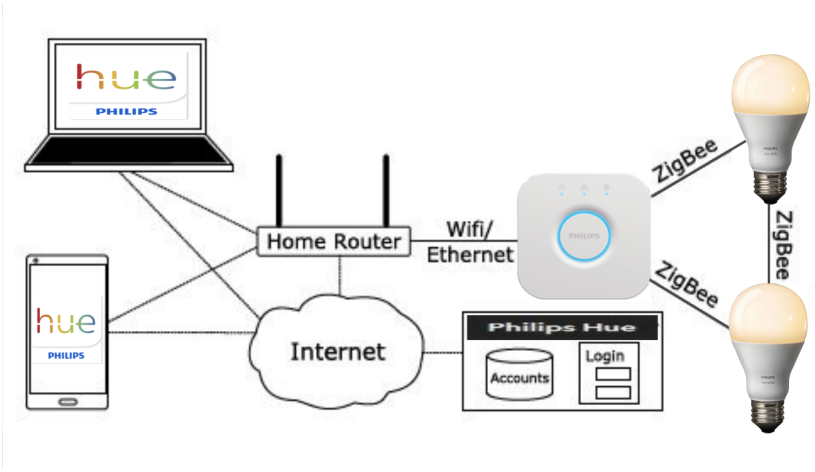
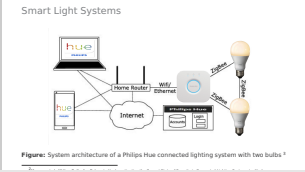


Figure: System architecture of a Philips Hue connected lighting system with two bulbs [3]



Theoretical Background

Extended Functionality Attack on Smart Lights

Julia Wanker, Bennett Piater

Theoretical Background
Extended Functionality Attack on Smart Lights
Julia Wanker, Bennett Piater

Controlling the Light

We use the Hue API for simplicity.

- Bridge controls light via ZLL
- We interface with REST-API on bridge

Controlling the Light

We use the Hue API for simplicity.
- Bridge controls light via ZLL
- We interface with REST-API on bridge

Controlling the Light

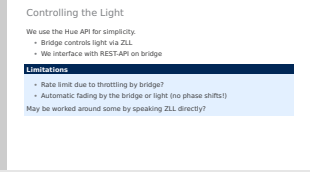
We use the Hue API for simplicity.

- Bridge controls light via ZLL
- We interface with REST-API on bridge

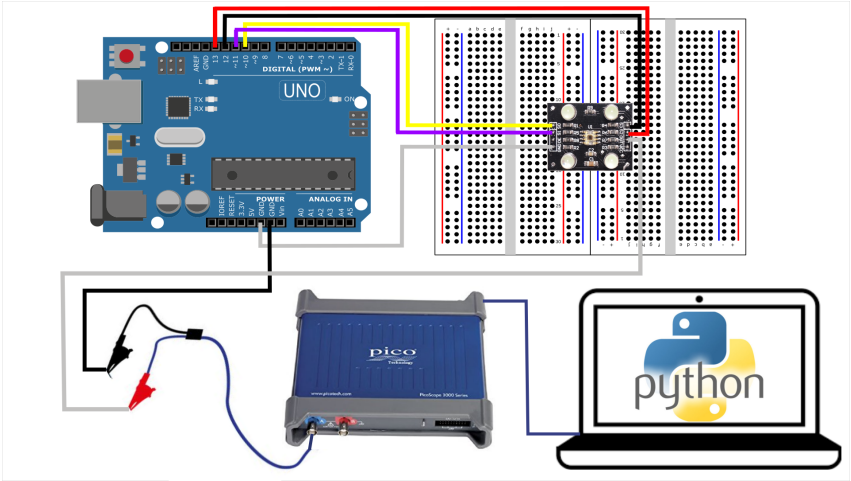
Limitations

- Rate limit due to throttling by bridge?
- Automatic fading by the bridge or light (no phase shifts!)

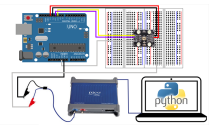
May be worked around some by speaking ZLL directly?



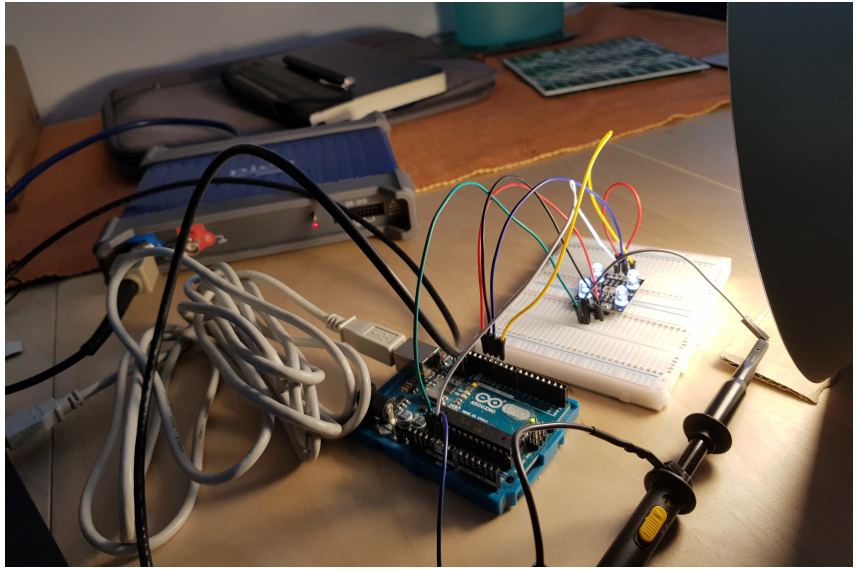
Overview



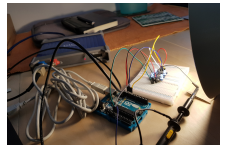
Overview



Experimental Setup



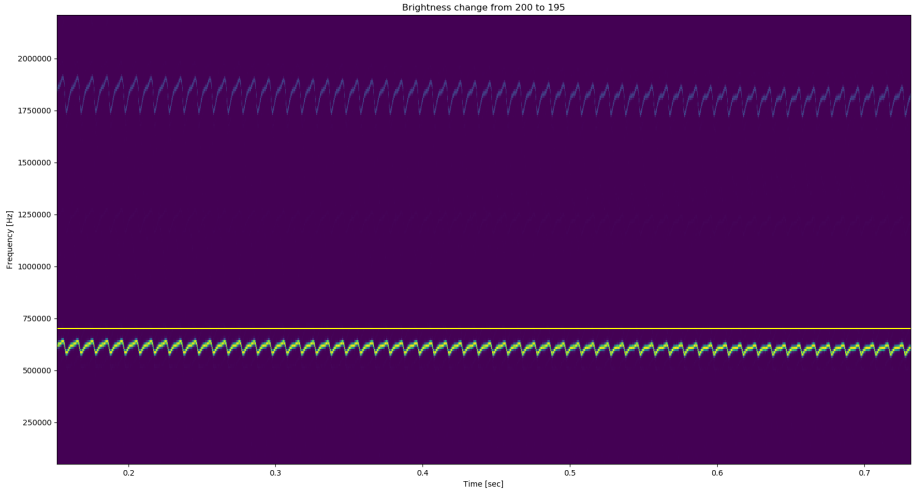
Experimental Setup



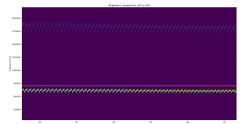
Some Results I

Some Results I

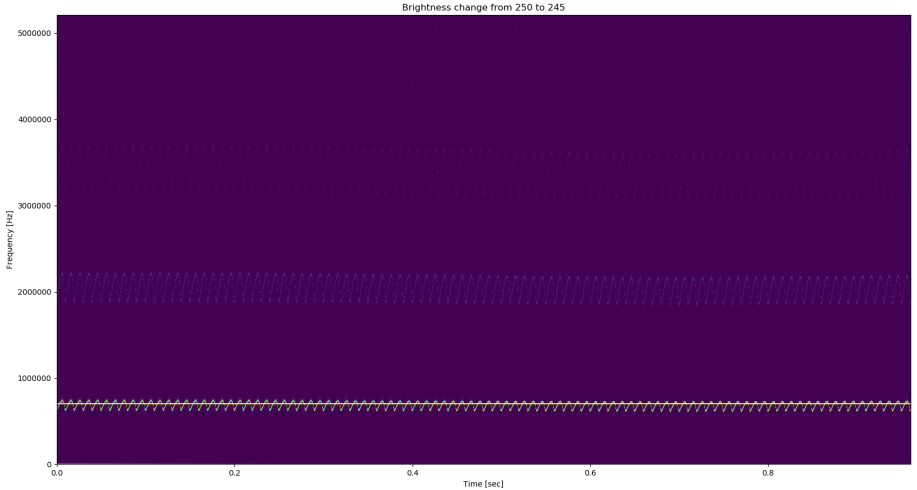
Some Results II



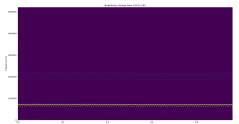
Some Results II



Some Results III



Some Results III



Theoretical Background

Extended Functionality Attack on Smart Lights

Julia Wanker, Bennett Piater

Theoretical Background
Extended Functionality Attack on Smart Lights
Julia Wanker, Bennett Piater

Demonstration

Covert Communication Channel on Philips Hue White Smart Light

Julia Wanker, Bennett Piater

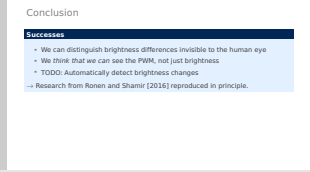
Demonstration
Covert Communication Channel on Philips Hue White Smart Light
Julia Wanker, Bennett Piater

Conclusion

Successes

- We can distinguish brightness differences invisible to the human eye
- We *think that we can* see the PWM, not just brightness
- TODO: Automatically detect brightness changes

→ Research from Ronen and Shamir [2016] reproduced in principle.



Conclusion

Successes

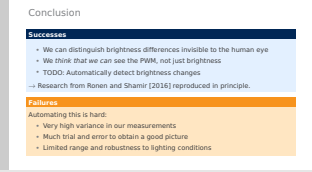
- We can distinguish brightness differences invisible to the human eye
- We *think that we can* see the PWM, not just brightness
- TODO: Automatically detect brightness changes

→ Research from Ronen and Shamir [2016] reproduced in principle.

Failures

Automating this is hard:

- Very high variance in our measurements
- Much trial and error to obtain a good picture
- Limited range and robustness to lighting conditions

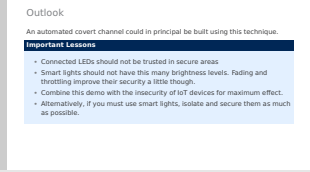


Outlook

An automated covert channel could in principal be built using this technique.

Important Lessons

- Connected LEDs should not be trusted in secure areas
- Smart lights should not have this many brightness levels. Fading and throttling improve their security a little though.
- Combine this demo with the insecurity of IoT devices for maximum effect.
- Alternatively, if you must use smart lights, isolate and secure them as much as possible.



Questions?

Julia Wanker, Bennett Piater

Questions?
Julia Wanker, Bennett Piater

Bibliography I

E. Ronen and A. Shamir. Extended functionality attacks on iot devices: The case of smart lights. In *EuroS&P*, pages 3–12. IEEE, 2016. ISBN 978-1-5090-1752-2. URL http://dblp.uni-trier.de/db/conf/eurosp/eurosp2016.html#RonenS16;http://dx.doi.org/10.1109/EuroSP.2016.13;http://www.bibsonomy.org/bibtex/21ec9f74336617b4511304c4b35818c79/dblp.

Bibliography I

E. Ronen and A. Shamir. Extended functionality attacks on iot devices: The case of smart lights. In *EuroS&P*, pages 3–12. IEEE, 2016. ISBN 978-1-5090-1752-2. URL http://dblp.uni-trier.de/db/conf/eurosp/eurosp2016.html#RonenS16;http://dx.doi.org/10.1109/EuroSP.2016.13;http://www.bibsonomy.org/bibtex/21ec9f74336617b4511304c4b35818c79/dblp.