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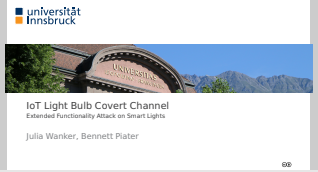
IoT Light Bulb Covert Channel

Extended Functionality Attack on Smart Lights

Julia Wanker, Bennett Piater



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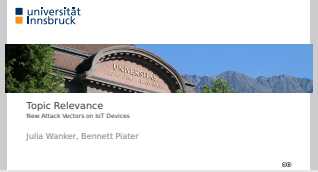
Topic Relevance

New Attack Vectors on IoT Devices

Julia Wanker, Bennett Piater



IoT Security in General

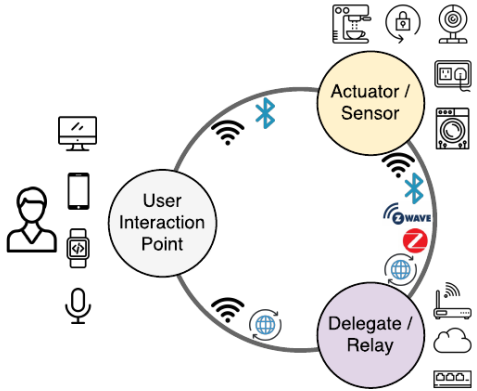
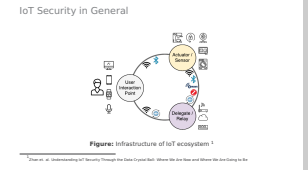


Figure: Infrastructure of IoT ecosystem [1]

[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

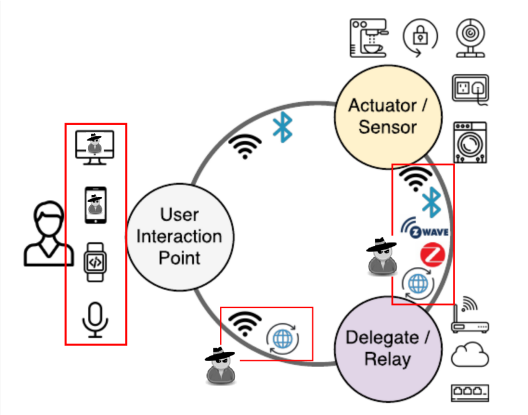
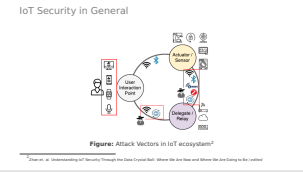


Figure: Attack Vectors in IoT ecosystem[2]

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



NETWORK SIZE -> keep energy consumption low -> limit in computation and energy capabilities –> skip authentication, encryption

HUMANS tightly involved -> access control and privacy –> attacker can steal this sensitive info

HETEROGINITY -> bulk of protocols co-exist –> need overall valid solution

Smart Light Security

Figure: NYC Blackout of 1977[3]

[3] Allan Tannenbaum/Getty Images

Smart Light Security

Figure: NYC Blackout of 1977[3]

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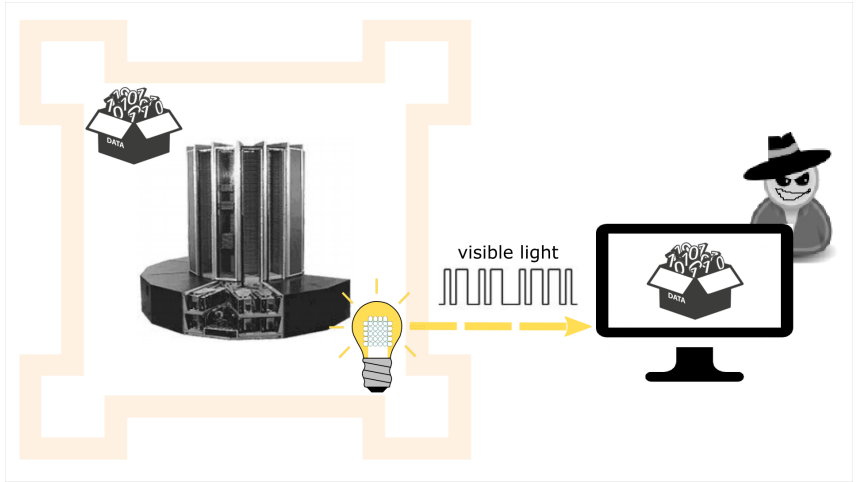
reminder: spread malware over whole city

Extending Functionality



Extending Functionality

our focus

remember: steal info through light communication

Theoretical Background

Extended Functionality Attack on Smart Lights

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Theoretical Background
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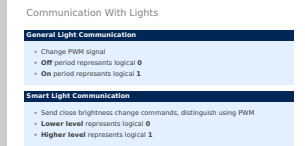
Communication With Lights

General Light Communication

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

Smart Light Communication

- Send close brightness change commands, distinguish using PWM
- **Lower level** represents logical **0**
- **Higher level** represents logical **1**



based on LEDs turned on and off at high rate –> pulse width changed according to data

smart light: not directly change PWM –> indirectly through brightness commands

(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

change between two brightnesses at high rate –> choose two close brightnesses

Hue 255 levels

Smart Light Systems

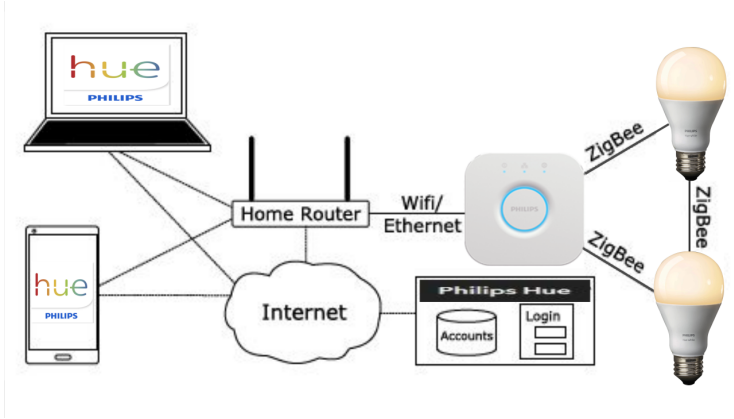
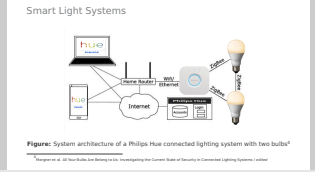


Figure: System architecture of a Philips Hue connected lighting system with two bulbs[4]

[4] Morgner et al. All Your Bulbs Are Belong to Us: Investigating the Current State of Security in Connected Lighting Systems / *edited*



Experiment

Covert Communication Channel on Philips Hue White

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Controlling the Light

We use the Hue API for simplicity.

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

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mention limits of bridge
restrictionss on rate of commands sent in system
brightness increased incrementally -> avoid sharp changes –> thus no phase shifts

Controlling the Light

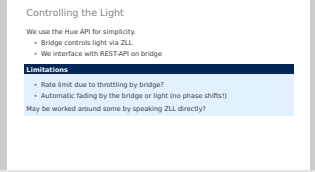
We use the Hue API for simplicity.

- 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?



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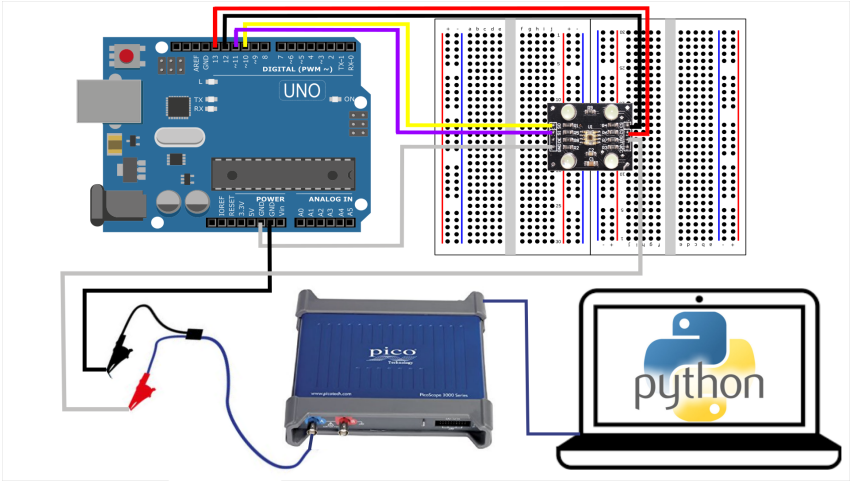
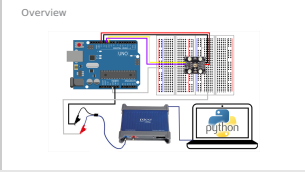
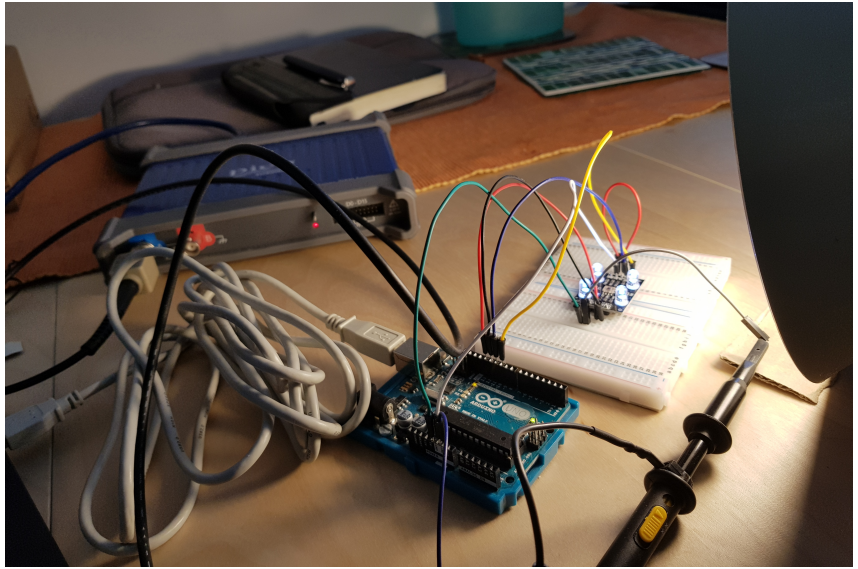
Overview





Arduino setup lght sensor + power supply
sensor frequency output interpreted by picoscope
pytho script set up pico + read out signal + plot to check40s

Experimental Setup



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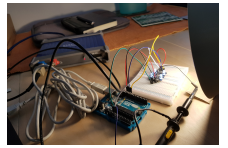
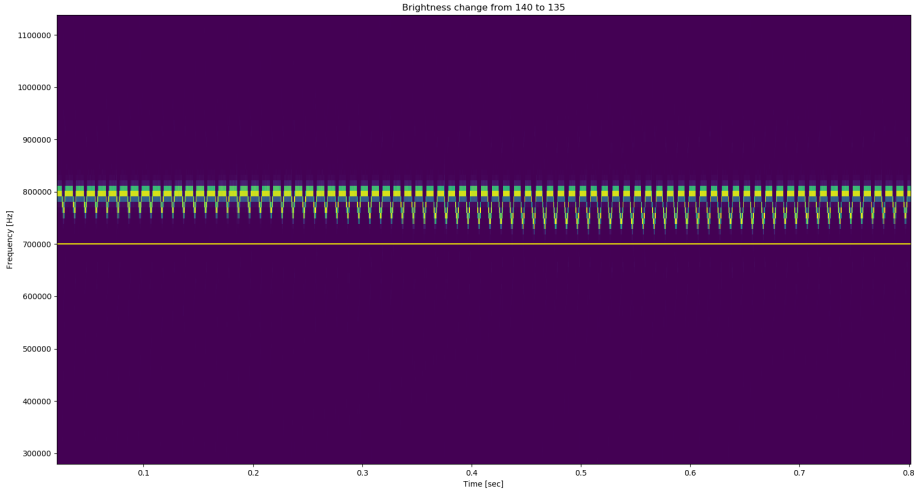


Some Results I



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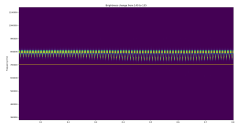
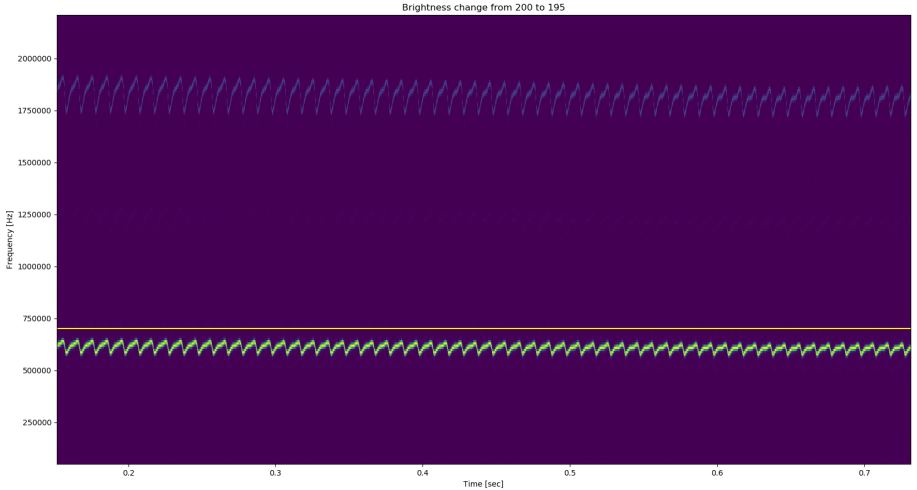


2m for the 3 images

Some Results II



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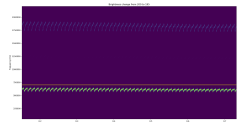

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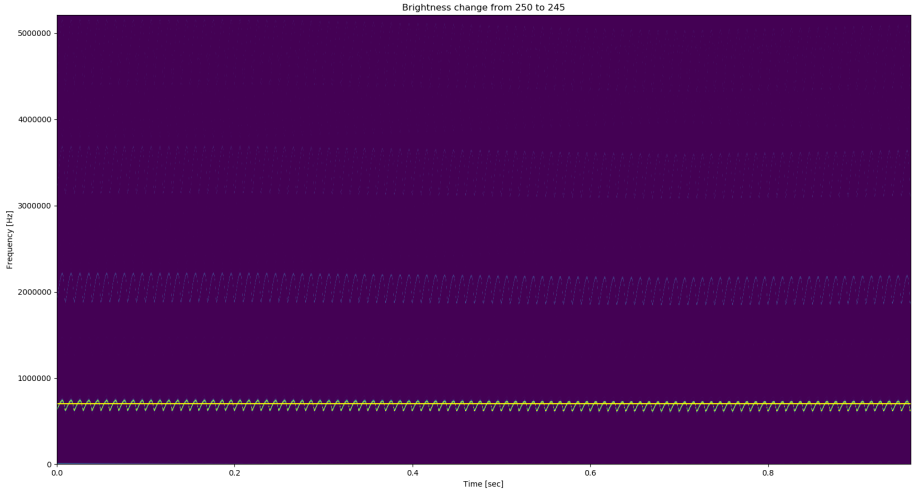
Some Results III



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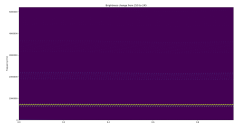

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Demonstration

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Conclusion

Summary and Outlook

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

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

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1.5–2m
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- Good channel encoding
- More robust PWM detection
- Higher range
- Automatic calibration

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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

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Outlook

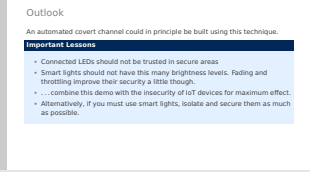
An automated covert channel could in principle be built using this technique.

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.

2018-06-14

Conclusion
└Conclusion
└Outlook



1m

Questions?

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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.

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