Master Thesis

Software Defined Optical Wireless Communication using On-Off-Keying on Microcontrollers for Less than One Euro

Background

Two microcontrollers communicating via OWC using an LED as sender and a photo resistor as receiver.

Software Defined Radio (SDR) describes radio communication in which the modulation and/or demodulation is performed in software, rather than in purpose-built hardware. Typically the goals of using SDR are gains in flexibility and control of the emitted signal or rapid prototyping. One area in which SDR is already widely used are infrared (IR) remotes (such as those often used to control TVs and multimedia systems), in which a microcontroller (MCU) encodes data in pulses emitted from an IR LED.

Communication using radio frequencies in the optical spectrum is refereed to as Optical Wireless Communication (OWC). Two subareas of OWC are the Visible Light Communication (VLC) – also referred to as LiFi – as well as IR communication. As an alternative to Wi-Fi, Li-Fi has been developed for use in special environments, e.g., hospitals where radiation must be as low as possible.

Motivation

The required hardware to modulate digital data using an LED and On-Off-Keying costs less than one euro (also taking the MCU into account) in large quantities. For many Smart Home use cases – such as indoor sensors for temperature, humidity, air quality, window status – only limited communication range and low data rates are required. However, these devices have to be extremely cost efficient for widespread use. An border router node connected upstream with more traditional technologies such as IEEE 802.15.4 that forwards connectivity downstream via OWC could enable the use of highly cost efficient wireless sensors and actuators.

Project type	Master Thesis		Contact	Marian Buschsieweke
Duration	1 Term		E-Mail	buschsie@ovgu.de
Language(s)	English, German		Room	G29-314
Field	Computer Science		Tel.	+49 391 67-52673

OTTO VON GUERICKE UNIVERSITÄT MAGDEBURG | INF

Communication and Networked Systems

Goal

The goal of this thesis is to implement a cheap mean of OWC by modulating an (IR-)LED with On-Off Keying and demodulating the signal from a raw voltage signal using the peripheral ADC of an MCU. Based on this an evaluation of the suitability of this mode of communication for practical Internet Protocol (IP) based communication should be performed.

Tasks

- Design a hardware setup suitable for implementing and evaluating SDR OWC in RIOT [1]
  - For ease of use a standard development board with integrated programmer/debugger should be used, rather than providing a cost-efficient design
  - Both the visible light and the infra red spectrum are acceptable
- Implement an SRD OWC network interface for RIOT
  - Implement an SDR OWC driver providing the `netdev` interface
  - Choose and possible adapt or implement a network interface for that driver for RIOT's GNRC network stack
- Evaluate the provided implementation ...
  - ... regarding its performance
    - Perform a set of experiments to obtain the packet error rate, throughput, goodput, latency (2 hop round trip time) for different modulation rates, sources of background interference (e.g. daylight), and communication distances
    - Compare the RAM and ROM requirements to other network interfaces
    - Evaluate the impact on CPU load compared to network interfaces that offload the (de-)modulation of the signal to purpose-built hardware
  - ... for suitability in the IP use case
    - Define a use case that uses IP over SDR OWC based on the quantitative performance numbers obtained above
    - Prototype this use case using at most 4 nodes
    - Only use software stubs to mock the "thing" part of IoT devices in the prototype
    - Unlike the performance evaluation, a qualitative results are acceptable here

References

[1] Emmanuel Baccelli and Oliver Hahm and Mesut Güneş and Matthias Wählisch and Thomas Schmidt. RIOT OS: Towards an OS for the Internet of Things. 32nd IEEE International Conference on Computer Communications (INFOCOM). 2013.

Project type	Master Thesis		Contact	Marian Buschsieweke
Duration	1 Term		E-Mail	buschsie@ovgu.de
Language(s)	English, German		Room	G29-314
Field	Computer Science		Tel.	+49 391 67-52673