Demo: OpenVLC1.2 for Increased Data Rate with Embedded Systems

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ABSTRACT

We introduce the OpenVLC1.2 platform for research in Visible Light Communication (VLC) systems. The platform builds on top of previous versions, that has attracted dozens of users from the research community. We maintain its advantages such as the support for communication with TCP/IP layers, software-based and programmable MAC and PHY layers, and low-cost front-end. In this new version, we make an effort to increase data rate and its overall performance. OpenVLC1.2 is available to the research community.

1 INTRODUCTION

OpenVLC was first introduced at the first edition of the VLCS workshop [1] as an effort to solve the problem of lack of flexible and open-source software to investigate novel network protocols in Visible Light Communication (VLC) systems. The platform has been used in several research works and made available to the community through open calls (www.openvlc.org). In this demo, we introduce the new version of the board, OpenVLC1.2, that makes an effort to include feedback from users.

The low-end embedded system (BBB) used in OpenVLC is very cheap ($60). As such, the design of OpenVLC must consider the inherent limitations of embedded systems, that cannot provide the same powerful functionalities of high-end platforms such as the widely used USRP and WARP boards ($5000). In addition to that, the OpenVLC front-end implements a minimal set of functionalities so that the communication can be programmed in software. The two main challenges with the software implementation using a low-end platform are two-fold:

- how to modulate the LED light at a high speed as possible at the transmitter;
- how to sample the incoming signal as fast as possible at the receiver, with the low-cost BBB platform.

The embedded system runs the Linux OS with Debian distribution. In order to modulate the LED and perform signal sampling, Linux offers an easy way to write/read the GPIO pins through the files linked to GPIOs. Besides, the GPIOs are assigned with physical memory addresses, which can be used to control the GPIOs at a much faster speed (around 10x in our test) than writing/reading GPIO associated files. However, these methods are not fast enough to support high enough sampling rate, mainly because of the non-realtime Linux OS. This issue can be mitigated via patching the Linux kernel with Xenomai that supports real-time operations and allows to achieve a sampling rate of up to 50 KHz, as demonstrated in previous versions of OpenVLC [2]. Yet, this speed is still far away from the target of at least 1.0 MHz of sampling rate, which can be considered as the minimum requirement for VLC systems.

2 OPENVLC1.2

In this demo, we introduce OpenVLC1.2. Its main improvements are both on the hardware and software sides:

- New circuitry to support high-power LEDs up to 3 W. Our high-power LED devices can be safely used for testing networking solutions, as they are DC supplied;
- Improved circuitry to communicate with low-power LED-to-LED at longer range;
- New photodetector that supports higher sampling rate;
- Usage of the existing Programmable Real-time Unit (PRU) of the embedded system for increasing the date rate.

In OpenVLC1.2, we use the existing PRU (micro-controller) of the BBB, written in assembler, to address the date rate problem of previous versions of the platform. The PRU is a fast processor operating at 200 MHz and 32-bit, it supports simplified assembly instruction set with single-cycle input/output access to a set of the BBB pins and full access to the internal memory and peripherals on the main BBB processor (http://beagleboard.org/pru).

Time-sensitive operations are performed in the PRU, that controls the GPIOs to modulate the LED light and performs the sampling at both the transmitter and the receiver. The communication between the main processor of the embedded system and the PRU occurs via shared memory. The OpenVLC driver takes care of the MAC protocol and non-time sensitive PHY operations. This has the advantage of maintaining the flexibility of previous versions of the board, as most of software implementation resides in the OpenVLC driver. OpenVLC1.2 integrates the OpenVLC driver, PRU micro-controller and optical front-end in one system. Through this novel implementation, we can modulate the LED light and perform sampling at MHz rate, satisfying the requirement of our system with off-the-shelf low cost hardware. We make the platform available to the research community through open calls.

REFERENCES

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