DarkLight:

Visible Light Communication offers an added layer of security and massive amounts of bandwidth unavailable at lower wireless communication frequencies. Challenges in accessing these benefits include high energy usage, interference from ambient light sources, and a potentially unpleasant visual experience to users. DarkLight is a visible light communication primitive that presents a novel approach to addressing these challenges.

The key concept that enables DarkLight is to send data within very short pulses so that they are imperceptible to the human eye in most conditions. DarkLight operates with a very small duty ratio ($d \cong 0.007\%$ amounting to a 500 ns pulse), but still allows for plenty of bandwidth because the wavelength of visible light is orders of magnitude shorter than the carrier pulse. Adapting to ambient light intensity, the duty ratio can be increased or decreased to optimize throughput in different scenarios. A prototype is implemented using low-cost off-the-shelf LEDs (as transmitters), photodiodes (as receivers), and relatively simple analog and digital circuitry. DarkLight is then evaluated on user perception, whether or not users actually notice the light pulses, and system performance regarding throughput under varying distances and viewing angles, and power consumption.

Discussion:

During the class discussion, students acknowledged the novelty of the concept and credited the authors for following through with a complete prototype implementation. However, skepticisms were voiced about the practical use case of DarkLight and the authors promises of improved security.

A key point of contention during the class discussion was a figure of merit used to justify the superiority of DarkLight over traditional VLCs. The authors claim that "DarkLight drastically reduces the power consumption of the LED front end from 19.8 W to 104 μW…". One student pointed out that this is not a fair comparison to an always on LED based system. DarkLight achieves this low energy expenditure at the cost of throughput and range. A proper comparison may have been bits-per-second per linear distance or watts per linear distance. Some metric should have been presented which accounted for throughput, power and distance, in order to properly compare DarkLight to traditional systems.

Some students took issue with the security claims regarding the DarkLight system and it was suggested that this was actually more of a drawback. The authors of DarkLight claim that, compared to RF communication, the system achieves better security by confining communication within a room as light cannot penetrate walls. It was discussed that limited range and line-of-sight nature could be thought of as a drawback. Students suggested that relying on security in the physical layer and neglecting basic encryption is often a mistake. This was supported by historical examples such as the early use of sonar on submarines.

The paper reviews the effects of rise time of the duty cycle on the performance of the DarkLight system but neglected to mention the effects of the fall time. Rise and fall time seem to resemble those of a typical RC circuit, but with some differences. Specifically, the fall time appears to begin with a much larger slope before resembling the typical logarithmic roll off. It was determined that rise time is of greater concern as it determines the peak voltage. The fall time is deemed important to the extent that it lengthened the duty cycle.

At the end of the discussion, comparison to IR communications were mentioned as the authors claim that DarkLight is safer. Although non-ionizing, with long exposure and high

power, IR has been shown to cause eye safety issues. Certain wavelengths of IR light can pass through the human cornea and be focused by the lens onto the retina, which is more dangerous than the color spectrum used by DarkLight.

DarkLight is an exciting innovation in the area of visible light communication; unlike other VLCs, data is sent on extremely short pulses of light with are not noticeable to humans in most cases.