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**Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)**

**Submission Title:** On Study Group Status for Camera Communications

**Date Submitted:** July 2013

**Source:** Rick Roberts                      Company: Intel Labs

Address

Voice: 503-712-5012

E-Mail: richard.d.roberts@intel.com

**Re:**

**Abstract:** A short presentation in regards to CamCom

**Purpose:** Presentation to WNG

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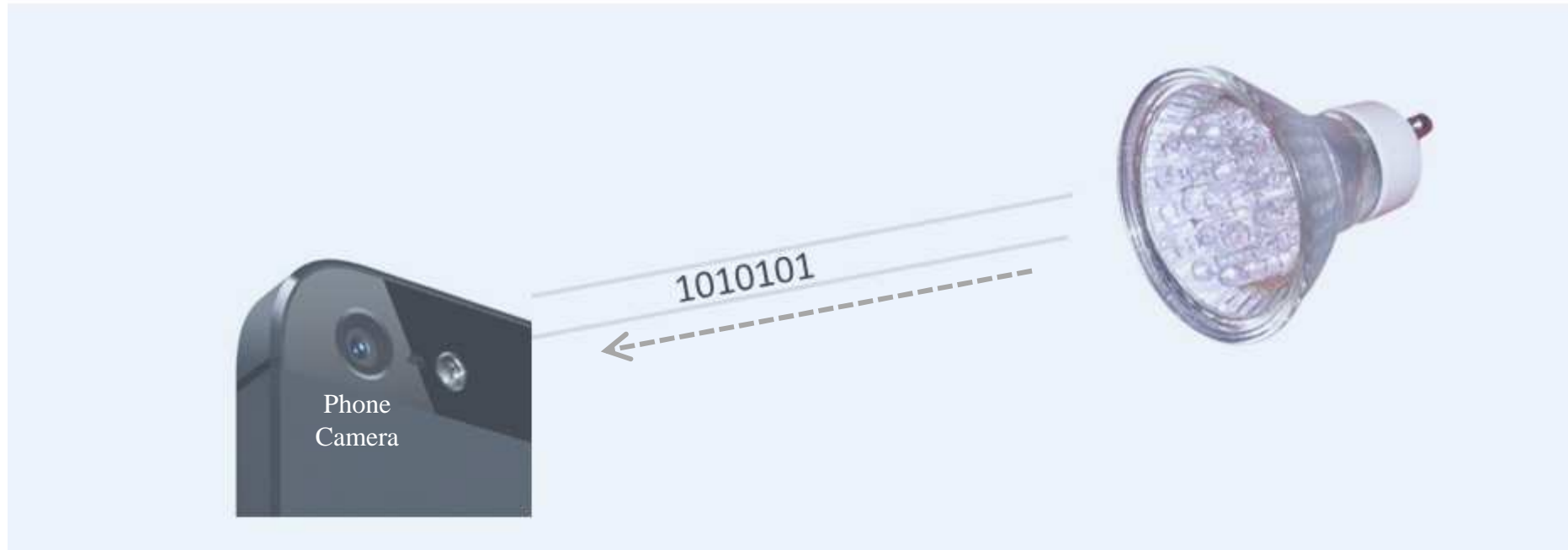
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## **Presentation to WNG in anticipation of SG status**

There is an emerging interest in the implementation of Visible Light Communications (VLC) for uni-directional, low data rate, short message broadcasts via LEDs using an image sensor as the receiving device. In response, IEEE802.15 LED ID IG is contemplating transitioning from an interest group to a study group focusing on writing a PAR and 5C in regards to camera communications (CamCom).

# Camera Communications (CamCom)

## A Pragmatic Form of Visible Light Communications



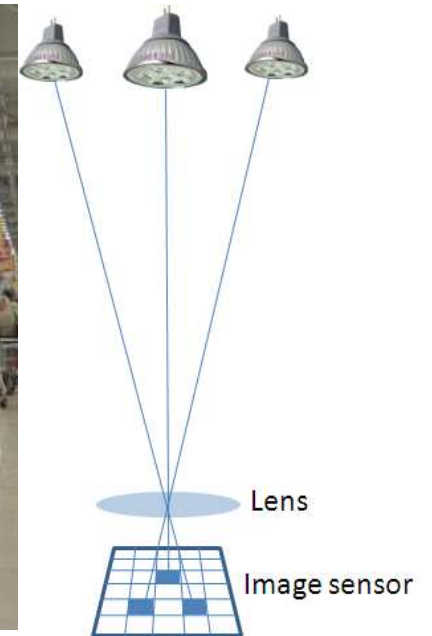
Today we have millions of mobile devices enabled to receive visible light communications via the camera, but we lack standards to describe the modulation format.

*This contribution discusses some CamCom topics of interest.*

## Some Use Cases



*Line of Sight Marketing*



*Indoor Location*

***Provides low cost, beneficial, augmented reality user experience***

**VLC has a complex ecosystem:**

- hinders technology adoption
- simultaneously building out both sides of this ecosystem is difficult
- unlike WiFi, no single source vendor

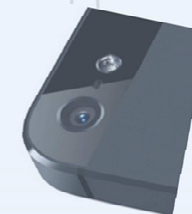
**A receive side APP solution enables:**

- no phone hardware modifications
- simplified ecosystem build out
- millions of potential receivers
- entice VLC enabled LED sources



LED Lights  
are in one  
ecosystem

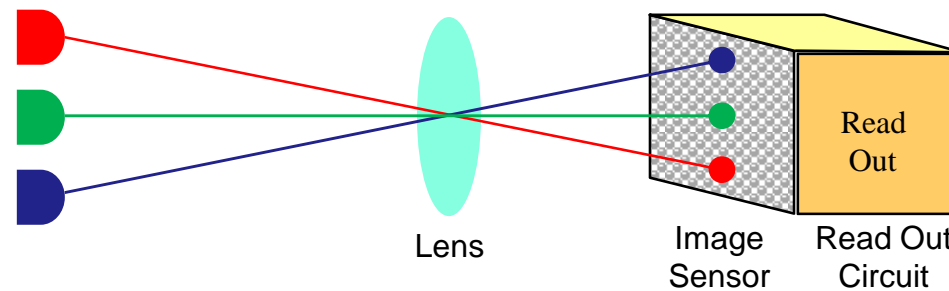
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Smartphones  
are in another  
ecosystem

***Standards Will Be Necessary!***

## But first some basics about electronic cameras

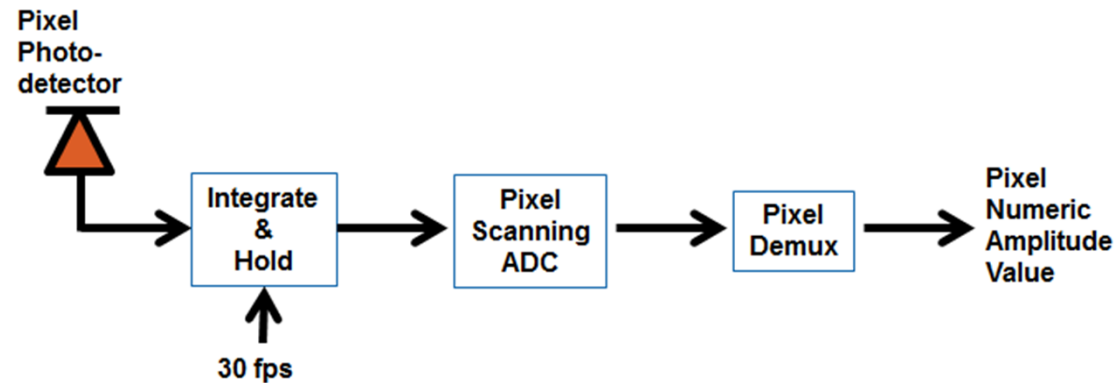


### Camera basic components

- Lens ... spatially separates sources
- Image Sensor ... array of photodiode pixels
- Readout Circuit ... convert pixel signal to digital data

### Cameras differ on how the pixels are exposed

- Global Shutter ... simultaneously expose all the pixels per frame
- Rolling Shutter ... time sequentially expose each row of pixels per frame



*image sensor model: 2 dimensional lightwave-to-digital converter*

**Sampling rate depends upon how the image sensor does the exposure**

- Undersampling (Undersampled Frequency Shift ON-OFF Keying)
- Nyquist Sampling (Picapicamera)
- Rolling Shutter Sampling

**Because of camera lens properties, spatial separation of multiple sources is possible enabling MIMO transmission.**



*Example LED Signage*

This LED sign has 321 LEDs ...

- each LED illuminates a unique pixel in the image sensor
- each LED can transmit a unique data stream
- 321 x 321 MIMO !!!



## **With multiple methods to realize CamCom ... ... standards will be necessary**

1. A SG → TG will explore multiple use cases
2. A SG → TG will discuss multiple modulation formats
3. A SG → TG will facilitate complex ecosystem adoption
  - via smartphone app
  - via MIMO modulated LED lights

## Some public demos available on the web

1. Under-sampled Frequency Shifted ON-OFF Keying (UFSOOK) (*Intel Labs*)

<http://www.youtube.com/watch?v=K0xsZqTRXes>

2. Nyquist Sampled Picapicamera (*Casio*)

<http://www.youtube.com/watch?v=t27x1sztArE>

3. Rolling Shutter Sampling (*PureVLC*)

<http://www.youtube.com/watch?v=laxD4SF3jsA>

**The LED interest group believes it is ready to transition to a study group to write a PAR and 5C leading towards the formation of a task group focused on writing a standard for camera communication (CamCom).**