

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

Submission Title: What is Optical Camera Communications (OCC)

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Re:

Abstract:

Purpose:

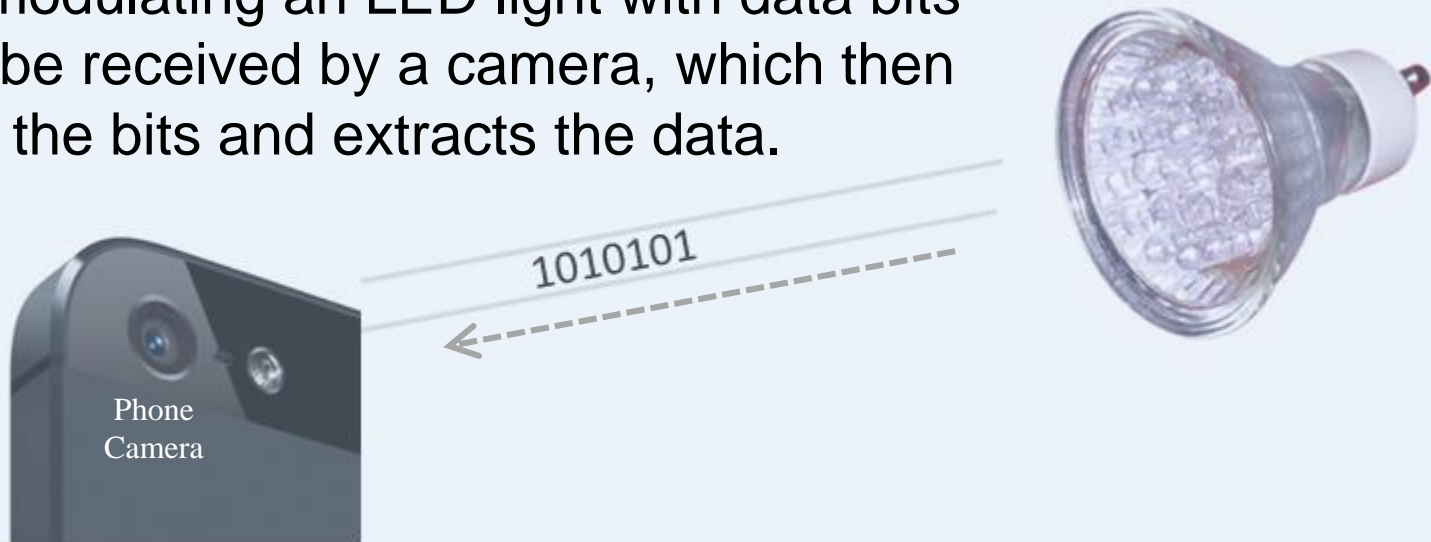
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Optical Camera Communications (OCC)

A Pragmatic Form of Visible Light Communications

OCC is modulating an LED light with data bits that can be received by a camera, which then decodes the bits and extracts the data.



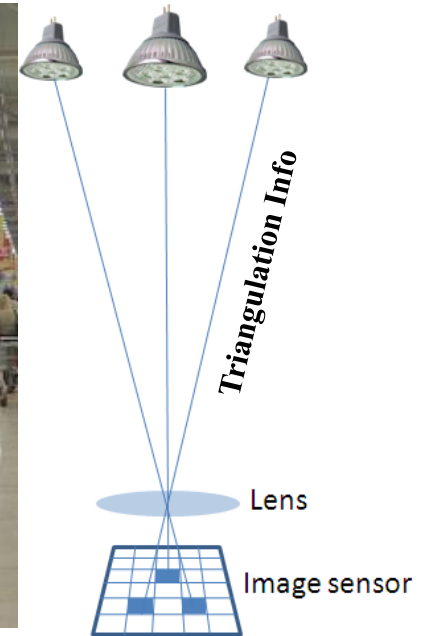
Today we have millions of mobile devices enabled to receive visible light communications via the camera, but we lack standards to describe the modulation format.

This contribution discusses some OCC topics of interest.

Some Use Cases



Line of Sight Marketing



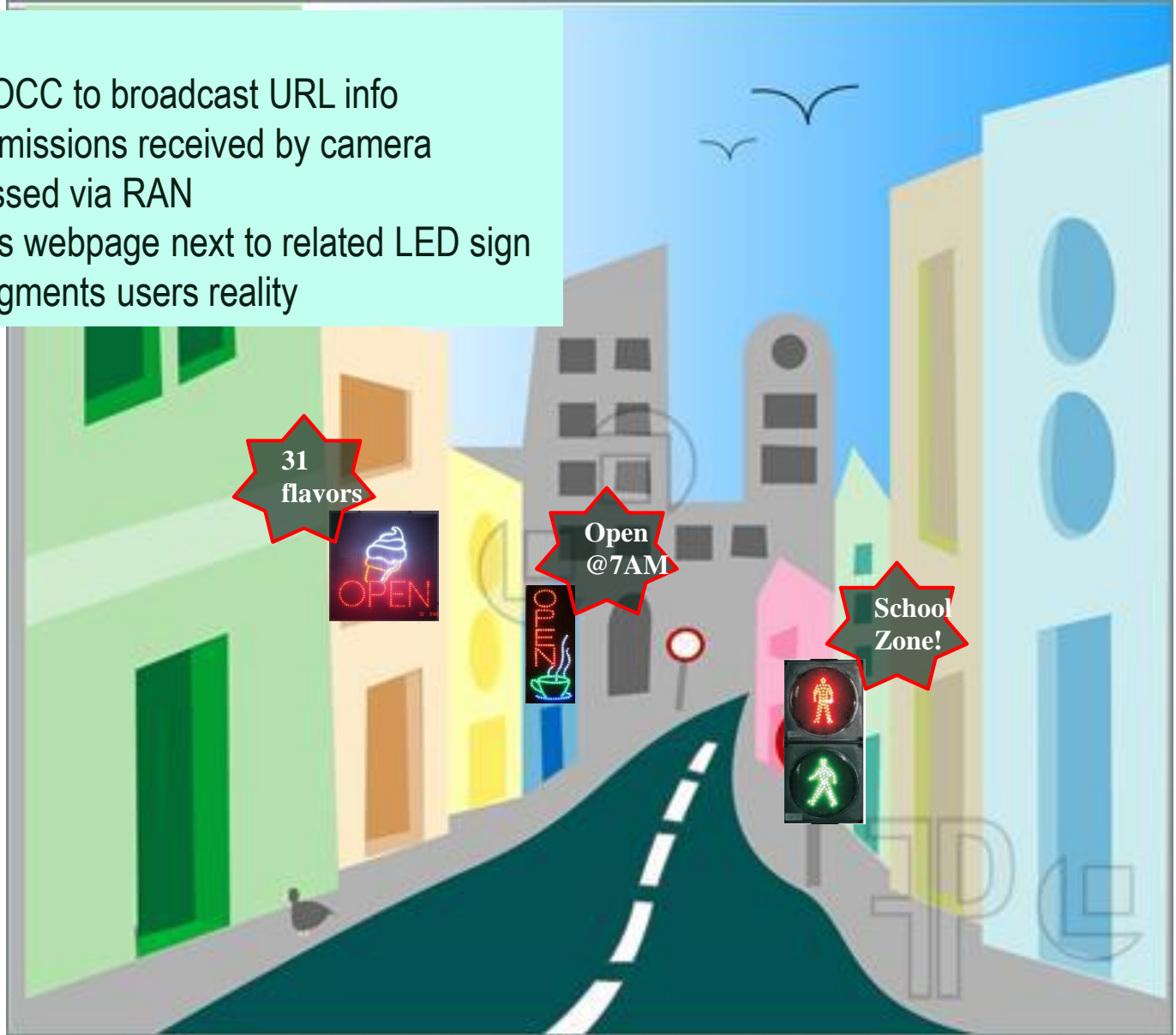
Indoor Location

Provides low cost, beneficial, augmented reality user experience

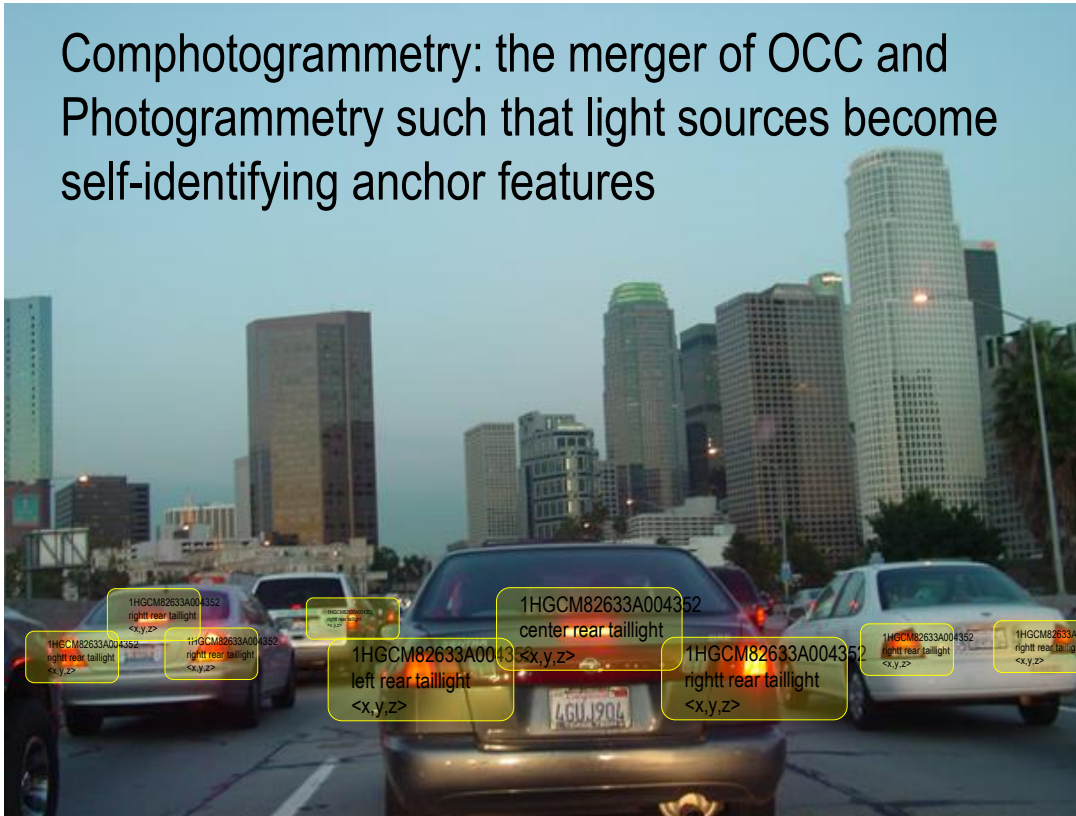
Basic idea:

- each LED sign uses OCC to broadcast URL info
- multiple parallel transmissions received by camera
- each web page accessed via RAN
- Google Glass displays webpage next to related LED sign
- added information augments users reality

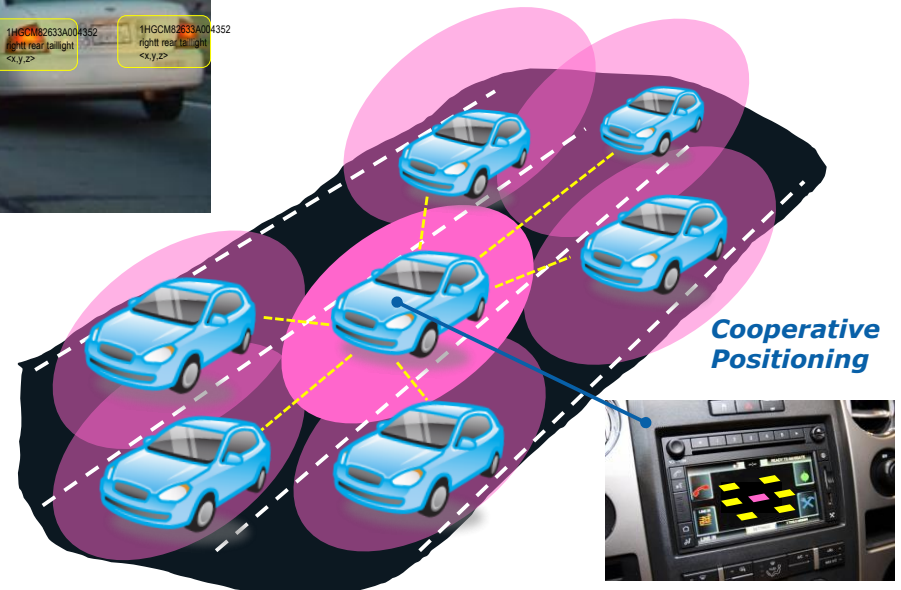
Augmented Reality



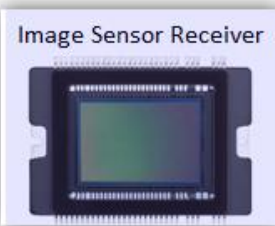
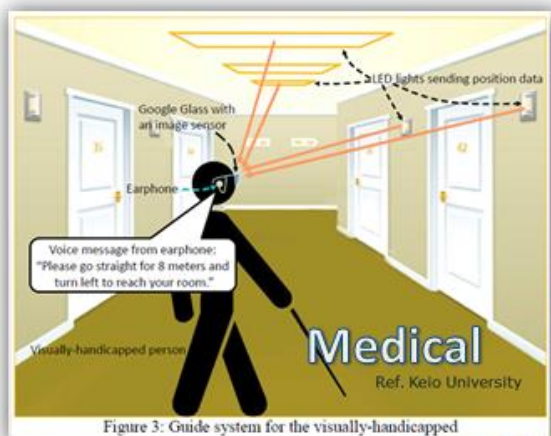
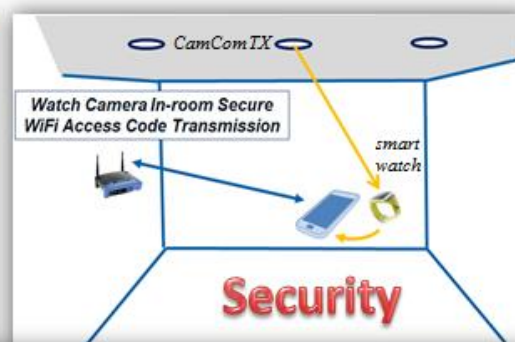
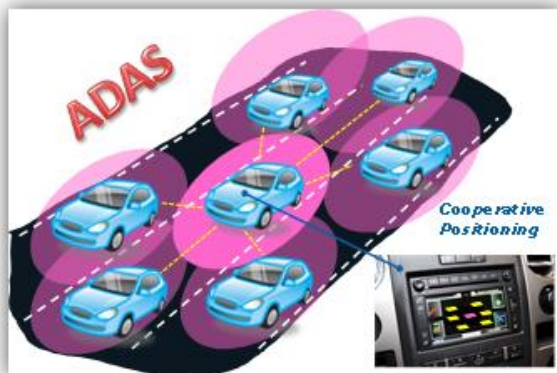
Comphotogrammetry: the merger of OCC and Photogrammetry such that light sources become self-identifying anchor features



High Resolution Automobile Positioning



Optical Camera Communications & Photogrammetry Positioning Applications



VLC has a complex ecosystem:

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

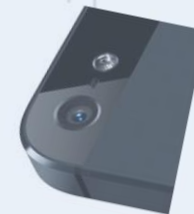
A receive side APP solution enables:

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



LED Lights
are in one
ecosystem

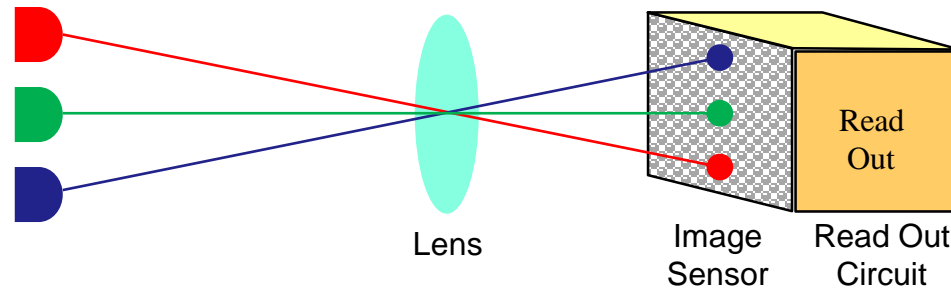
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Smartphones
are in another
ecosystem

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

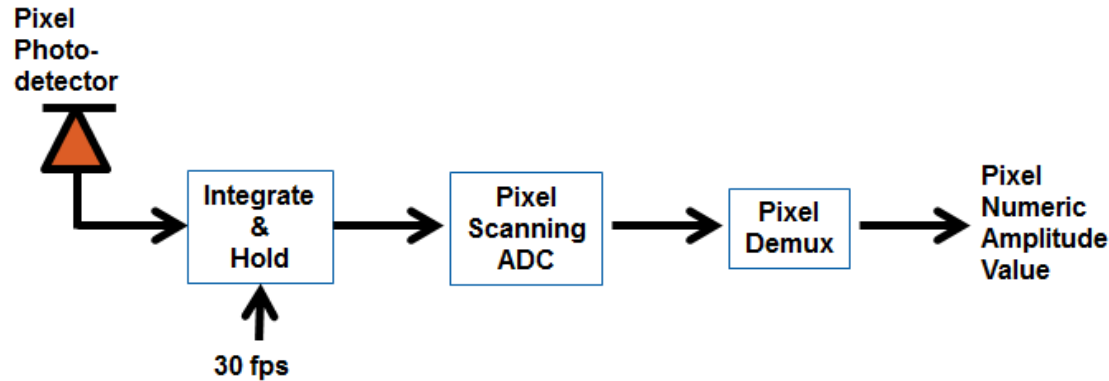


image sensor model: 2 dimensional lightwave-to-digital converter

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 OCC, standards will be necessary. The task group will ...

- explore multiple use cases
- discuss multiple modulation formats
- facilitate complex ecosystem adoption
 - ✓ via smartphone app
 - ✓ via 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>