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

Submission Title: Intel Response to 15.7r1 CFA
Date Submitted: March, 2015
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Abstract:

Purpose: Call for Applications Response

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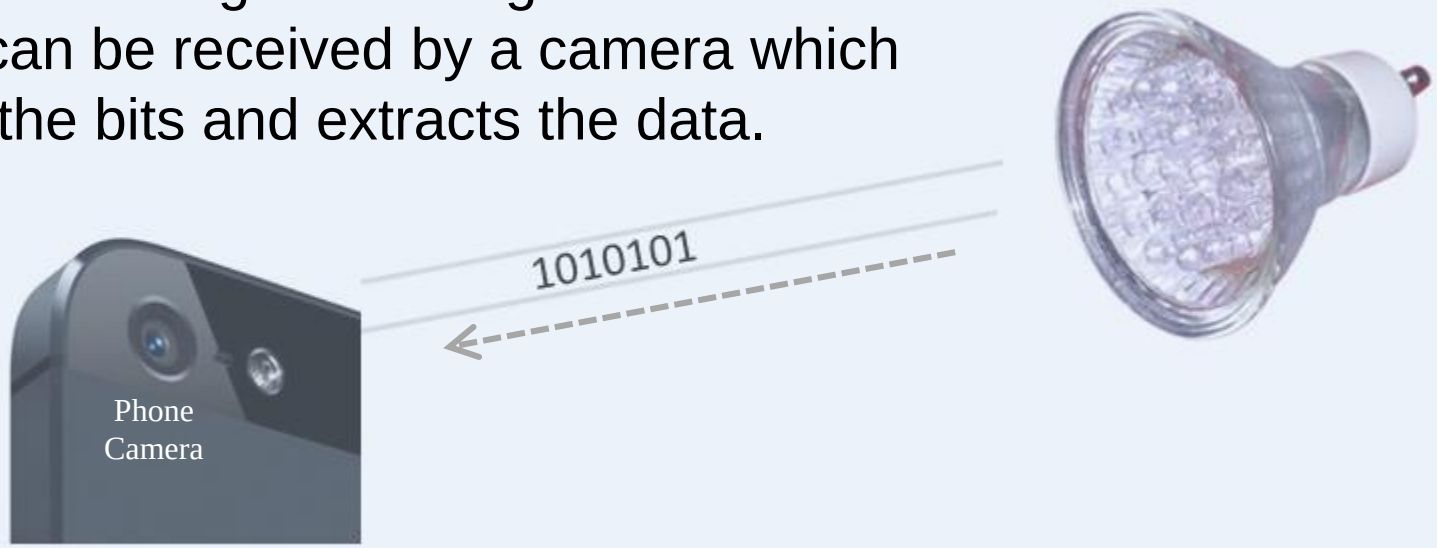
Intel CFA Response for Optical Camera Communications

A Pragmatic Form of Visible Light Communications

OCC is modulating an LED light with data bits that can be received by a camera which 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 presents some OCC applications of interest

RULE OF THUMB

If it can be done with RF, then do it with RF instead of OWC (VLC).

RF is …

- more energy efficient
- favorable cost vs. performance trade-off
- easier to integrate

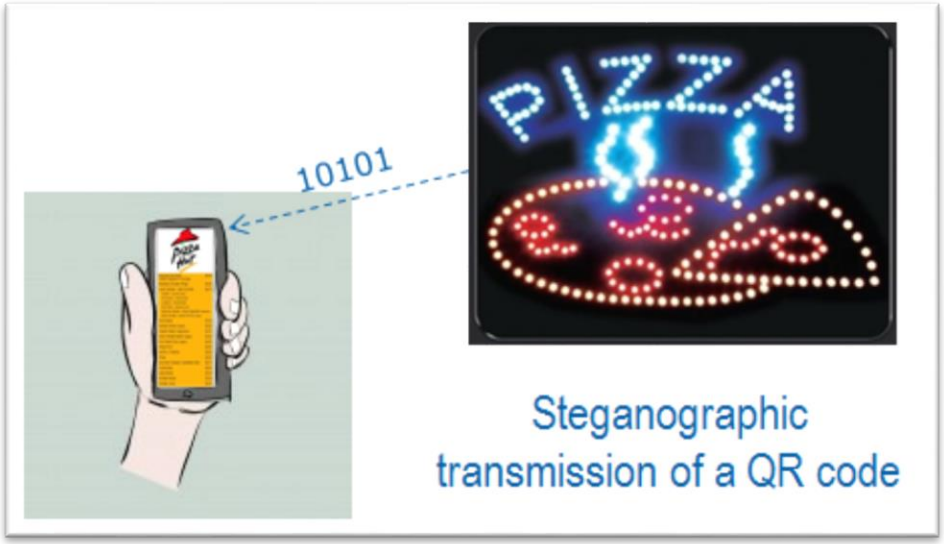
OWC's strong points are …

- fantastic line-of-sight extraction
- excellent beam forming
- supporting low cost location based services

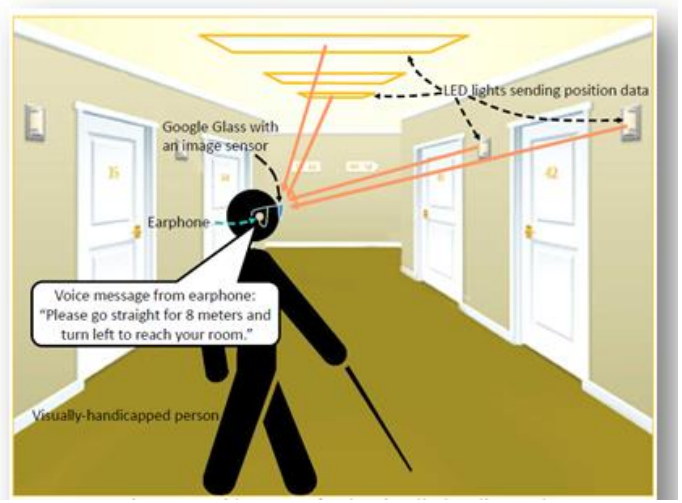
OCC, which is the merger of image processing and data communications, should leverage OCC strengths.

In this contribution we'll look at two classes of OCC applications:

i) communications
ii) location/positioning



Communications



Location/Positioning

Communication Applications of Interest to Intel

Steganography: hiding a message within an image.

Line of Sight Comms/Marketing

Provides low cost, beneficial, augmented reality user experience

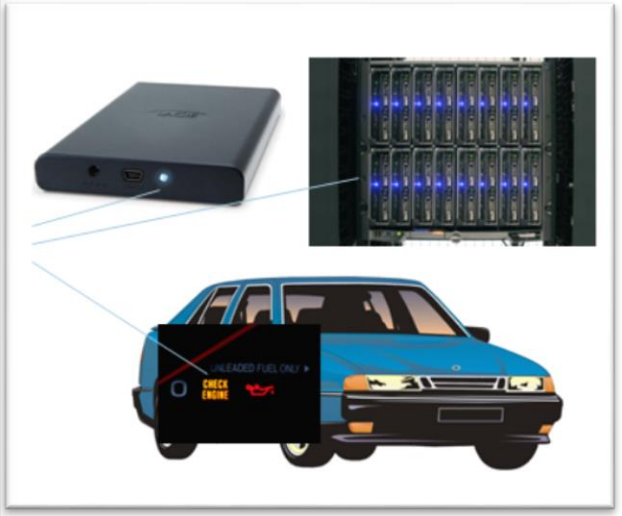
Basic idea:

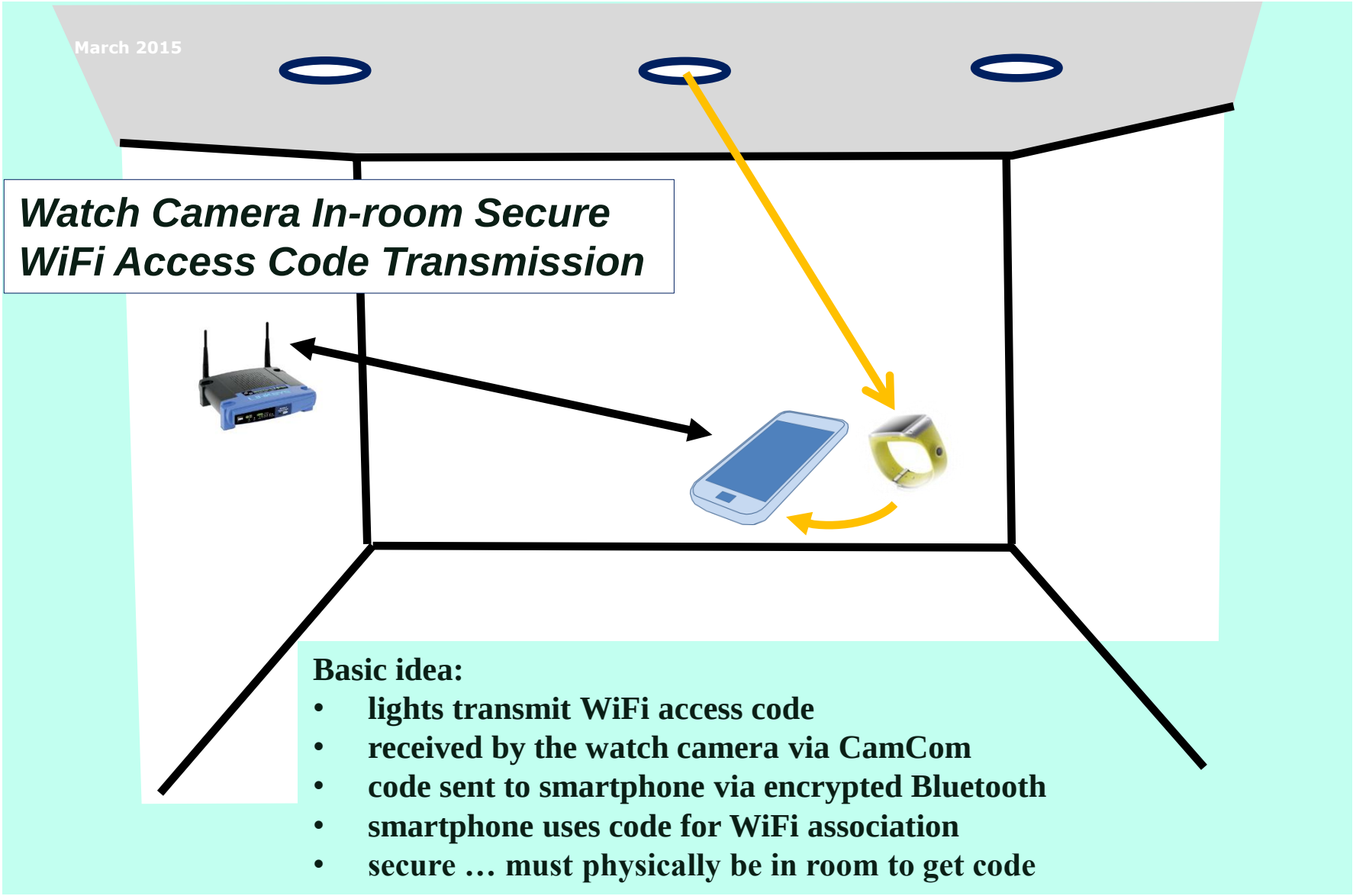
- each LED sign uses CamCom to broadcast URL info
- multiple parallel transmissions received by camera
- each web page accessed via RAN
- Google Glass displays webpage next to related LED sign
- added information augments users reality

Augmented Reality

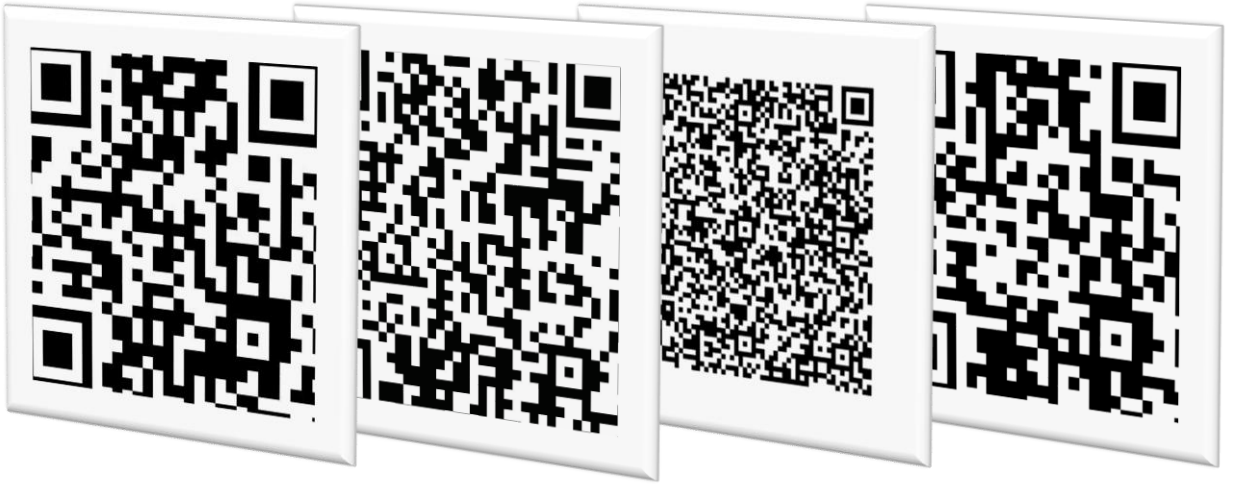
IoT – Simple Message Transmission

Mobile platform is the display unit, we just need a low cost message broadcast link.




March 2015
Watch Camera In-room Secure
WiFi Access Code Transmission
Basic idea:
• lights transmit WiFi access code
• received by the watch camera via CamCom
• code sent to smartphone via encrypted Bluetooth
• smartphone uses code for WiFi association
• secure … must physically be in room to get code

High Rate OCC via QR Code Sequence Imaging (Huge MIMO)

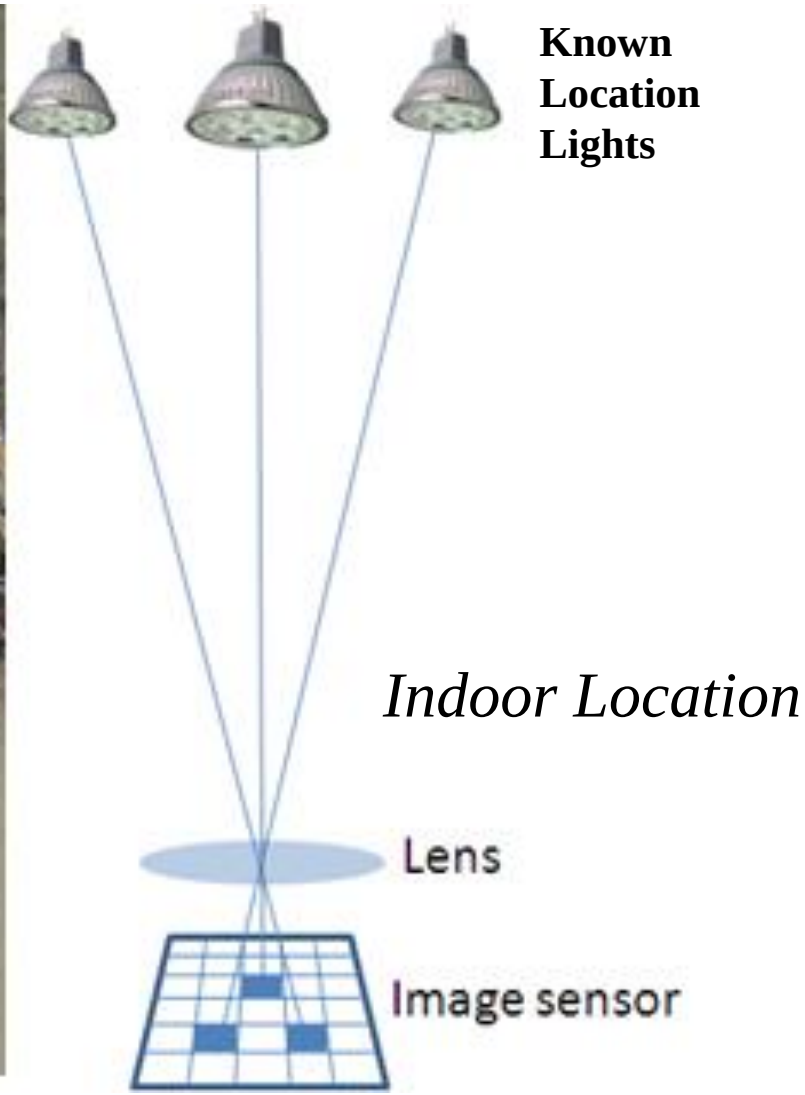


Video Frame Transmission (e.g. 10 frames per second)

QR Code Standard ISO 8859-1

- 23,624 bits per code
- Assume 10 codes/sec
- 236,240 bps
- FEC defined per code

Location/Positioning Applications of Interest to Intel



Determining user location based upon angle-of-arrival.

Smart watch 3-D positioning use case example

Photogrammetry provides 3-D positioning with static heading information.

For example, it can be statically ascertained that this camera watch is at a 3rd shelf elevation, orientated towards the cereal products, and specifically at the coordinates for ***Special K*** cereal.

Blind Vision Assist

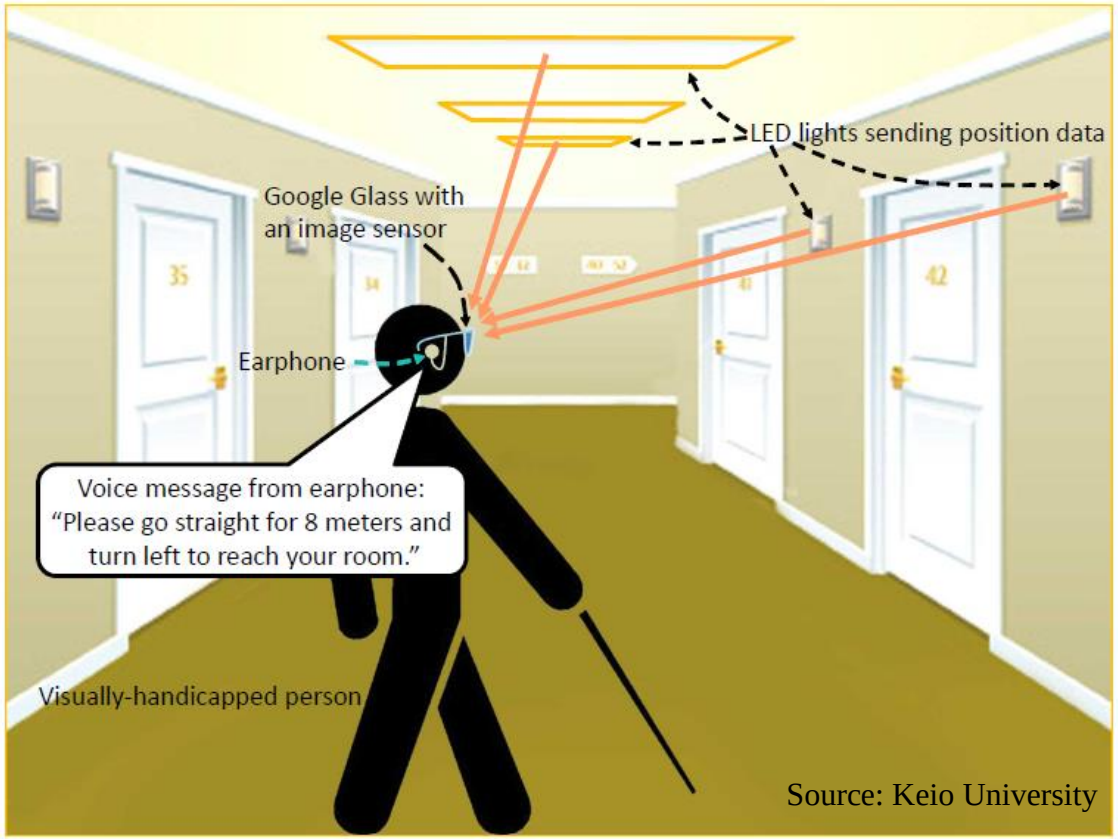
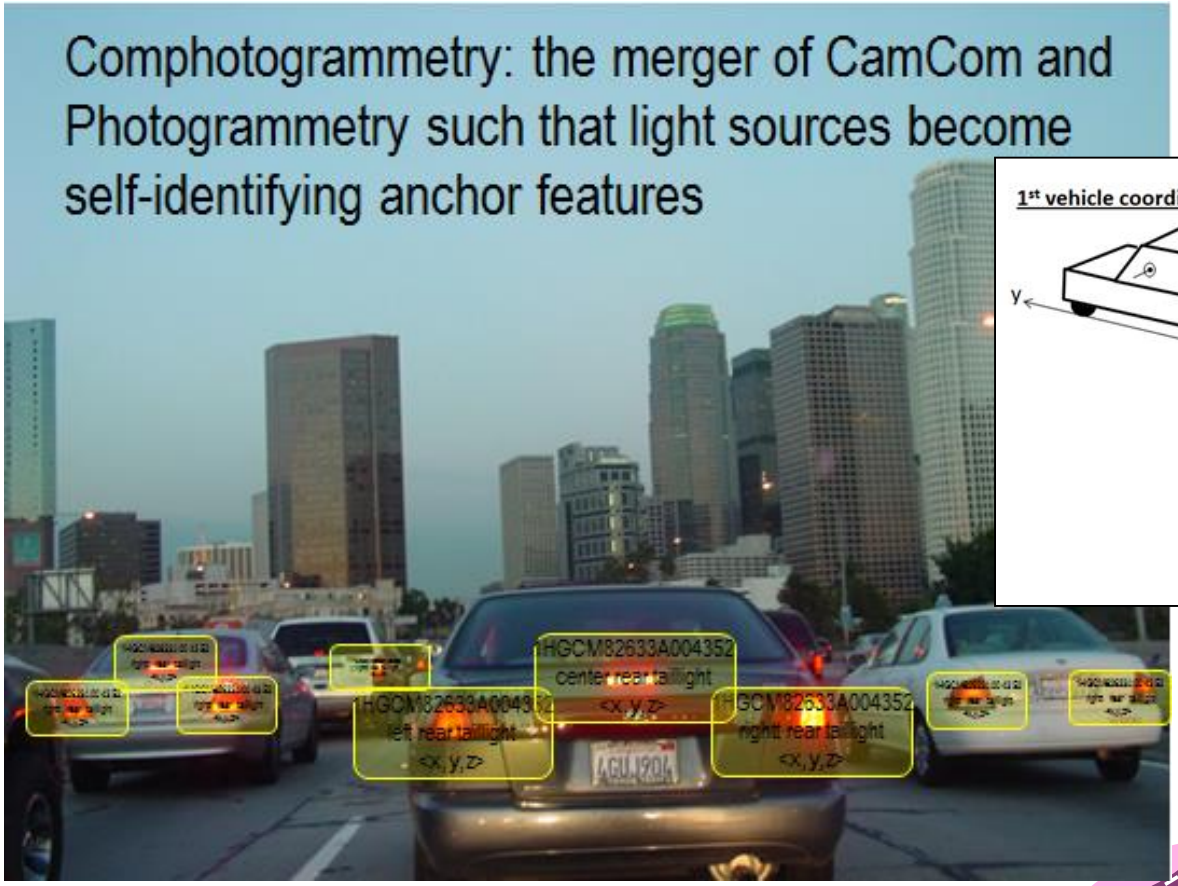


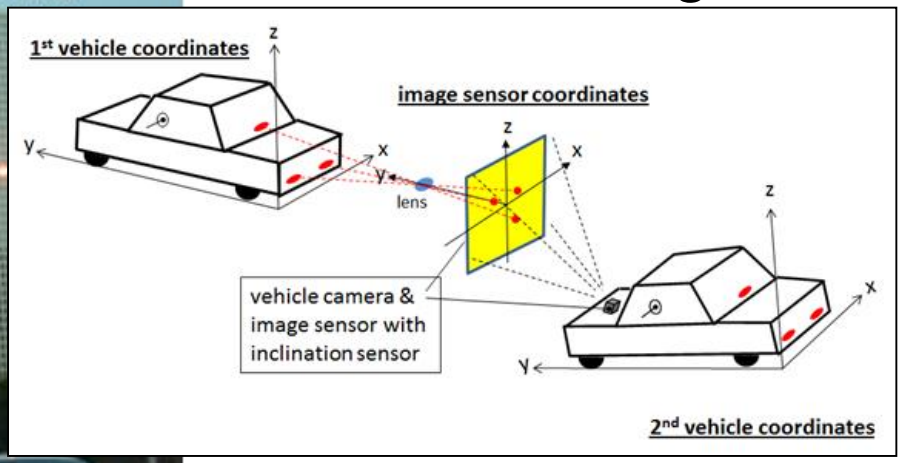
Figure 3: Guide system for the visually-handicapped

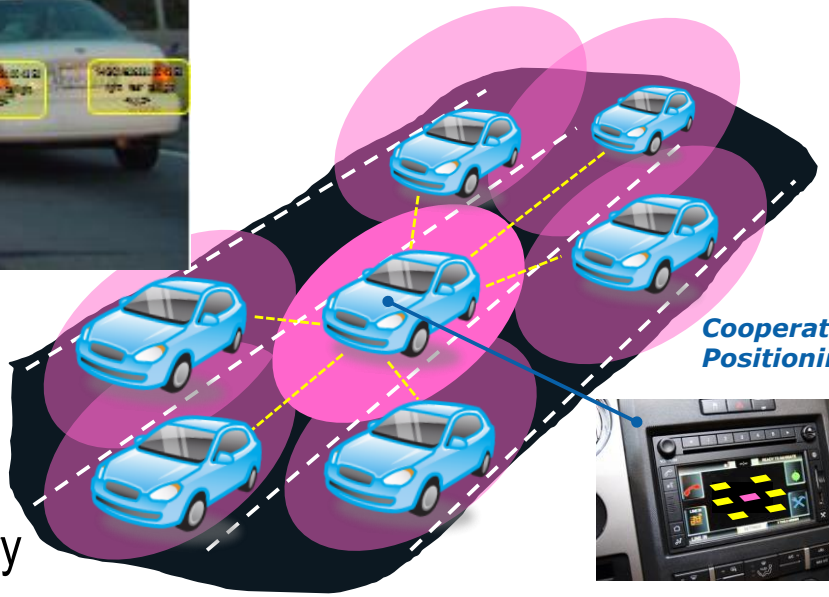
Basic idea:

- lights broadcast <x,y,z> location via OCC
- camera decodes light locations
- camera position is determined via photogrammetry
- directions for blind user are analytically determined
- audio transmission of directions to blind user



Photogrammetry Positioning





- car has multiple lights (either visible or IR)
- each light broadcast an ID message
- ID message is processed by camera
- relative position determined by photogrammetry

OCC MAC Applications of Interest to Intel

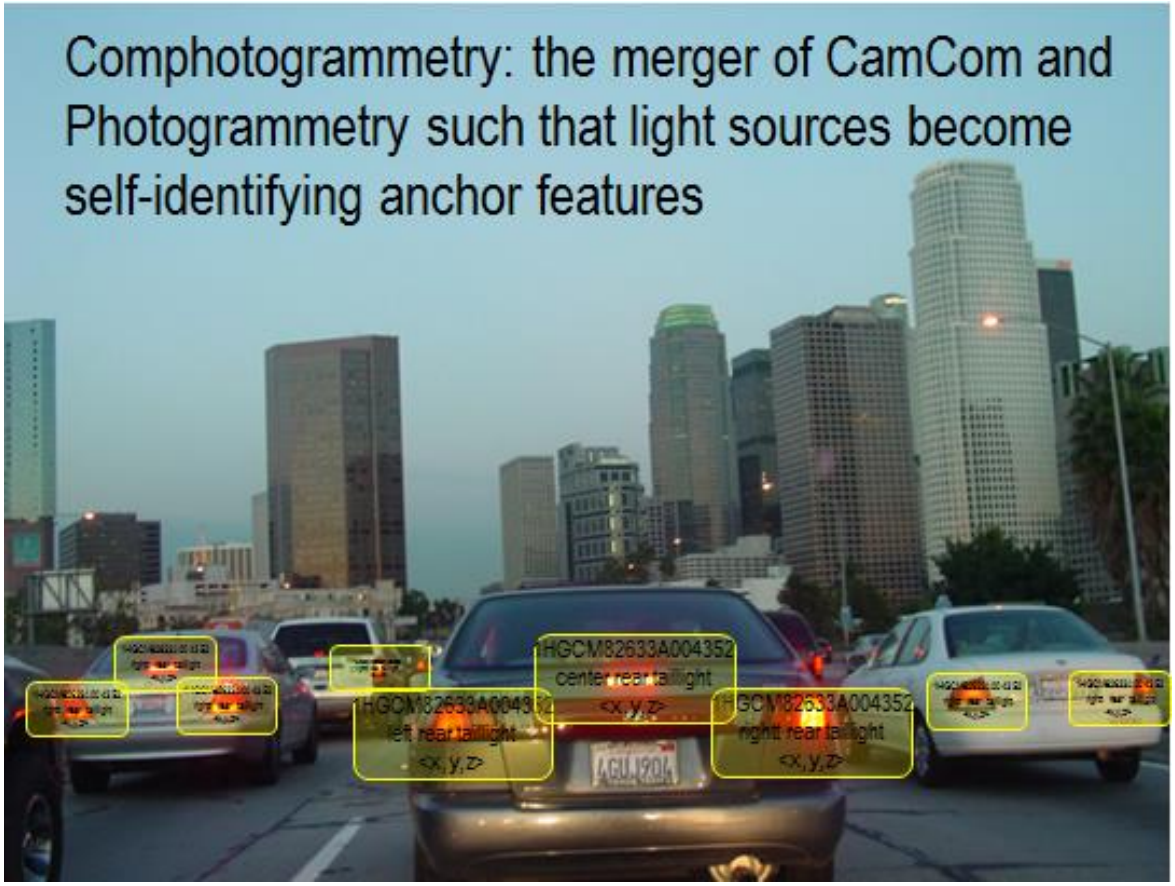
Because of camera lens properties, spatial separation of multiple sources is possible enabling MIMO transmission.

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 !!!

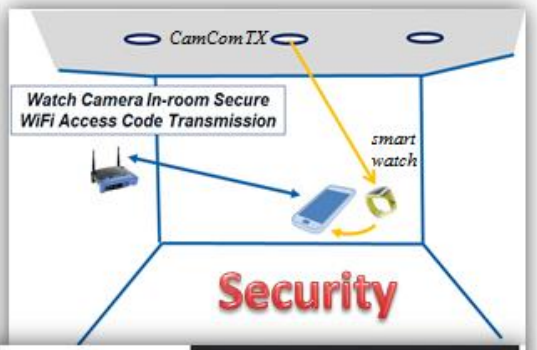
Fast modulated LED source identification and region of interest sub-sampling support.



Quickly sort through lights in an image and determine which ones are modulated.

Summary of Applications of Interest to Intel

Optical Camera Communications & Photogrammetry Positioning Applications



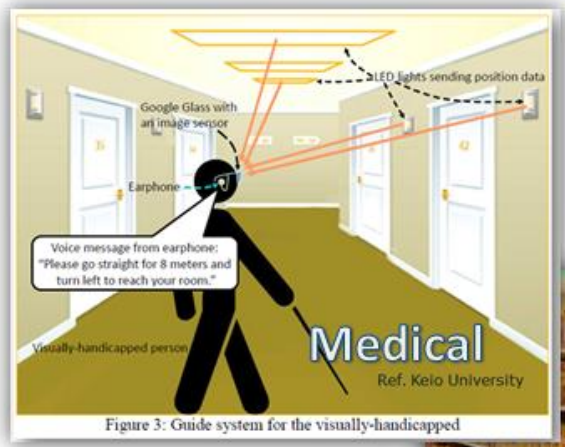
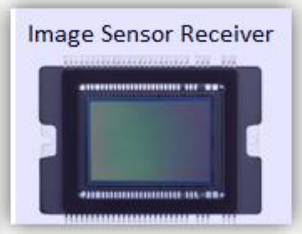


Figure 3: Guide system for the visually-handicapped



Ecosystem Build Out Challenge!

Desired OCC Standard Technical Features

Intel is requesting that …

1. The standard provide at least one OCC PHY mode that works with both/either a rolling shutter camera or a global shutter camera.

2. The standard provide at least one OCC PHY mode that works when the LED light source appears as nearly a point source; that is, the LED illuminates only a small number of image pixels.

3. The standard provide at least one OCC PHY mode that works with spatially separated LED light sources; that is, it must support simultaneous ingest of data from multiple uncoordinated spatially separated LED light sources.

4. The standard provide OCC PHY MIMO support for multiple coordinated LED light sources.

5. The standard provide at least one OCC PHY mode that simultaneously allows OCC modulated LED light sources to be identified at a low camera frame rate and then demodulated at a high camera frame rate using region-of-interest sub-sampling.

6. The standard provide at least one OCC PHY mode that supports OCC transmission, at very short range, in excess of 100 Kchips per second using camera frames rates equal to or less than 30 frames per second.

7. The standard provides at least one OCC MAC mode that supports unidirectional data transmission from one or more coordinated or uncoordinated LED lights.

8. The standard provide at least one MAC mode that supports repetitive informational broadcast at very low data rate; that is, the frame format has very little overhead and is optimized for short payloads sent in a repetitive manner.

9. The standard provides support for OCC dimming with the PHY modes requested in bullets 1, 2, 3, 4, 5, 6, and 7; and that at least one dimming method be based upon pulse width modulation (PWM).

Questions?