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

Submission Title: VLC System Deployment Discussion
Date Submitted: March 4, 2013
Source: Richard Roberts [Intel Labs]
Address Hillsboro, Oregon
Voice: 503-712-5012, E-Mail: richard.d.roberts@intel.com

Re:

Abstract: *VLC has been around for over a decade, has been standardized and yet is not seeing wide spread deployment. What is wrong? This document discusses some of these issues.*

Purpose: Informative

VLC System Deployment Discussion

- VLC (visible light communications) based upon LED lighting has been investigated for over a decade and demonstrated numerous times.
- Every demo seems to be accompanied by verbiage indicating how wonderful VLC is and how it is going to revolutionize wireless communications.
- Coinciding with this decade of VLC research was the release of several VLC standards, including IEEE802.15.7, yet there seems to be a lack of VLC products.
- Meanwhile in this same decade we've seen the development and deployment of 802.15.4, 802.11g, 802.11n, 802.11ac and 802.11ad.
- So what is the problem with VLC? Why is it not being widely deployed today?

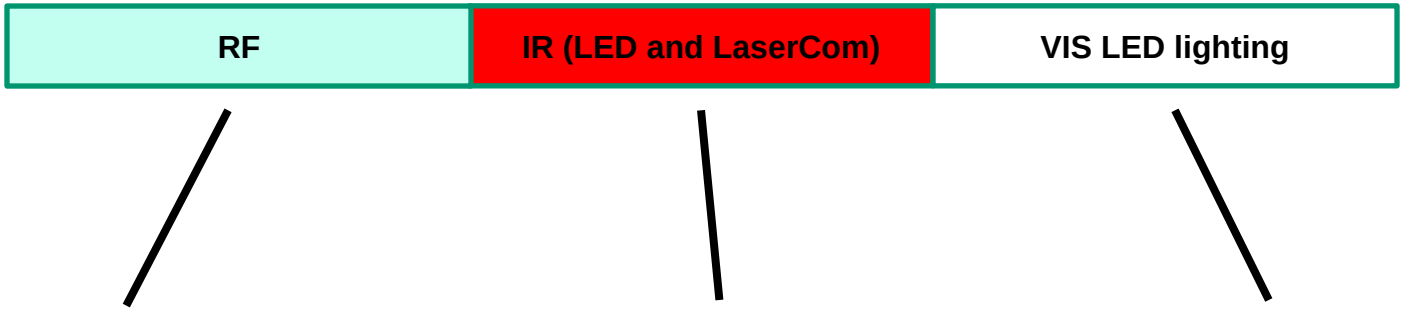
Impediments to wide spread deployment …

1. Complicated ecosystem
   - Return on Investment (ROI) Concerns
   - Business Case Justification

2. Addressing a Unique Problem
   - Enhanced User Experience
   - Duplicating WiFi is not an Enhanced User Experience

3. Cost
   - Increased cost of LED light or signage
   - Cost impact on mobile unit

Opinion on “services by wavelength”



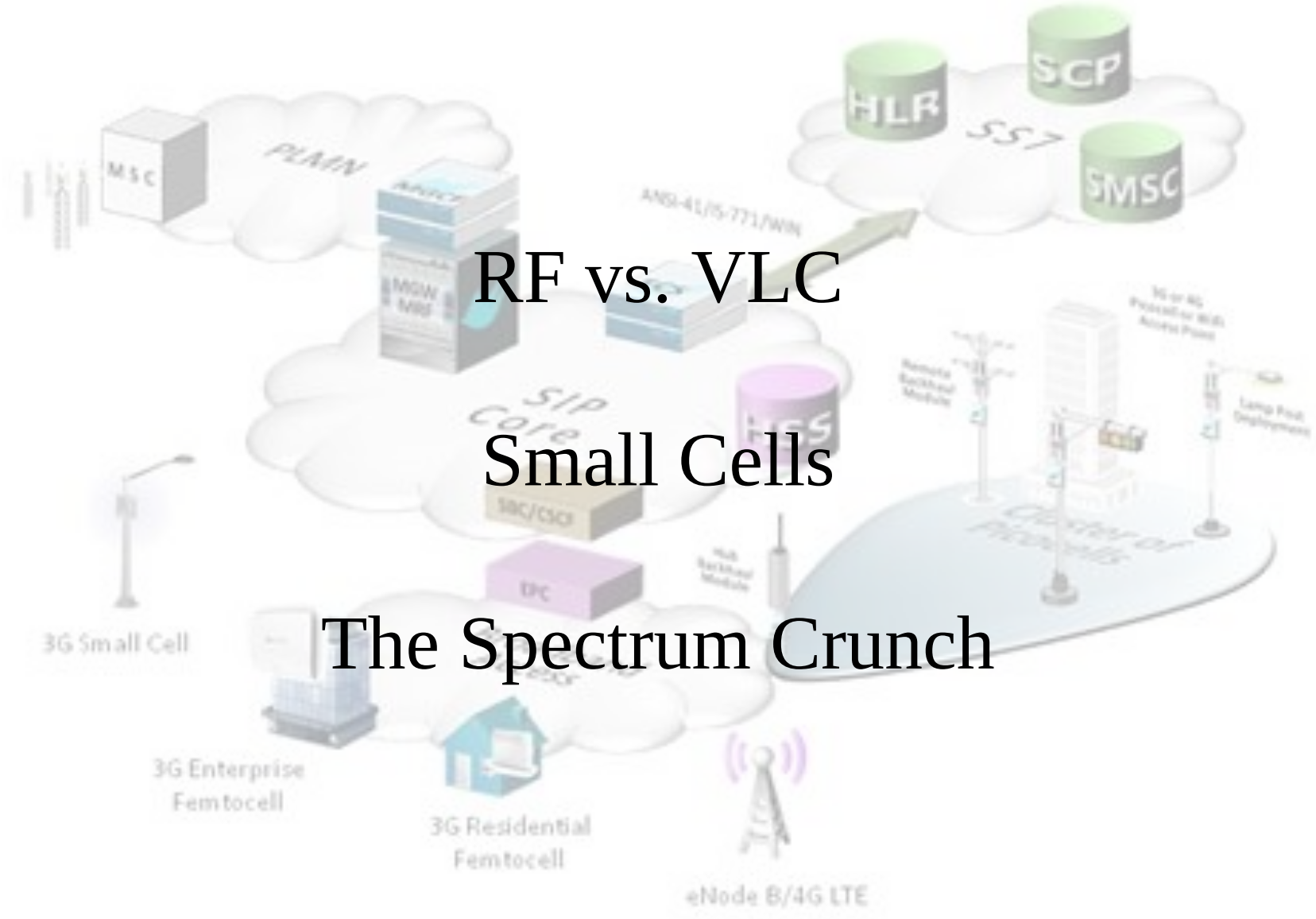
Preferred for QoS
data distribution with
random device orientation

Preferred for QoS,
high data rate distribution,
point-to-point

Preferred for AR-UX

QoS = quality of service

AR-UX = argumented reality user experience



RF vs. VLC

Small Cells

The Spectrum Crunch

1. According to the Small Cell Forum, small cells are spectrum crunch solution

2. Data distribution within a room is a small cell (i.e. LiFi use case)

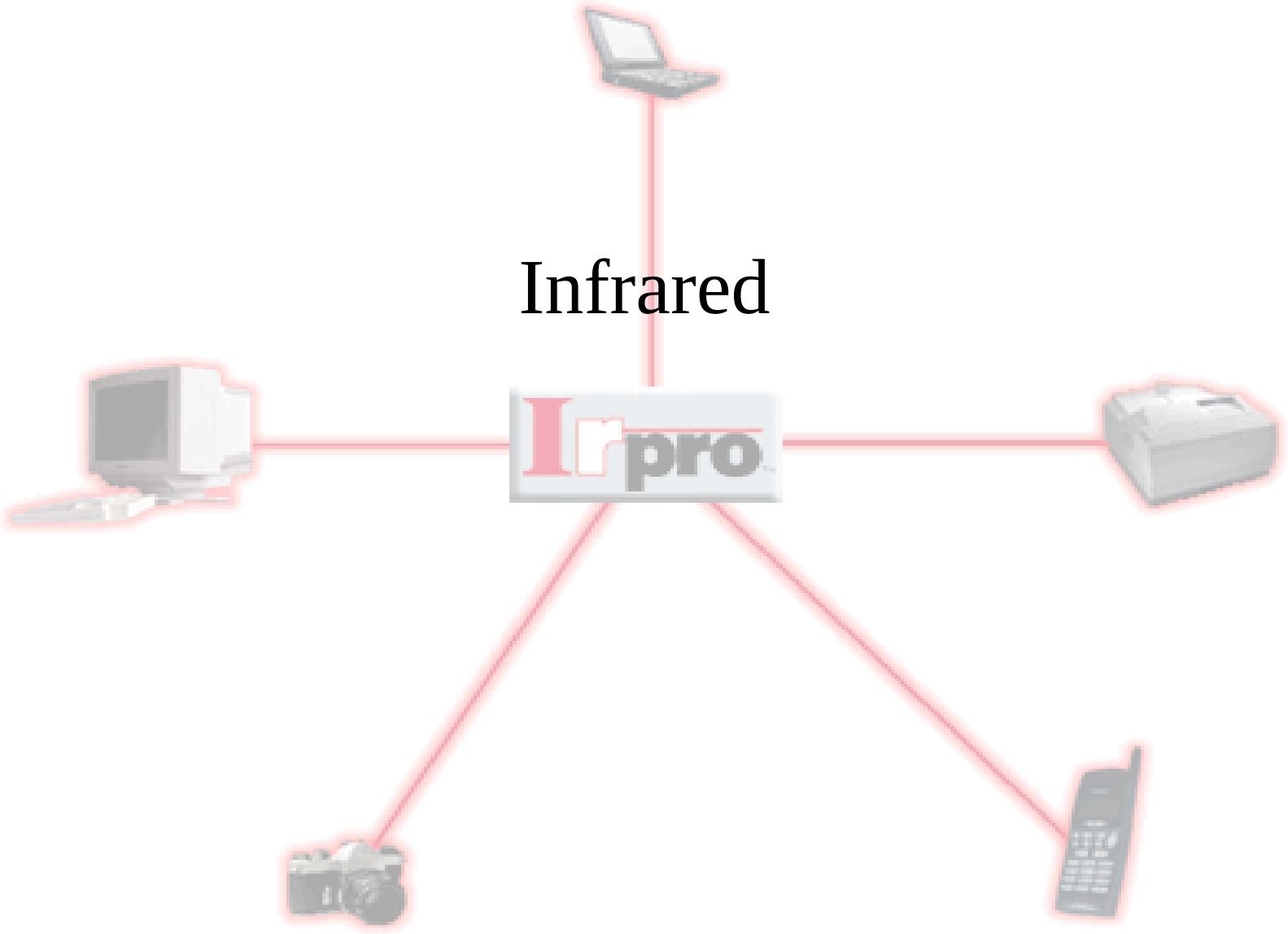
3. So both the Small Cell Forum and VLC "LiFi" agree small cells are the solution

4. The question is "what is the data distribution technology"?
   - VLC or RF

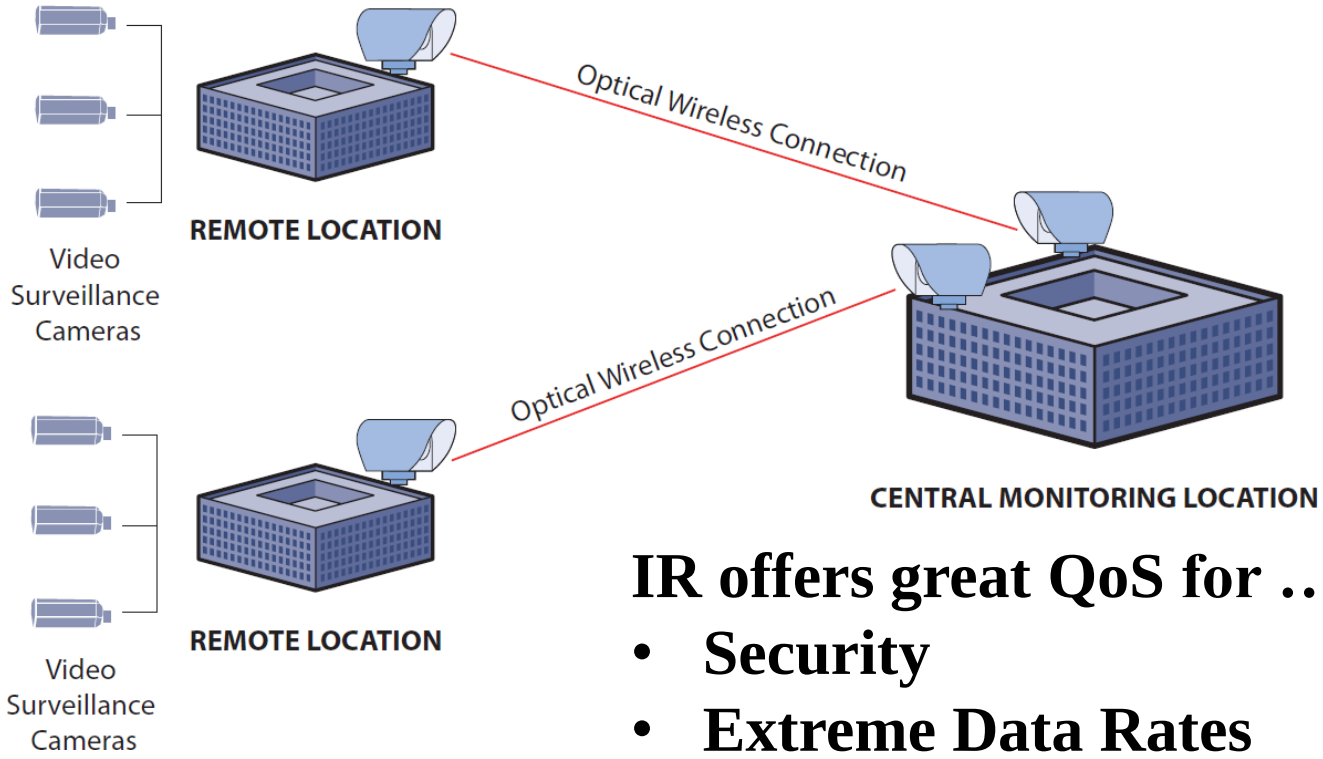
5. Intel Labs believes RF is the best technology for small cells
   - Already ubiquitous
   - Supports device random orientation
   - Feasible downlink and uplink connectivity

We believe RF small cells are the solution for the "spectrum crunch"?

Take away: VLC non-starter → pursuit of use cases already adequately served by RF (i.e. WiFi, 3G, 4G)


Infrared
Irpro

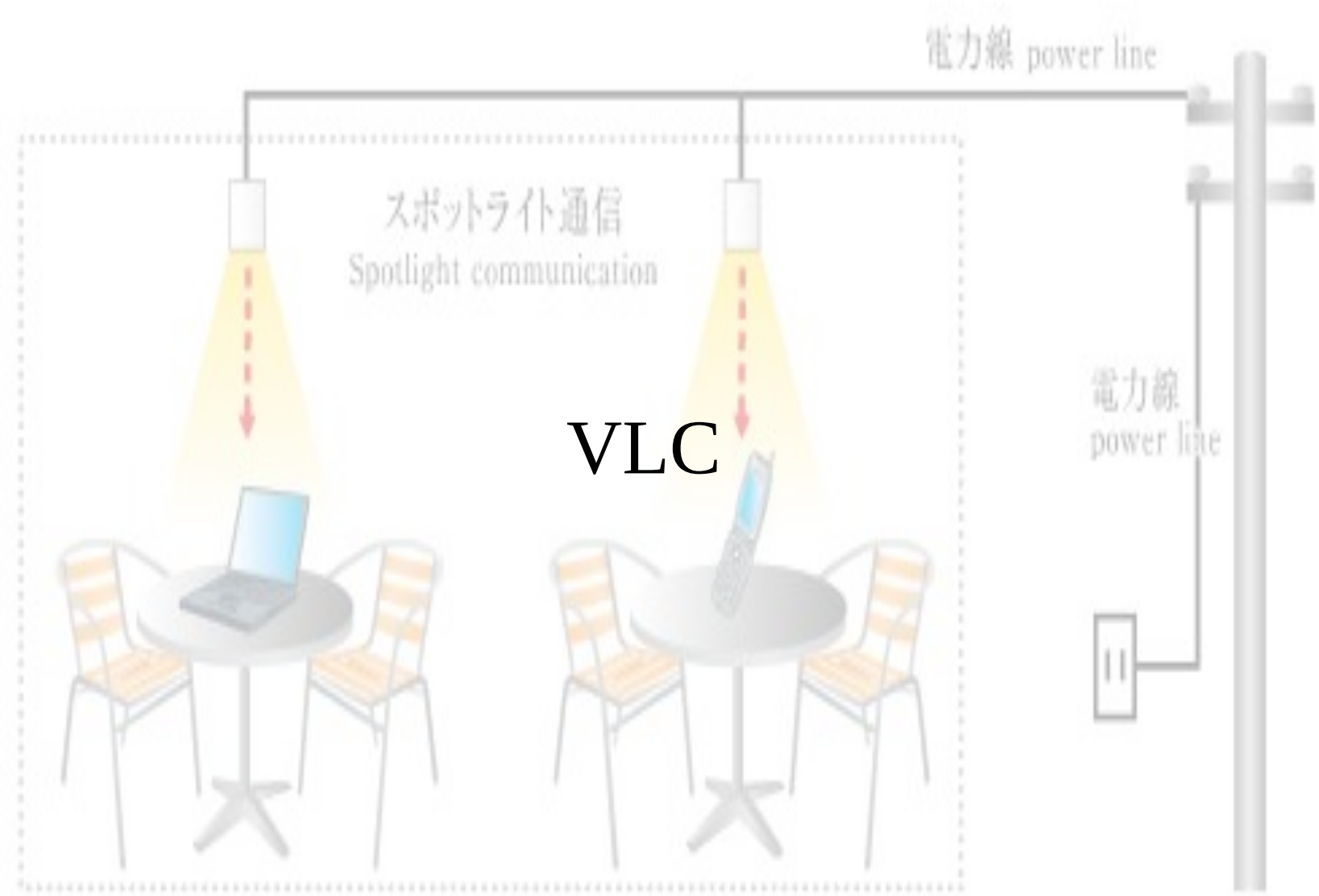
Infrared is great for pt-to-pt LOS QoS deployments!



IR offers great QoS for …

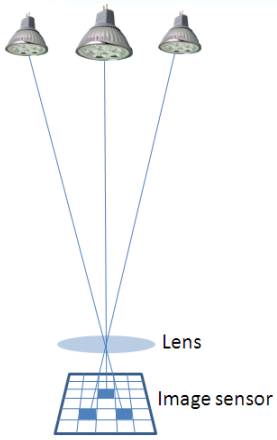
- **Security**
- **Extreme Data Rates**
- **Long Distances**

Take away: IR is excellent for QoS - can be dedicated to data transmission (i.e. not also used for human illumination)


電力線 power line
スポットライト通信
Spotlight communication
VLC
電力線
power line

So what is a viable use for VLC? … Argumented Reality (AR)!

- Line-of-sight Marketing
- Informative Broadcast



- Indoor Positioning

Take away: VLC best choice for AR via informative broadcasts … to keep cost low use the camera image sensor (i.e. run an APP)

Mobile handset form factor is a constraint

Very tight mechanical packaging
Very sensitive to battery usage
Already has a light detector … the camera (CamCom)
Installation of multiple fly-eye lenses and such are not feasible
Camera flash LED not ideal for VLC transmission

For VLC success, deployment cost (i.e. complexity) is critical!

1. Must not increase cost of smartphone mobile platform
   - Just using an APP is the best solution

2. Must not significantly impact cost of LED lights
   - High speed data transmission requires extensive redesign of LED lights and extensive infrastructure upgrade

3. AR use case does not necessarily need high data rates
   - Example … VLC transmission of QR code equivalent

Intel Labs believes the most viable immediate market opportunities are either VLC niche products or CamCom products

CamCom Demo

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

And please – no more VLC down-link demos!

- We all understand that the SNR on the VLC down-link is very high and that hundreds of Mbps can be transmitted.
- The hard part is the mobile device orientation and the up-link!
- Please show us mobile “in motion” demos of smartphones taking advantage of all that VLC down-link data rate while supporting reasonable up-link data rates using VLC

And yes, there will be VLC niche markets where device orientation can be fixed. The more widely deployed smartphone market will require support for mobility and random orientation.

The End