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

Submission Title: [OCC Proposal of Scope of standardization and applications]

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Abstract: [Scope of standardization proposal and applications case studies]

Purpose: [Contribution to IEEE 802.15 TG7a.]

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Optical Camera Communication (OCC)
Proposal of
Scope of standardization
and applications

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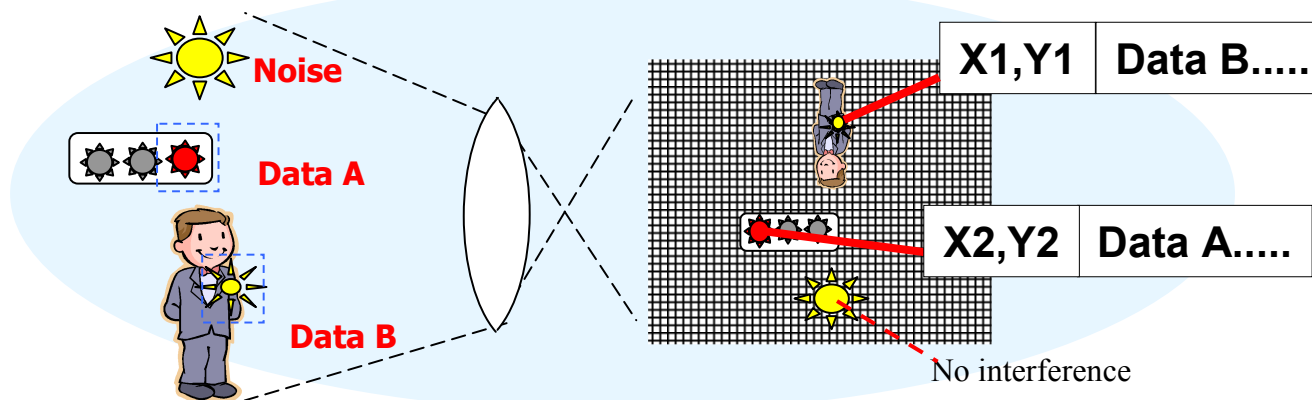
Nobuo IIZUKA

iizukan@casio.co.jp
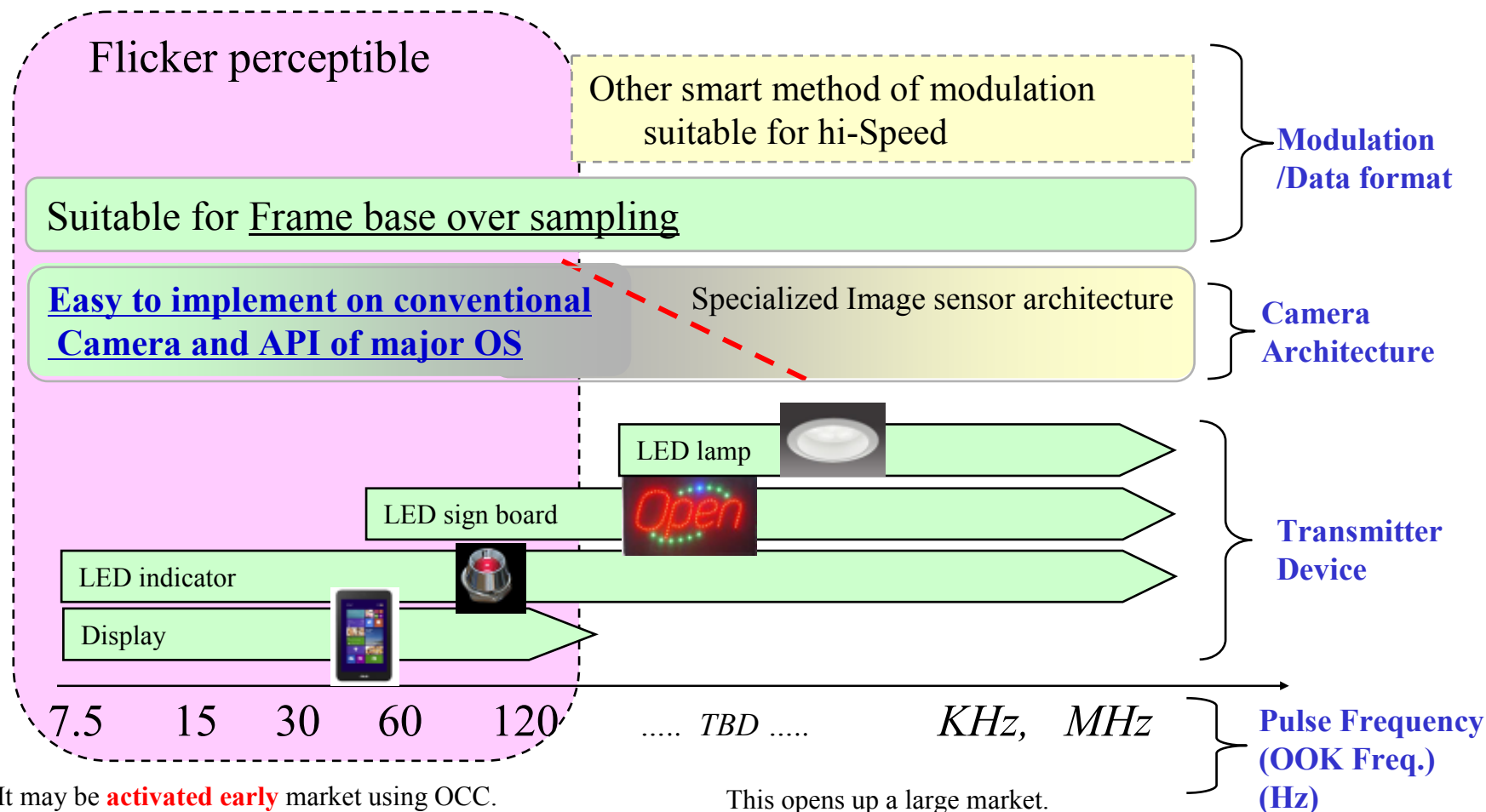
Outline

1. Modulation Frequency and Data Format

2. OCC Application and Case Studies
   – High speed camera based applications
   – App based OCC

Possibility of OCC

- ## Special separation capability
    - Highly spatial resolution
    - No interference
        - Noise separation
        - Multi Point to Point communication
- ## Grasping the position in the Image
- ## Promising applications:
New user experiment,   AR (Augmented Reality) ,   line of sight marketing, real-world-oriented interface.   IOT (Internet of Things)

Noise

Data A

Data B

X1,Y1 | **Data B.....**

X2,Y2 | **Data A.....**

No interference

Slide 4 <Nobuo Iizuka>, <CASIO COMPUTER CO., LTD.>

Modulation frequency band plan and requirements

Flicker perceptible

Other smart method of modulation suitable for hi-Speed

Modulation /Data format

Suitable for <u>Frame base over sampling</u>

<u>Easy to implement on conventional Camera and API of major OS</u>

Specialized Image sensor architecture

Camera Architecture

LED lamp

LED sign board

LED indicator

Display

Transmitter Device

7.5   15   30   60   120   ..... *TBD* .....   *KHz,   MHz*

Pulse Frequency (OOK Freq.) (Hz)

It may be **activated early** market using OCC.
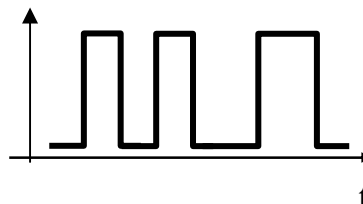
This opens up a large market.

Band plan (color using)

To be the standard that contains two standards.

1. White or Mono-color modulation
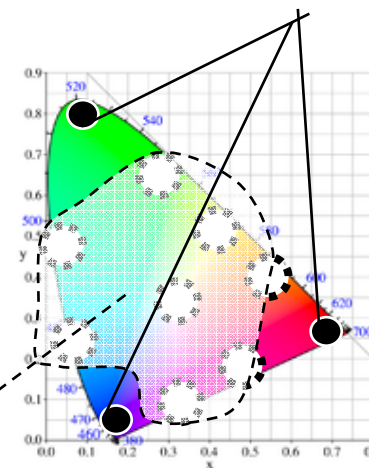
– Brightness level

2. Color modulation

RGB is obligatory

Do not proceed only in a theoretical point of view.
In the required specification to the combined the characteristics of the API and camera devices for now, then, it should define optional.
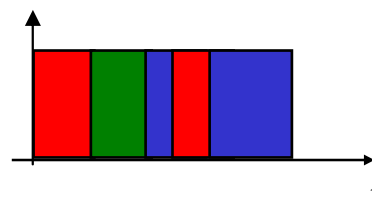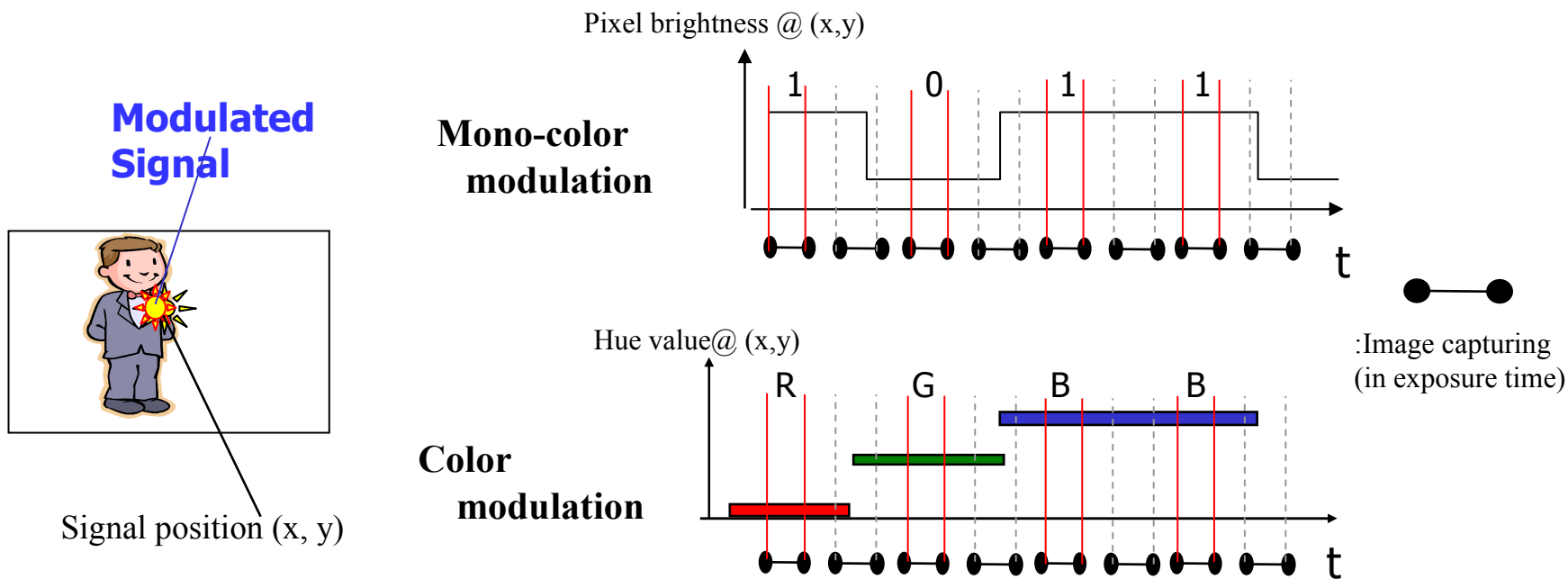

Use of **neutral colors** might be optional.

<January 2014>

Basic concept of bit decoding

- Baseband modulation and Simple frame base over sampling
  - Frame rate = pulse rate x 2
  - **Easy to implement on conventional Camera and API of major OS**

Modulated Signal

Signal position (x, y)

Pixel brightness @ (x,y)

Mono-color modulation

1   0   1   1

t

:Image capturing (in exposure time)

Hue value@ (x,y)

R   G   B   B

Color modulation

t

Slide 7   <Nobuo Iizuka>, <CASIO COMPUTER CO., LTD.>

Requirement Data format

To be the standard that contains two standards.

- ## Short block format (e.g16-32pulse)
    - – Suitable for ID transmitting
    - – In particular, it is necessary for the application of low speed.

- ## Long data block format
    - – Suitable for normal data transmission

OCC applications and Case studies
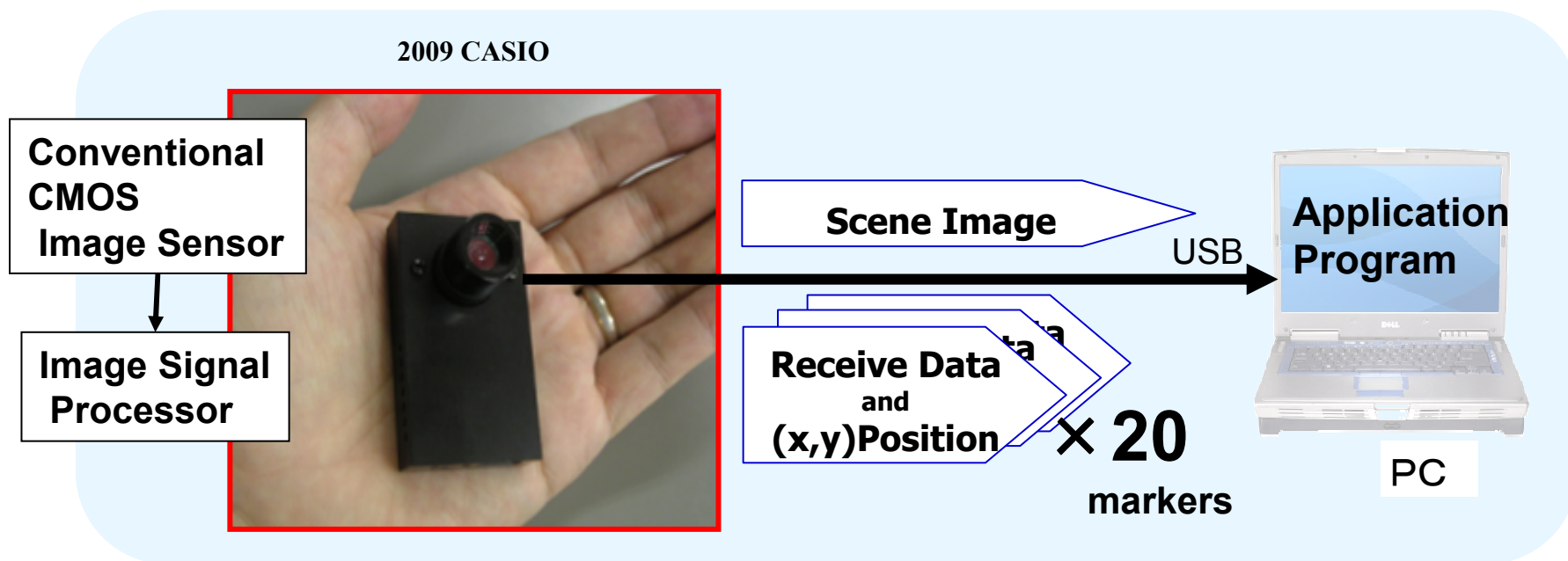
OCC case studies by CASIO

1. Hi-Speed cam based OCC (prototype Image sensor module)

    • Mono-color OOK, Pulse rate 300-2.3kHz

    • 600 - 4.6k fps (150bps-1.1kbps)

    • Tracking markers of 20 or so at the same time.

2. Picapicamera, App-based OCC

    • Pulse rate 5.5Hz with color modulation

    • 11fps, 5bit/s, 4-10 markers simultaneously and in parallel

    • iOS / Android / PC   ready

    • Flicker safe on display (W3C guidelines compliance)

    • The ID management in conjunction with cloud server, services can be build practical

1. Hi-speed cam based OCC

Prototype of OCC sensor module

- From Low Speed@High-resolution (100bps@QCIF)
  to High Speed@Low-resolution (1.1k bps@64x32pix)

2009 CASIO

Conventional CMOS Image Sensor

Image Signal Processor

Scene Image

USB

Application Program

Receive Data **and** (x,y)Position

× **20 markers**

PC

A demo movie by Hi-speed cam based OCC

- Simultaneous receiving 30 ID-data and positions
- Tracking up to walking speed

2009.Sep.

| Parameters		
Receive	Frame Rate	**600fps**
	Bit Rate	**150bps / 1ID**
	Maximum parallel	**30 IDs**
	Distance	8m (@2mmx2mm chip LED and FOV of This Lens)
Send	Color	Not use (Brightness base)
	Modulation	I-4PPM base, 16pulse block

Achievements by Hi-speed cam based OCC-1

2008 **600fps/150bps/10m**

Multi sensor node data acquisitions with its position

2006 **150fps/ 75bps /70m**

Man search on the street
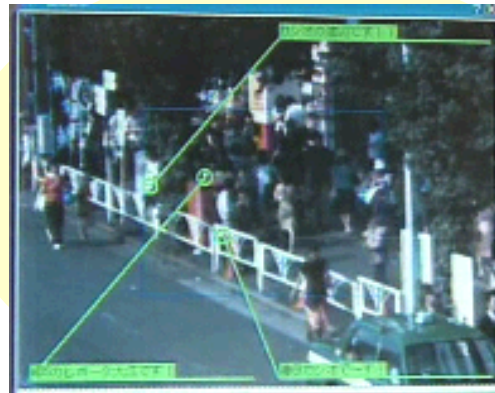
2006 **150fps/ 75bps /70m**

Receiving from indirect light

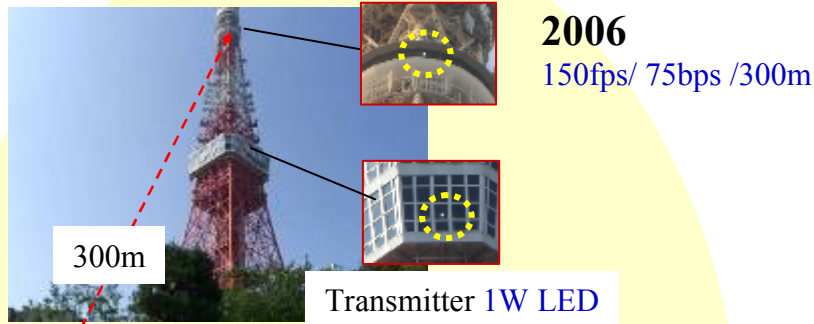2011 **4600fps/1.1kbps/2km**

Light house (Buoy)

2009 **4600fps/1.1kbps/2km**
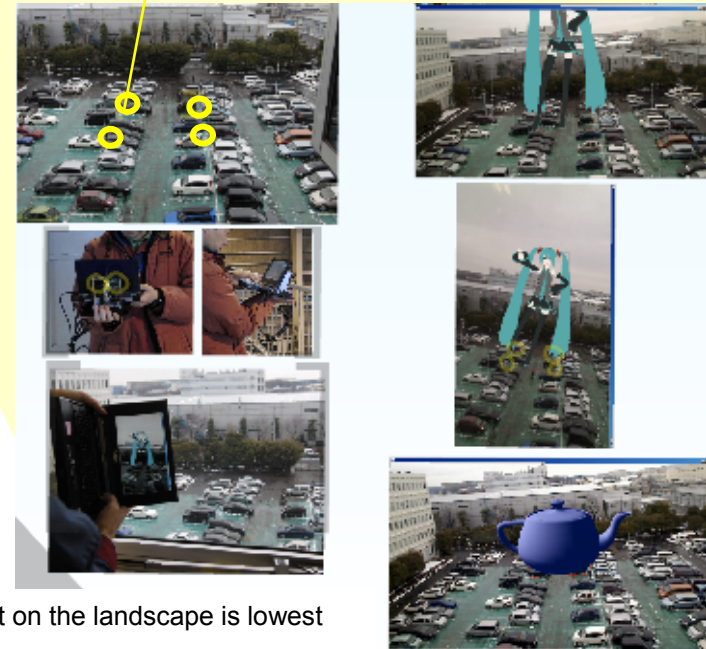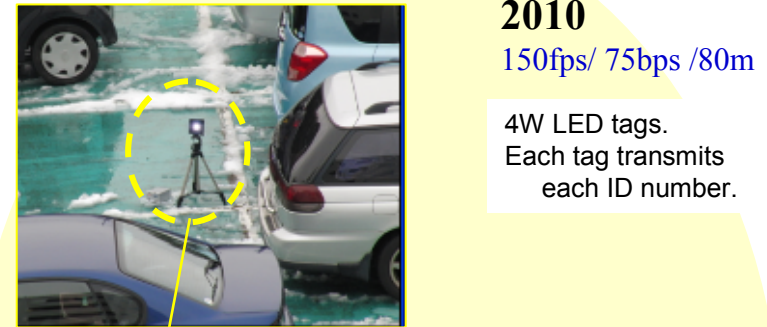
Traffic signal master-slave control data transmit

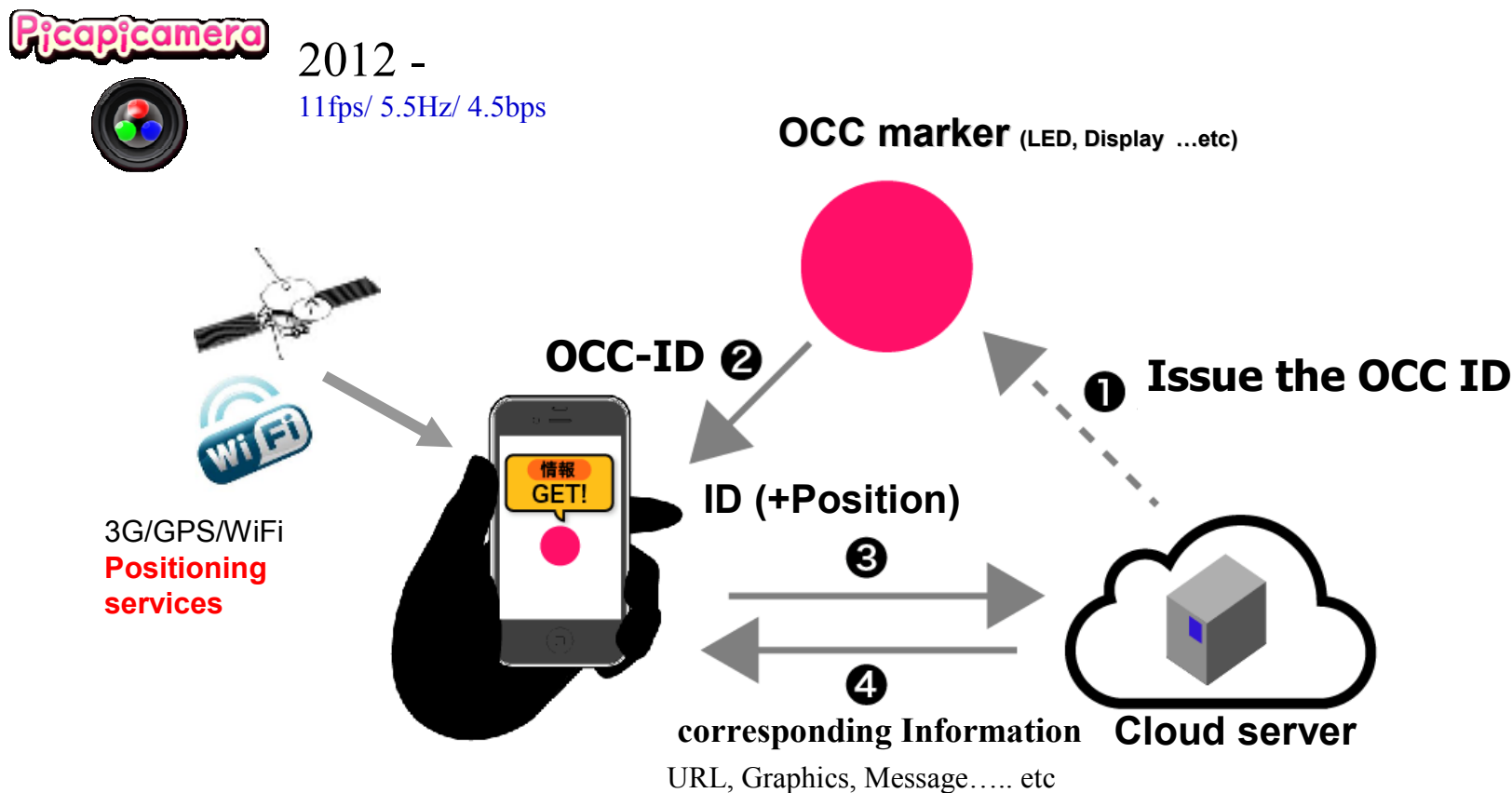# Achievements by Hi-speed cam based OCC-2

Transmit from TOKYO tower

2006
150fps/ 75bps /300m

300m

Transmitter 1W LED

camera

Huge Outdoor AR

2010
150fps/ 75bps /80m

4W LED tags.
Each tag transmits
each ID number.

•Impact on the landscape is lowest

2. Picapicamera, App-based OCC

Mechanism to receive rich content all over the world by low speed OCC.

Picapicamera

2012 -
11fps/ 5.5Hz/ 4.5bps

OCC marker (LED, Display …etc)

OCC-ID ❷

❶ **Issue the OCC ID**

情報 GET!

ID (+Position)

3G/GPS/WiFi
Positioning services

❸

❹

corresponding Information
URL, Graphics, Message….. etc

Cloud server

Technical specifications are as of January 2014 Ver2.x

Service trial by Picapicamera

2013 Nov. – Dec.
Tama-city of TOKYO Christmas illumination
17cm LED marker was placed in the Xmas illumination at several points. Visitor gathered stamp images from that LED markers.

up to 10m distance

2014 TOKYO motor show SUZUKI
(and OSAKA/ FUKUOKA/ SAPPORO motor show)

Electric bike prototype, speaks using the light.
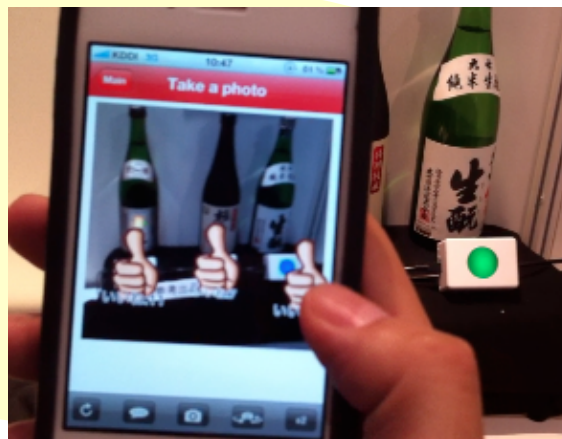For example, "I'm Hungry!! Give me Electricity!"

Picapicamera, Other demonstrations

2012 ~ 2013

2012
18cmΦ LED array panel
20m

Image Sensor Communication V0.9
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Outdoor signage
20-30m
Marker size 50cmΦ

"Like button"
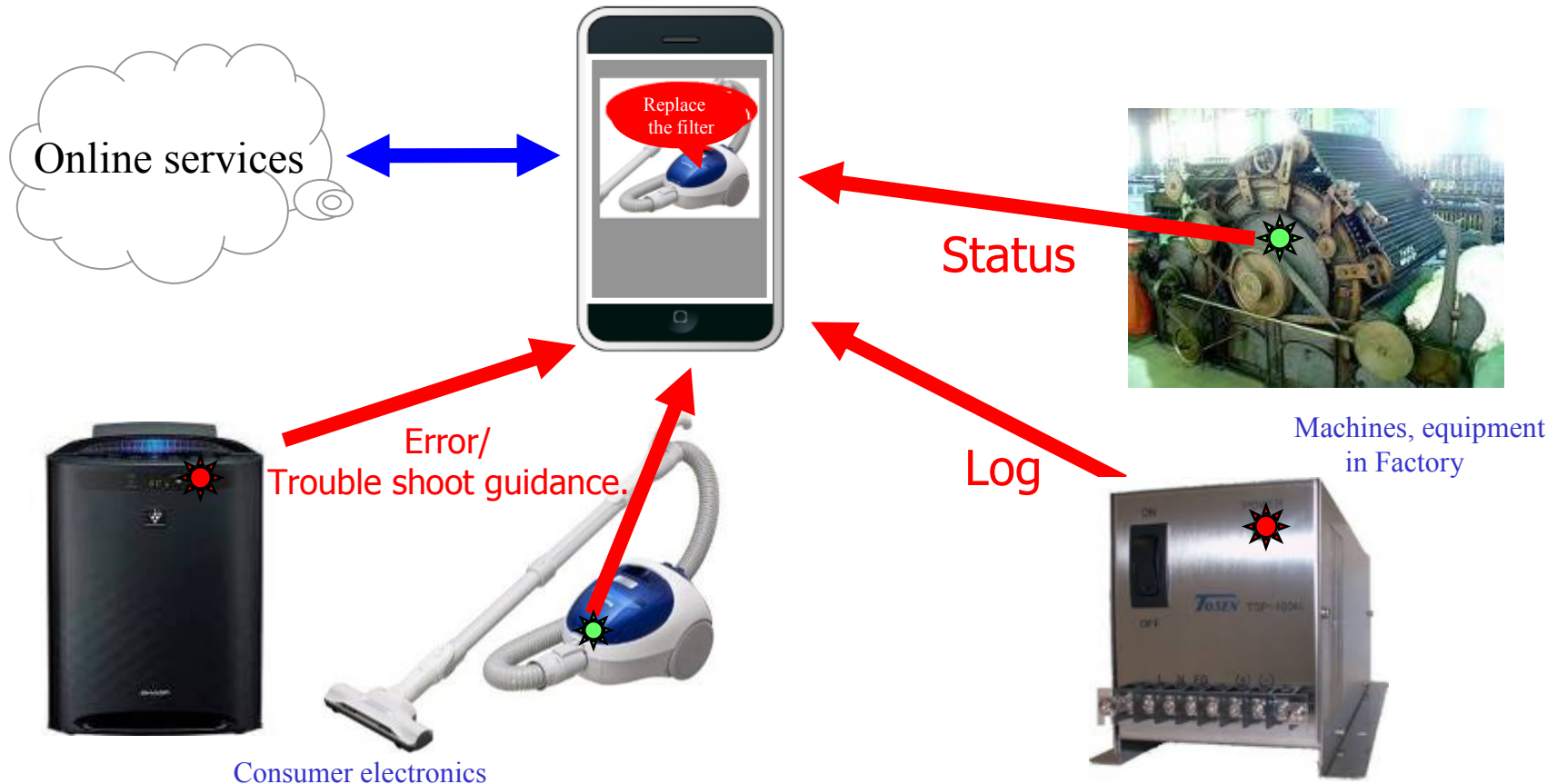comes up from LED
and You can push "like".

TV display
Marker size 5cmΦ

Other promising applications

1. LED indicator and smartphone OCC

- When Information came out , the human eye can feel.
  By OCC, we can get more information.
- Lowest cost way to send to simple dynamic information to the smartphone
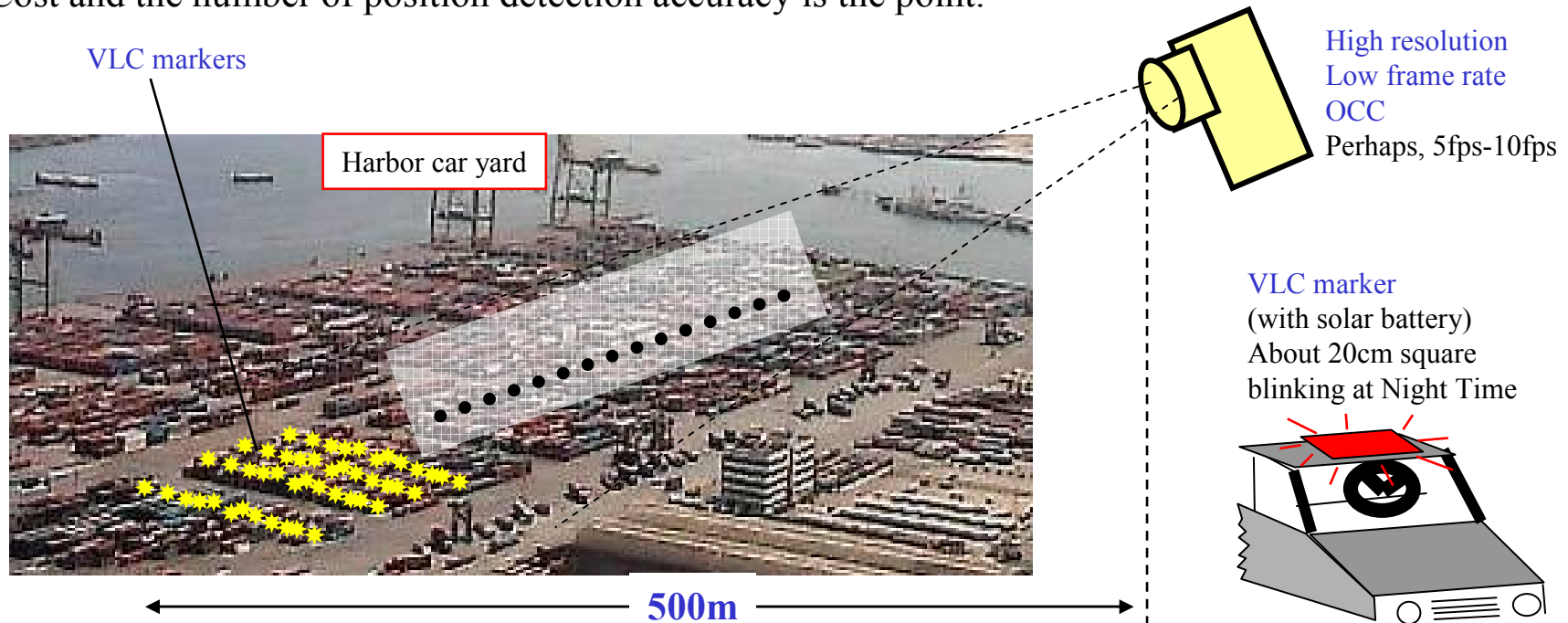 from the machine with LED.

Online services

Replace the filter

Status

Machines, equipment in Factory

Error/ Trouble shoot guidance.

Log

Consumer electronics

2. Object location management of large amounts in the distance

For example at the harbor car yard……
Assuming you may be positioning at night every day, it may be a very slow communication.
Cost and the number of position detection accuracy is the point.

VLC markers

Harbor car yard

High resolution
Low frame rate
OCC
Perhaps, 5fps-10fps

VLC marker
(with solar battery)
About 20cm square
blinking at Night Time

500m

Marker size assumption
    ex) Lens FOV:40degree, camera resolution 1920x1020 pix => 0.000 36 degree/Pix => **18cm@500m marker is available.**
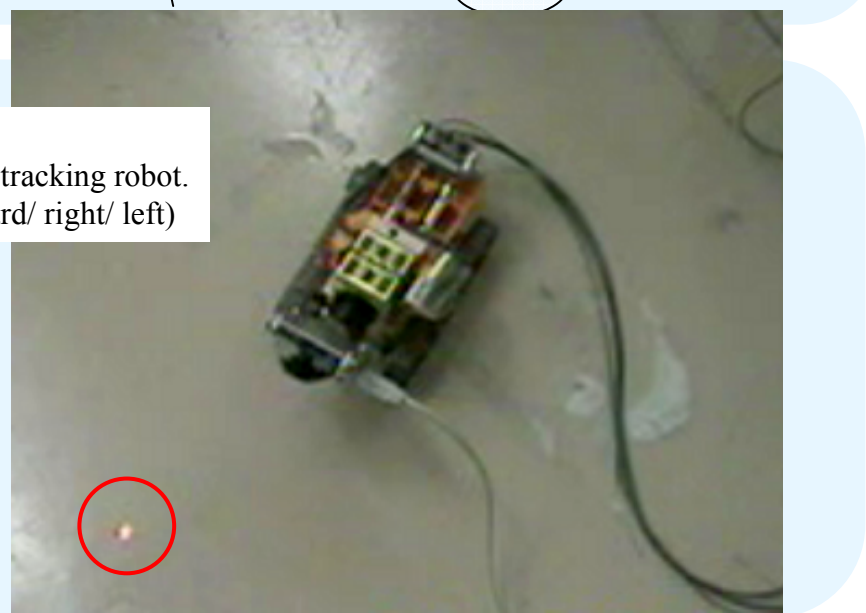
 There are solutions such a wide range, high precision positioning using radio waves,
 but it requires the installation of an antenna of a large amount. The cost is like several million U.S. dollars or more for it.

3. Robotics -command and spatial Information -
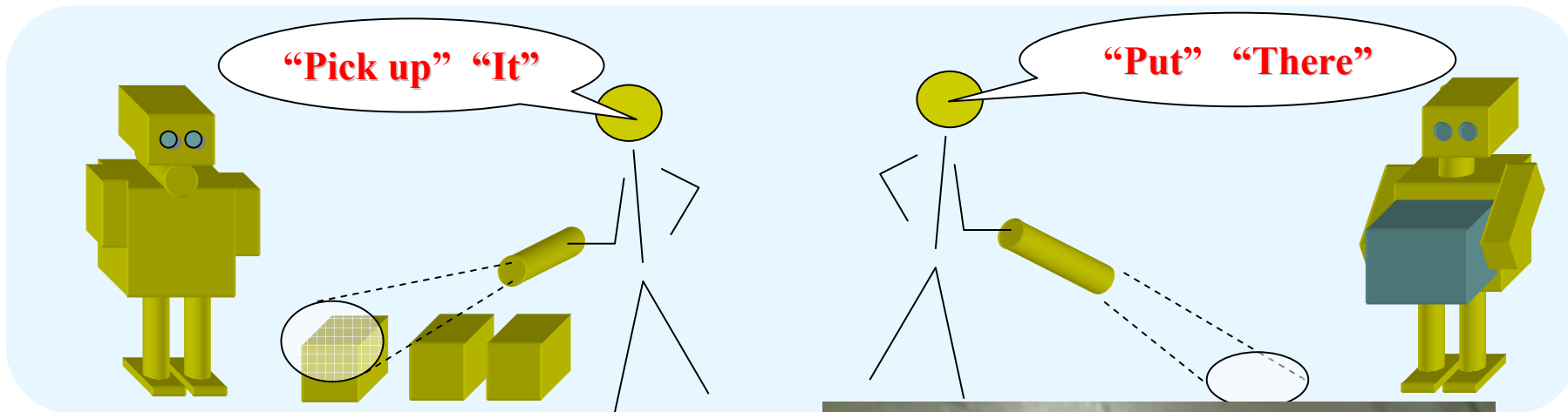
2001
Command beam tracking robot.
(Forward/ backward/ right/ left)

4. Vehicle to vehicle communication
for "**Pre-crash safety**".

The reaction to the braking lights of the car in the positional relationship of the critical front.

Judgment :
    forward car : **emergency brakes! !**

OCC device

Transmit the **braking pressure**
 by a stop-light (VLC modulated)
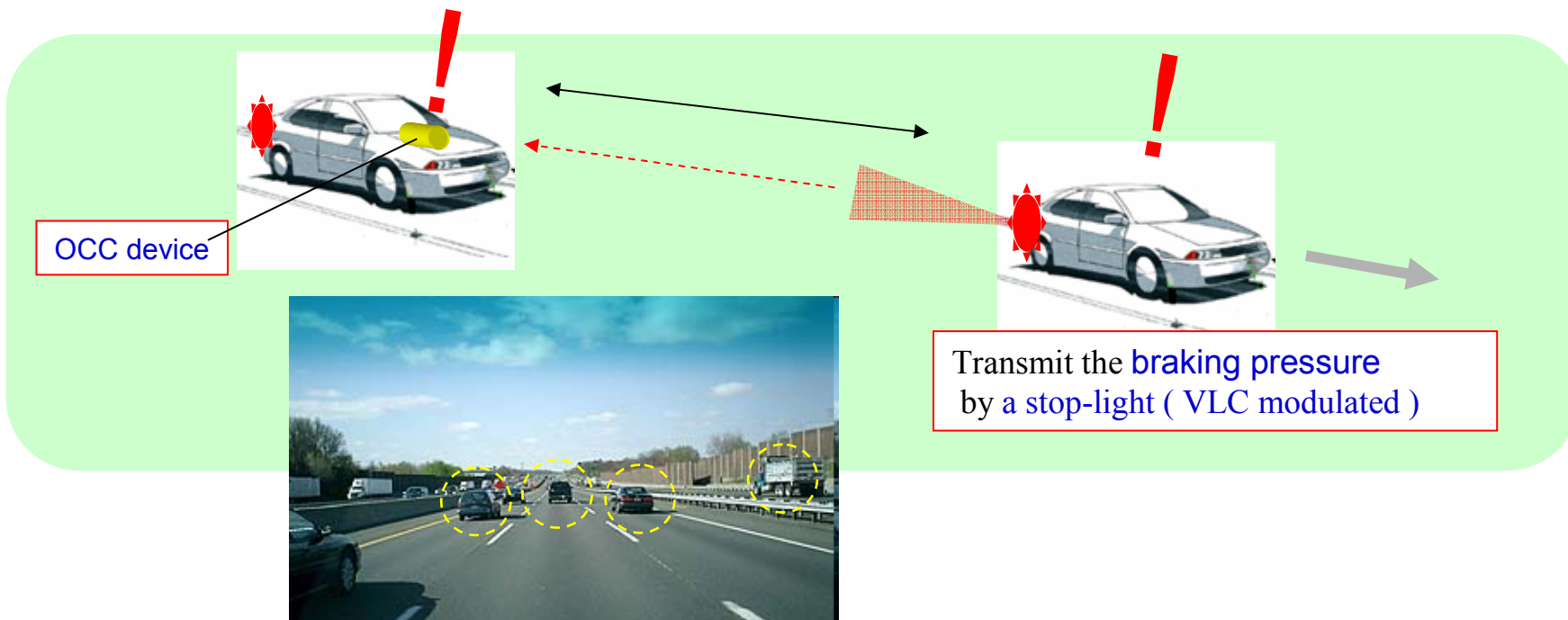
Relative positional relationship is important.

Summary

1. Band Plan

   - High frequency (- KHz, MHz) for a data transmission with large size market in the future

   - Low frequency (5 to 120 Hz) for ID transmission with earlier adopted market (existing camera and API)

   - Mono-color modulation and Color modulation

   - Base band modulation

   - Block format can be 16 to 32 pulse for ID transmission

2. OCC Application and Case Studies

   - ID tracking with walking speed

   - Multi-sensor node, Long distance, AR marker

   - Events, Digital signage, Equipments Indicator

   - Real time location, Robotics, Cars