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

Submission Title: [Kookmin University Response to 15.7r1 CFA: Applications of OCC]
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Abstract:

Purpose: Call for Application Response

Kookmin University Response to 15.7r1 CFA:

Applications of OCC

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- OCC issues to be solved
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- D2D based display to display communication
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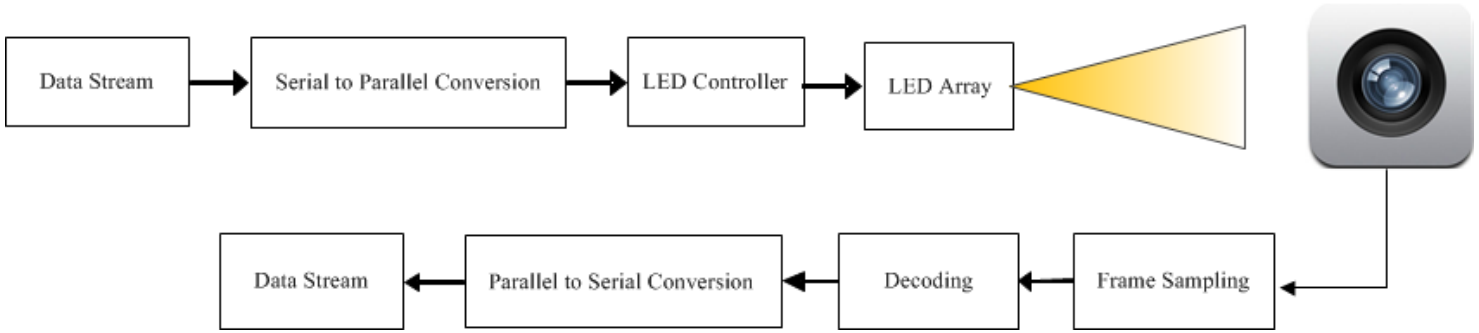
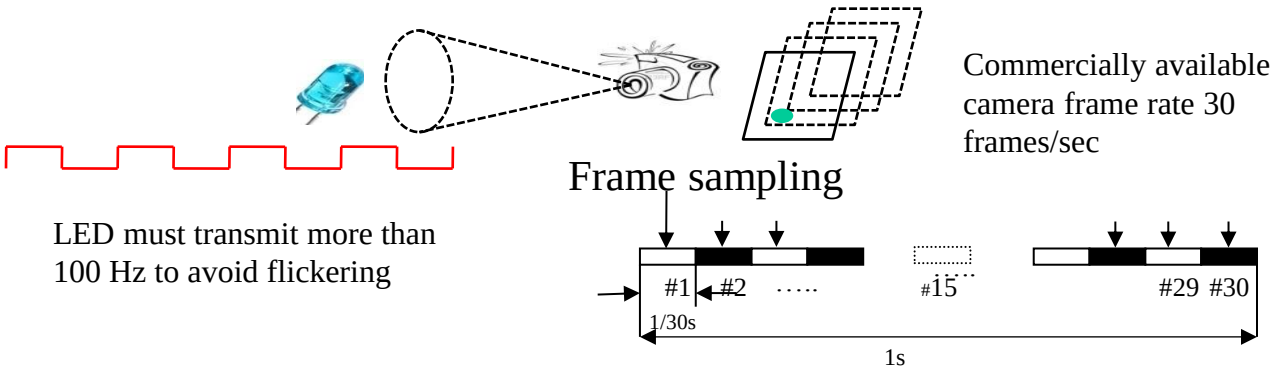
Data Decoding Procedure of OCC



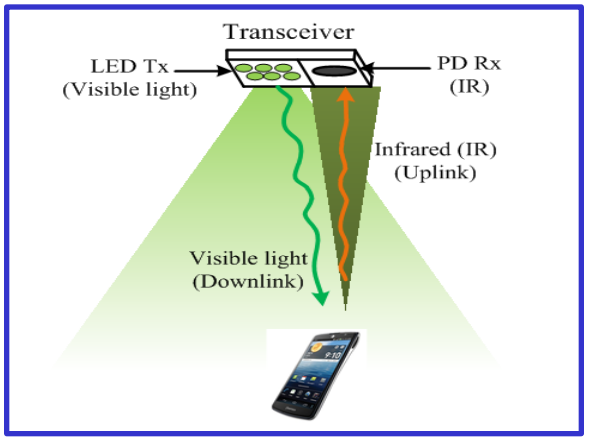
Proposed block diagram for OCC system



Data decoding procedure

OCC Issues to be solved

- **Uplink transmission development with reliable and simultaneous communication:**
  - IR based uplink, LED Flash, and Smart Phone Screen
- **Line-of-sight interruption problem**
  - Need to improve link switching scheme for seamless connectivity
- **Cell overlap region:**
  - Could communicate in two adjacent cell overlap region using subcarrier modulation
  - Need link switching
- **Backhaul network & Supporting network:**
  - Light fixture needs to plugged into wire network
  - Power line communication (PLC)

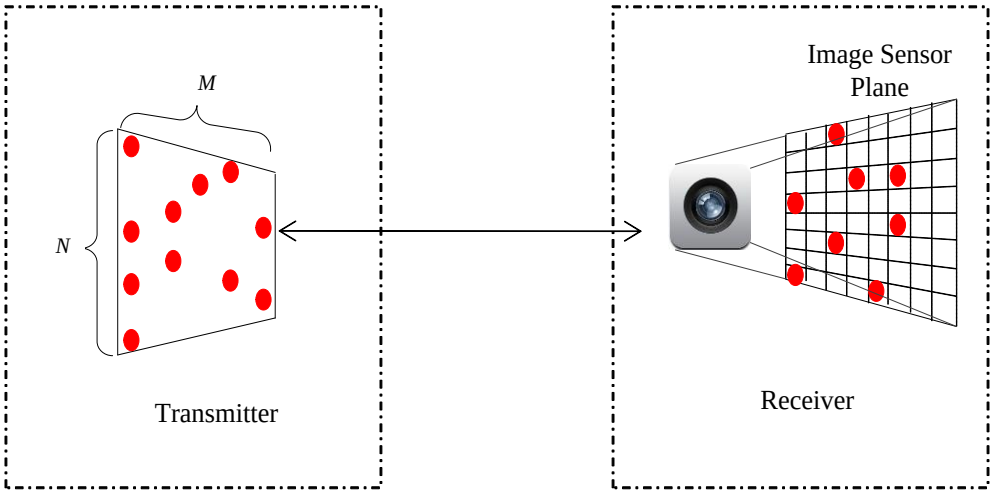


VLC-IR combination for downlink-uplink communication

Optical MIMO

- **Low data rate due to low frame rate can be overcome using optical MIMO**

- **Transmitter:**
  - Multiple arrays of LEDs should be considered
  - Each LED or group of LEDs can be used as transmitting antenna.
- **Receiver:**
  - Either camera or image sensor (IS) can be used as receiver



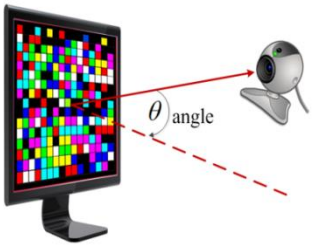
Spatial separation of multiple LED at receiver side

Challenges for MIMO OCC System

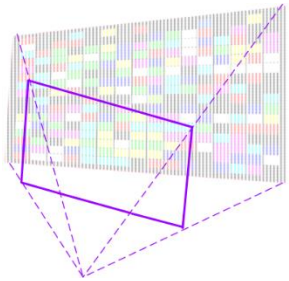
- **Combining multiplexing and diversity for OCC**
  - **Objective:** Capacity enhancement (for speed) and robust communication link (for reliability)
  - **Problem:** To achieve optimum gain when both diversity and multiplexing are combined
  - **Remark:** To introduce MIMO coding schemes (V-BLAST and STBC) into OCC
- **Spatial Separation of pixels (channels)**
  - **Objective:** Distinguish the multi-channel by successful pixel separation
  - **Problem:** Pixels may overlap and result inter-symbol interference
  - **Remark:** Efficient algorithm to distinguish pixel. Selection and combining schemes (e.g. MRC, generalized selection combining etc.) can be used in OCC to select channels (pixels) with highest SNR values
- **Transmitter and receiver alignment problem**
  - **Objective:** To increase the number of rank of the channel matrix
  - **Problem:** Placing receiver in corner of the room reduce the channel rank to one, therefore it is impossible to achieve diversity as well as multiplexing
  - **Remark:** To introduce angle diversity and tilting receiver arrangement

MIMO OCC and multi-colors transmission

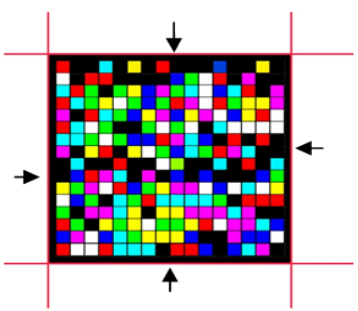
Design of LEDs transmitter to mitigate Perspective Distortion:



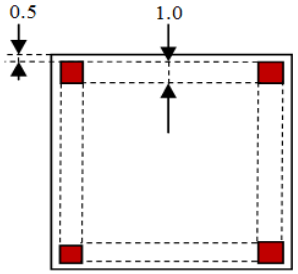
(a) Angle of Capturing



(b) Perspective Distortion

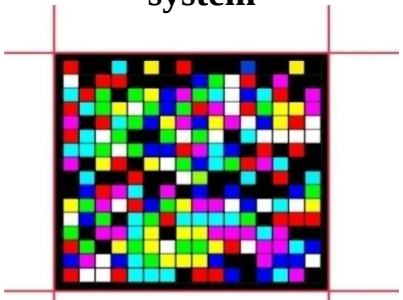


4 surrounding edges

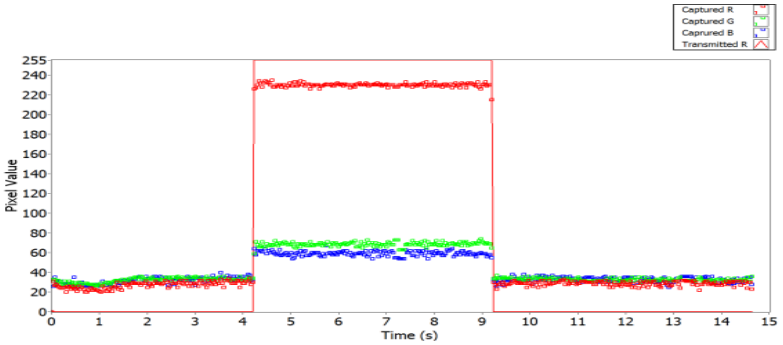


Reference LEDs

Multiple colors transmission in MIMO system

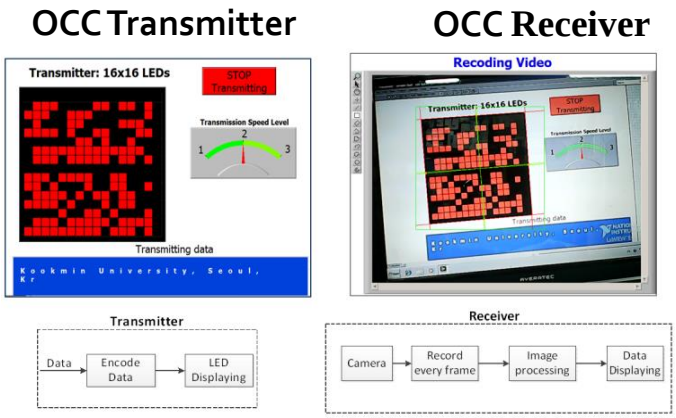


16x16 LEDs Transmitter with 8 colors used

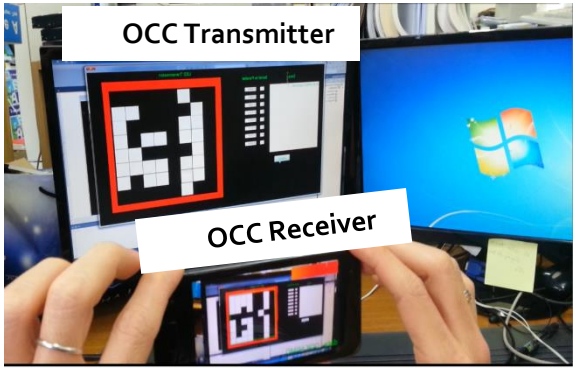


Interference between color channels

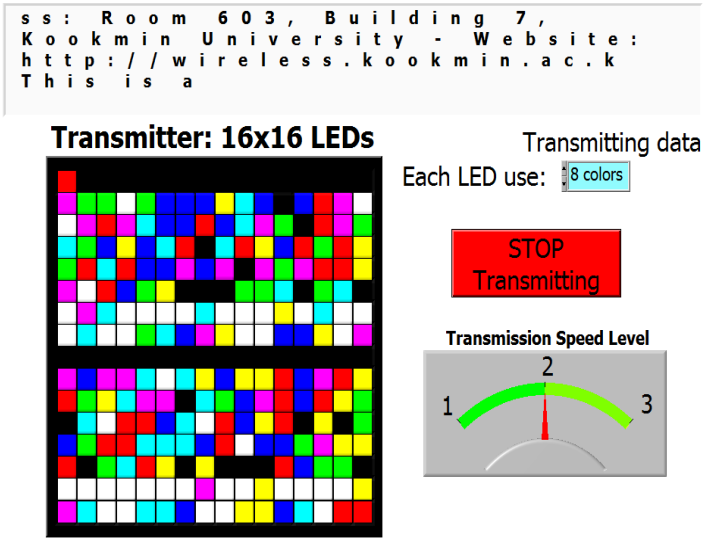
MIMO OCC and multi-colors transmission



PC application of Screen-to-Camera



Smartphone application of Screen-to-Camera



User Interface of multi colors-MIMO-OCC transmitter

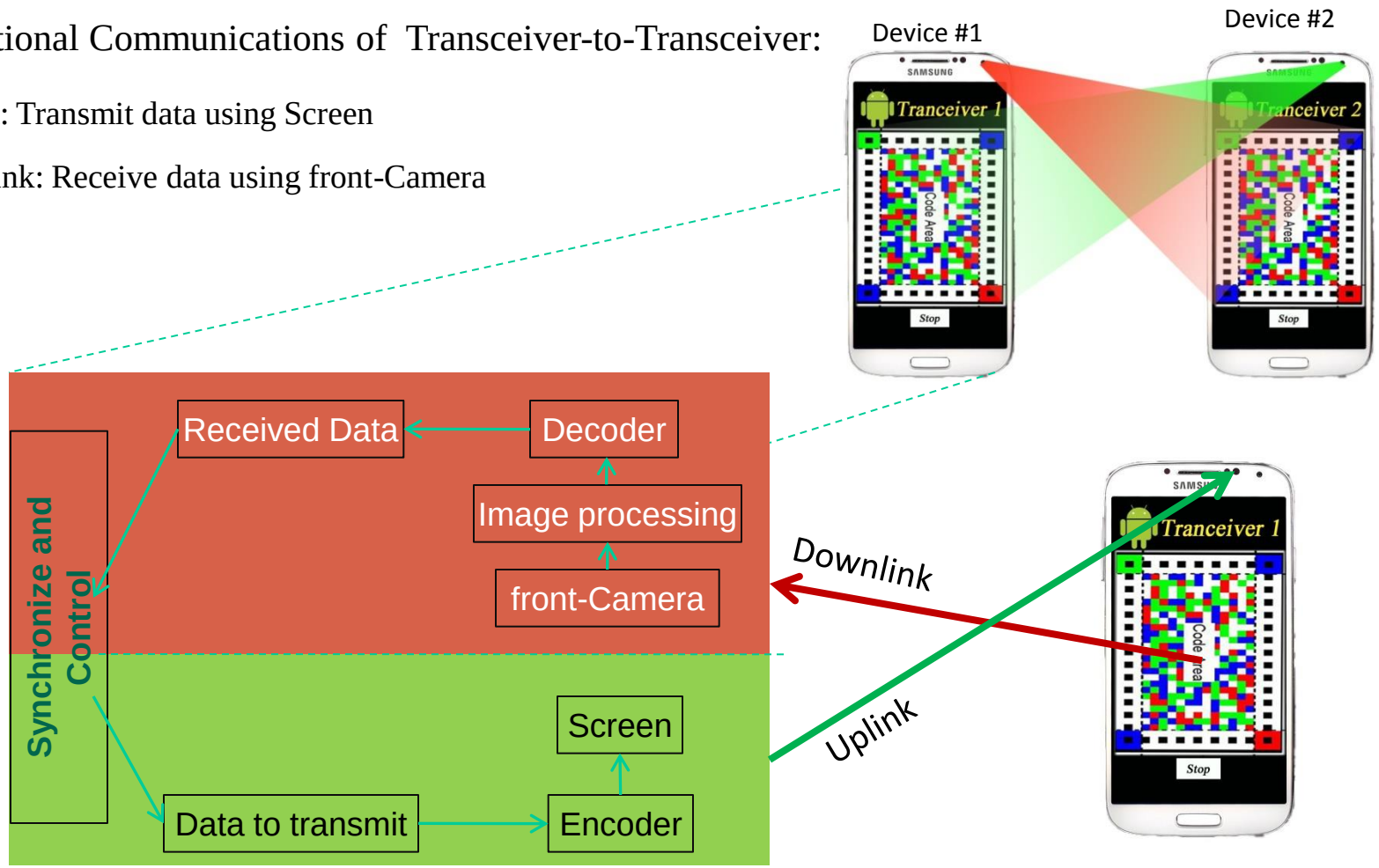
- **Data rate = 3 bits x (16 x16 LEDs) x 2/3 x 30(fps)**
  = 15360 [bps] = 15 [kbps]

- **Asynchronous Scheme is applied to mitigate Variation in Camera frame rate**

D2D based Display-to-Camera Communication

Bidirectional Communications of Transceiver-to-Transceiver:

- Uplink: Transmit data using Screen
- Downlink: Receive data using front-Camera

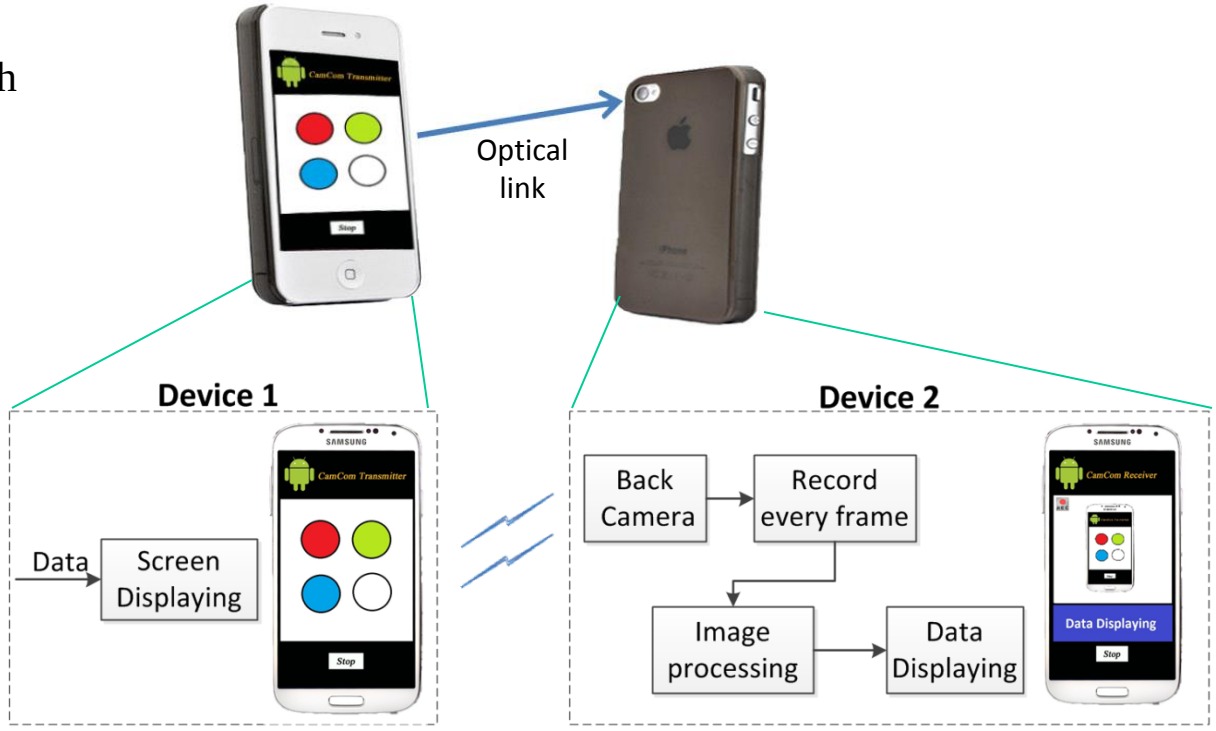


D2D based Display-to-Camera Communication

Unidirectional D2D Communications using Display-to-Camera

One-way Communications with

- Transmitter: Screen of Device #1
- Receiver: Camera of Device #2



Conclusion

- **OCC will be the new paradigm in the IEEE 802.15.7r1 OWC**
- **Need PHY for bidirectional and unidirectional communication**
- **Need to solve pixel overlap issues due to perspective distortion to support MIMO**
- **Need some directions for switching between multiplexing and diversity mode in MIMO**