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

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

Purpose: Call for Application Response

Kookmin University Response to 15.7r1 CFA:

Applications of OWC

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- Data decoding procedure of OWC
- Asynchronous rolling shutter based OWC
- LBS application
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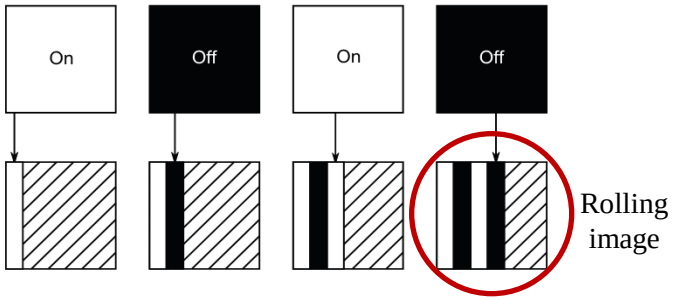
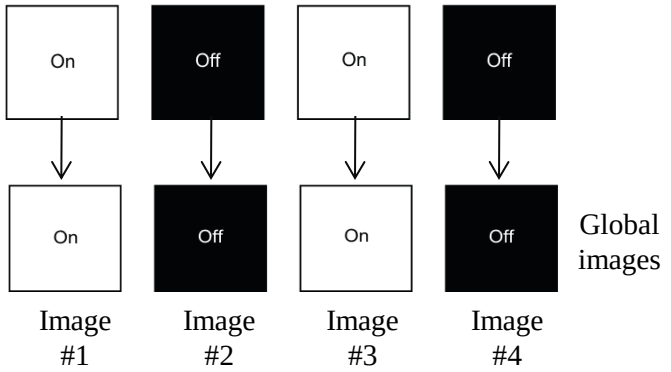
Data Decoding Procedure of OWC

Camera based OWC

Rolling shutter operation



Global shutter operation



- ❖ Rolling shutter sequentially exposes each row of the image sensor.
- ❖ Thus when the LED is on, the output of the exposed row will be a white band (bit 1).
- ❖ On the contrary, when the LED is off the output of the exposed row will be a black band (bit 0).

- ❖ Global shutter exposes whole part of the image sensor simultaneously.
- ❖ When LED is on, the whole frame will give a bright band (bit 1), and a dark band while it is off (bit 0).
- ❖ Therefore, in each frame only single bit information can be received

Also PD can be used to decode data in OWC

Comparison Between Different OWC Receiver

Tech item	Rolling shutter	Global shutter	PD
Operation	Sequentially exposes each raw of image sensor	All pixels are exposed at the same time	Always being exposed and no frame sampling
SNR	High	Low	High
Skew	Appears due to the horizontal motion of a camera	No	No
Wobble	Appears due to vertical motion of a camera	No	No
Data rate	Rolling shutter effect can be used to increase data rate	MIMO can be used to increase data rate	By increasing LED modulating frequency

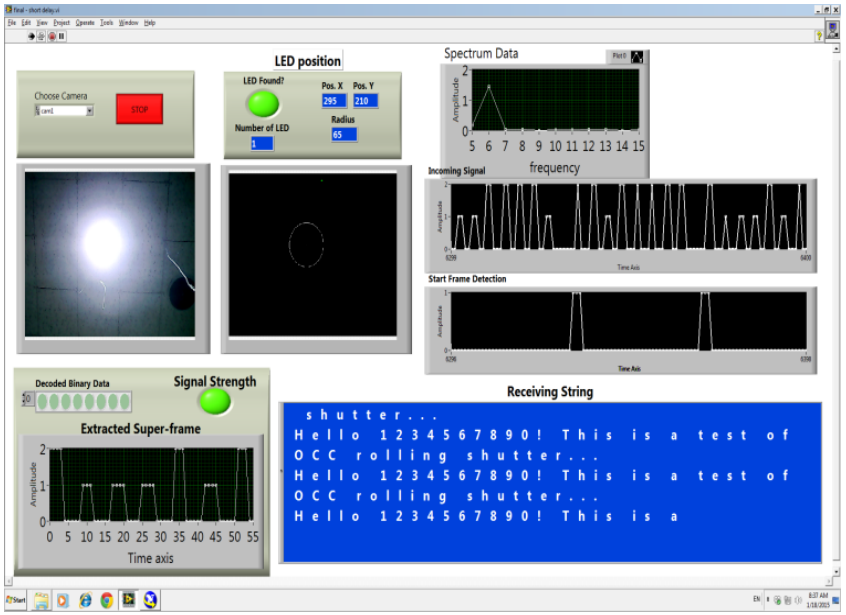
The standard provides PHY for supporting Rolling shutter and global shutter camera for OCC

Asynchronous LED-to-Rolling shutter camera based OWC

LED acts as transmitter

- Short distance: Data rate achieved = 600bps
- 3m distance: Data rate achieved = 8bps

User Interface of near-field OCC receiver (600bps)

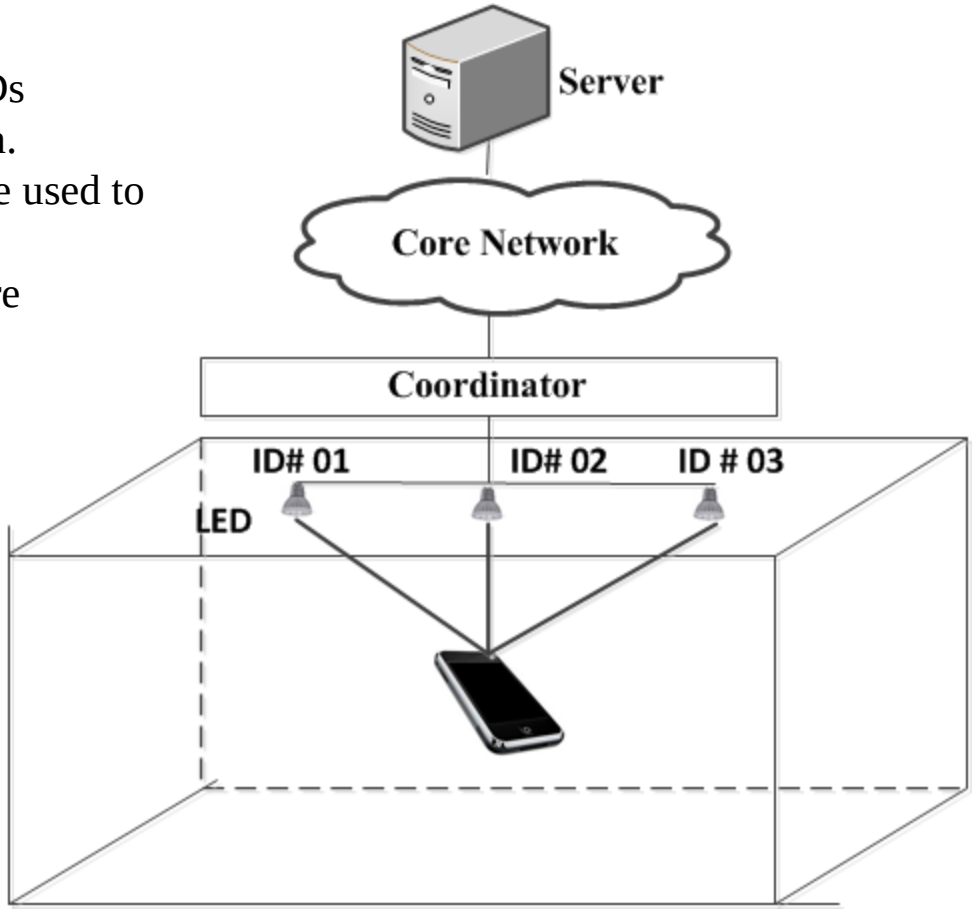


User Interface of far-distance OCC receiver (8bps)

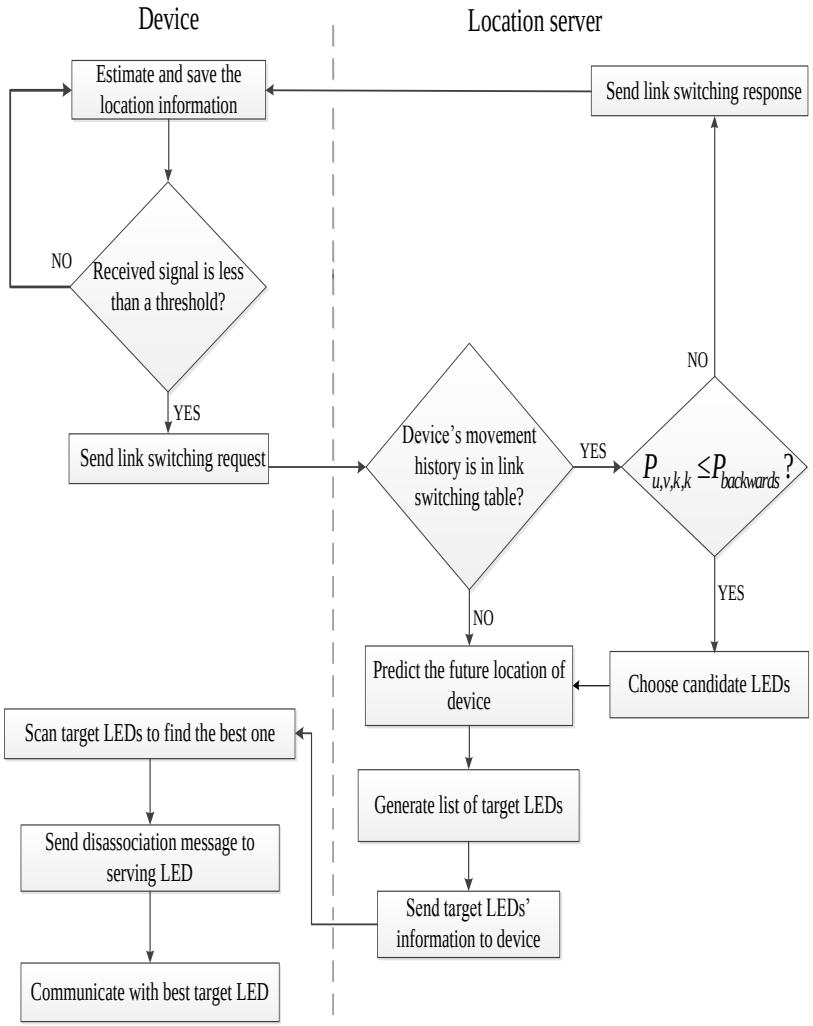
- **Asynchronous Scheme is applied for unidirectional communication, mitigating variation in camera frame rate**
- **600bps data rate achieved at short distance**
- **3m distance can be achieved by transmitting low speed.**

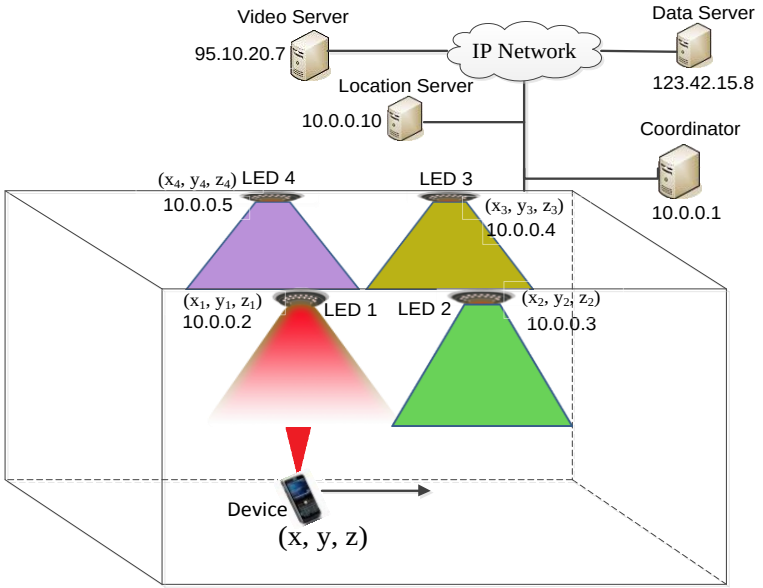
OWC based Positioning

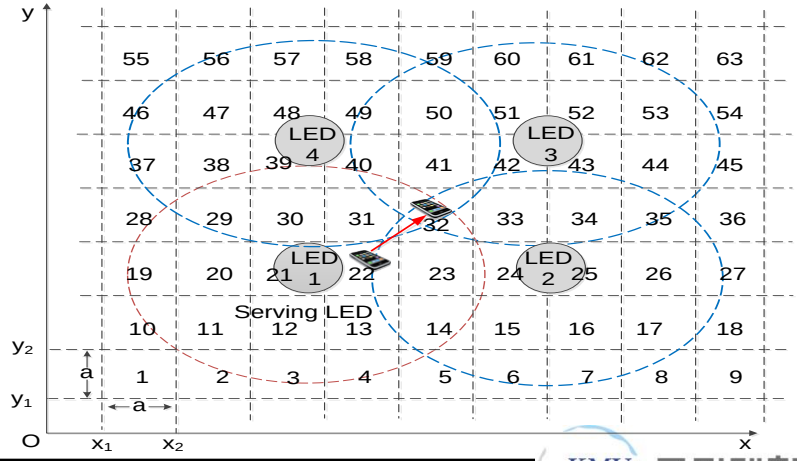
- Transmission of ID (coordinate) through LEDs
- Camera can be used to decode ID information.
- Triangulation method along with LEDs ID are used to determine user's position.
- Some legacy positioning methods for OCC are
  - TOA
  - TDOA
  - AOA
  - RSS
  - Cell ID



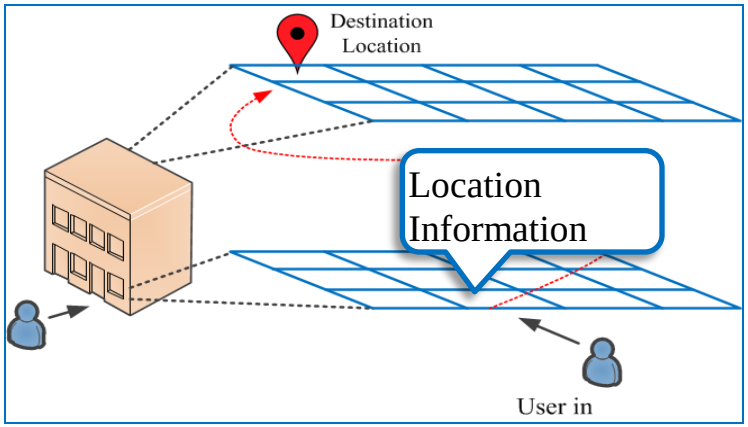
LBS application (Location Based Link Switching)



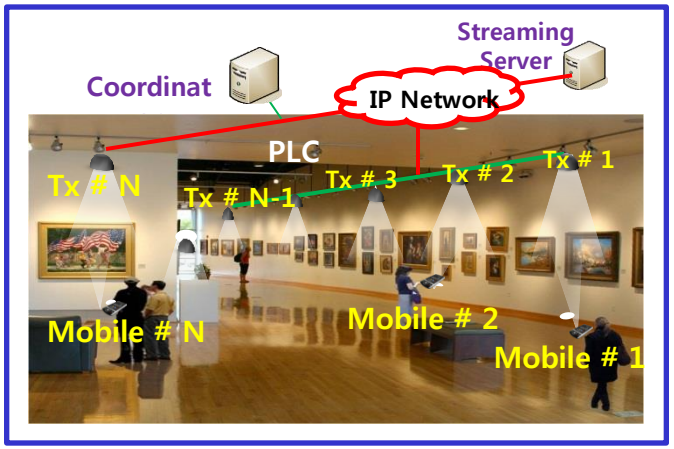




Positioning and Navigation using OWC



Indoor navigation

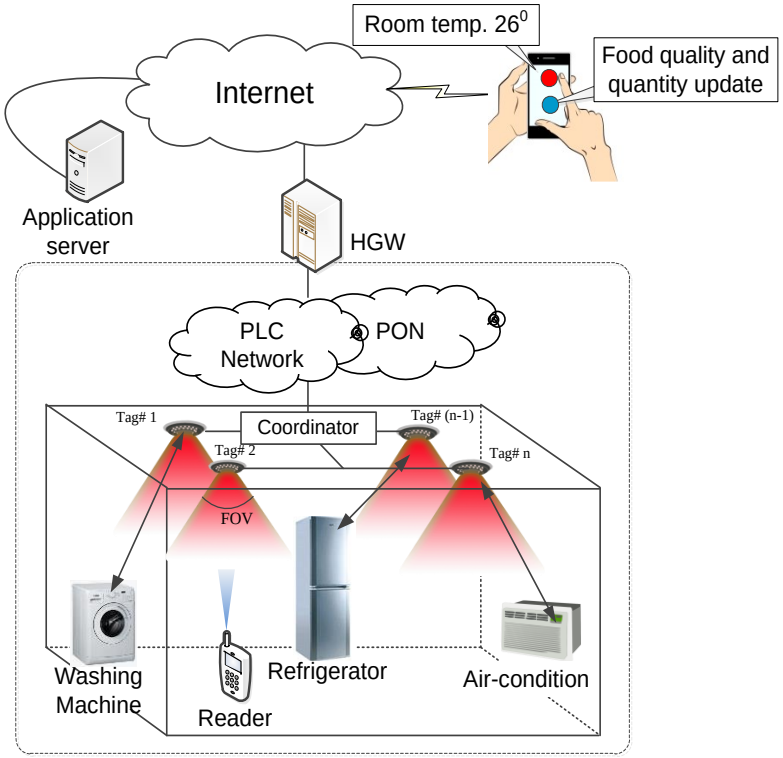


Guiding in museum scenario

Products information marketing

Internet of LED (IoL)

- Network Model considered–
  - Transmission medium – visible light
  - Functional architecture compatibility – IEEE 802.15.7r1 (Ongoing standardization)
  - Supported network topology – star, peer-to-peer and broadcasting
  - Coordinator –mainly network operation and resource allocation
  - PLC or PON as backhaul
  - Home gateway (HGW) connects indoor networked devices with internet

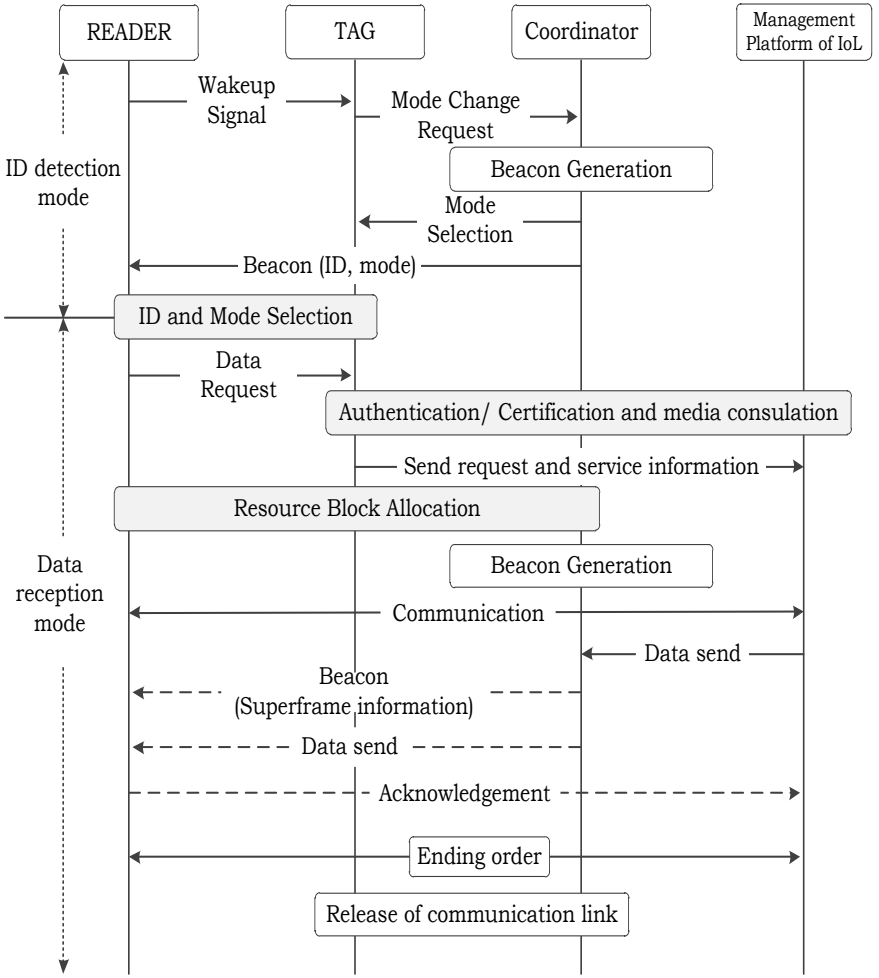


- **User can control networked devices in home with an app**

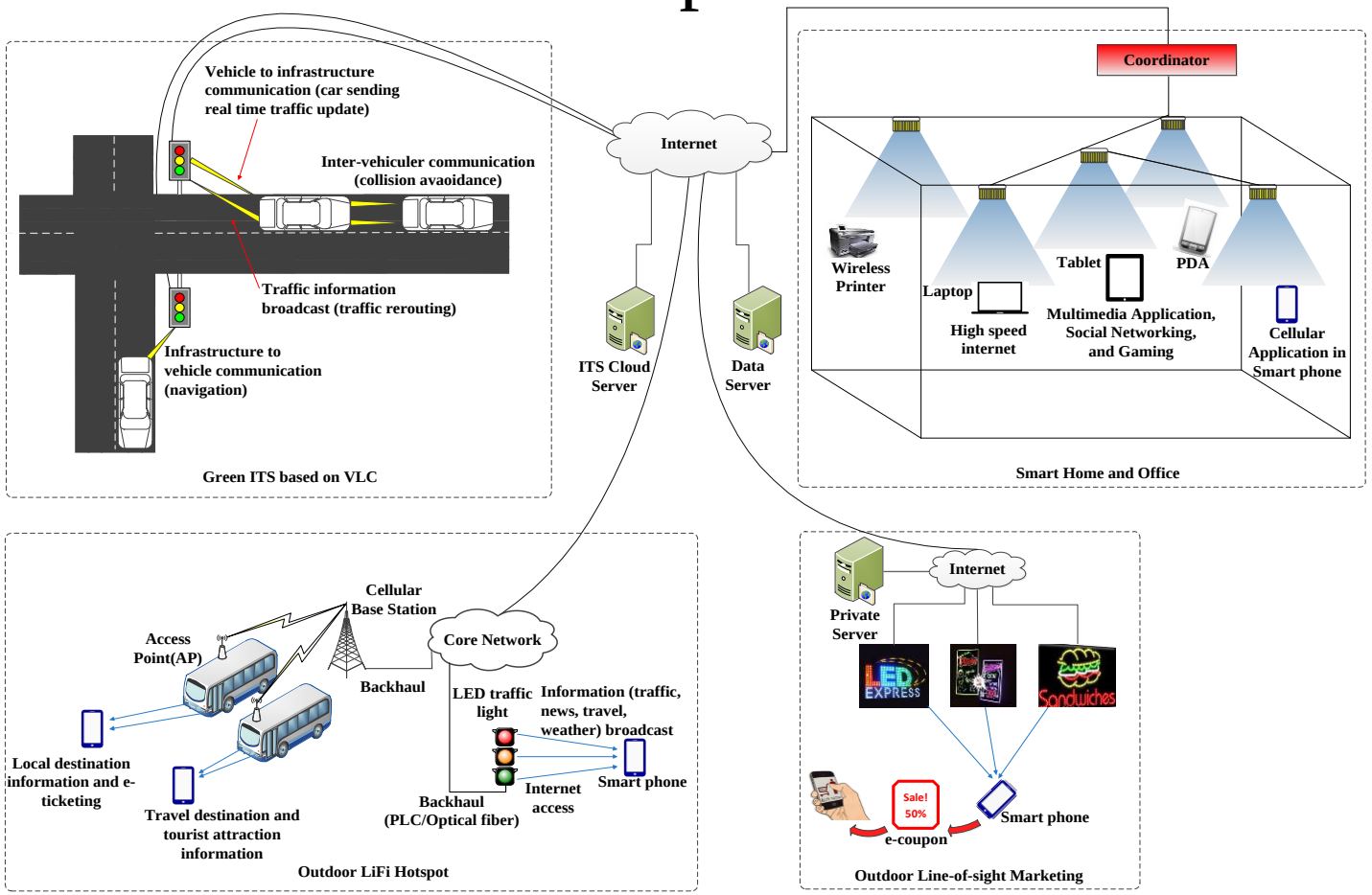
LED-ID: Reader-Tag Operation in IoL

- Two different modes: ID-Detection mode and data reception mode
- ID-Detection (IDD) operation is completed in CAP mode

Wake up	Tag wakes up when readers send request
Beacon	Tag will be synchronized by superframe
Request	Reader request traffic
Resource allocation	Tag allocates slots based on reader's request
Data Transmission	Data transmission using allocated slot



Connected Object Domain in IoL: An Application Perspective



- Saha, N.; Ifthekhar, M.S.; Mondal, R.K.; Hosain, M.A.; Yeong Min Jang, "The internet of LED: A LED-ID based interoperability and interconnectivity perspective," ICTC2014, vol., no., pp.535~540, 22-24 Oct. 2014

Conclusion

- **Need PHY for bidirectional and unidirectional communication**
- **Need PHY for rolling shutter and global shutter camera**
- **Need application dependable PHY and MAC**
- **Need to have a link switching functionality**
- **Need to put the IoT concept using LED, digital signage, display and**
- **Need to have a LED-ID operation**