WHERE COMMUNICATION MEETS LED LIGHTING

Optical Wireless Communication (OWC)

Kickoff meeting, January 26, 2010

Zhengyuan "Daniel" Xu

Director, UC-Light Center & Wireless Info. Technol. Lab

Professor, Department of Electrical Engineering

University of California, Riverside, CA 92521

Tel: 951-827-2986, dxu@ee.ucr.edu

http://www.ee.ucr.edu/~dxu

Acknowledgement

1

Outline

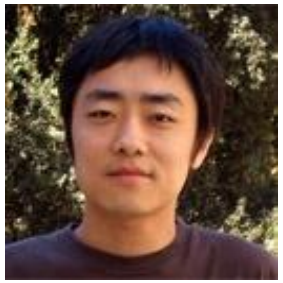
- Introduction to WIT Research Group
- Introduction to OWC
- Ultraviolet (UV) Communication
  - Motivation, applications
  - Our focused topics
  - Test-beds
- Visible Light Communication (VLC)
  - Motivation, applications, research groups
  - Our focused topics
  - Test-beds
- News Report for WIT Research

2

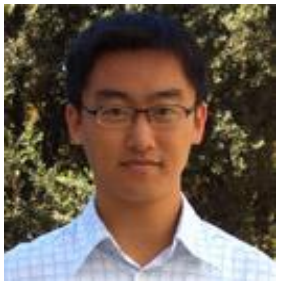
Wireless Info. Technol. Group

Director: Daniel Xu

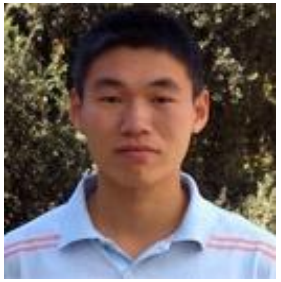
Postdoc: Gang Chen



PhD: Ning Liu



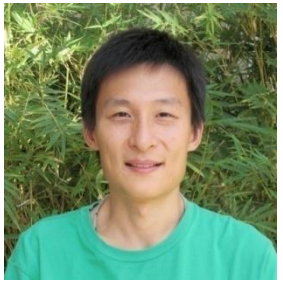
PhD: Michael He



PhD: Haipeng Ding

PhD: Kaiyun Cui

PhD: Yiyang Li



PhD: Leijie Wang

PhD: Zongyu Dong

Visiting PhD: Bo Bai

Visiting Prof.: Dongweon Yoon

3

Research Areas

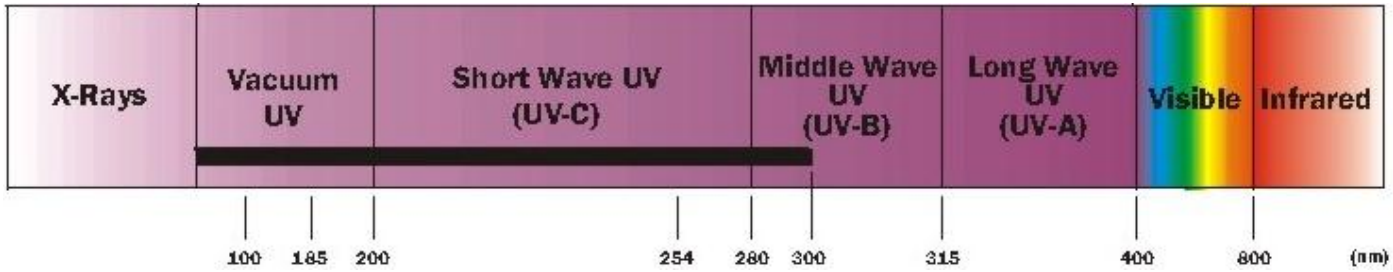
Analytical, experimental and simulation study

http://witLab.ee.ucr.edu

4

Introduction to OWC

Optical Spectrum



Optical vs. Radio Frequency

- Unlicensed, six orders of magnitude larger
- Short wavelength
- Little harm in visible, little EMI to RF equipment
- High gain antenna and high quality links

Current Focused Areas in OWC

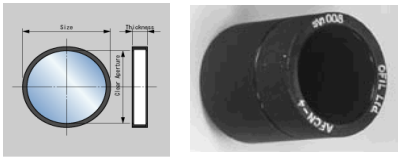
- Ultraviolet (UV) communication, visible light communication (VLC)

5

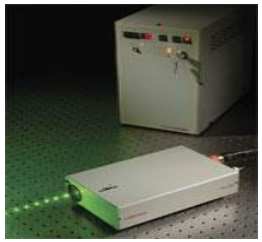
UV Commun. Motivation

- **Unique Channel Characteristics**
  - Solar blind (λ=200-280nm) → high SNR
  - High scattering → NLOS (relaxed PAT), penetration to fog
  - High absorption → secure, covert and anti-jamming (to RF)
- **Recent Advances in Enabling Technologies**
  - UV LEDs, UV solid state laser
  - High fidelity UV PMTs, UV APDs (DARPA's DUVAP program)
  - UV solar blind bandpass filters

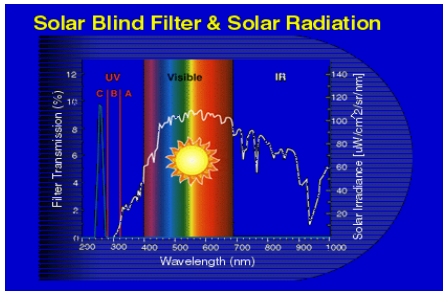
Rugged cheap LEDs



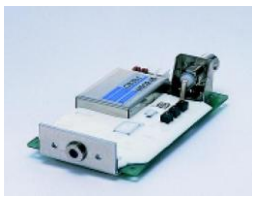
High sensitivity PMTs



Compact laser



Solar blind filters



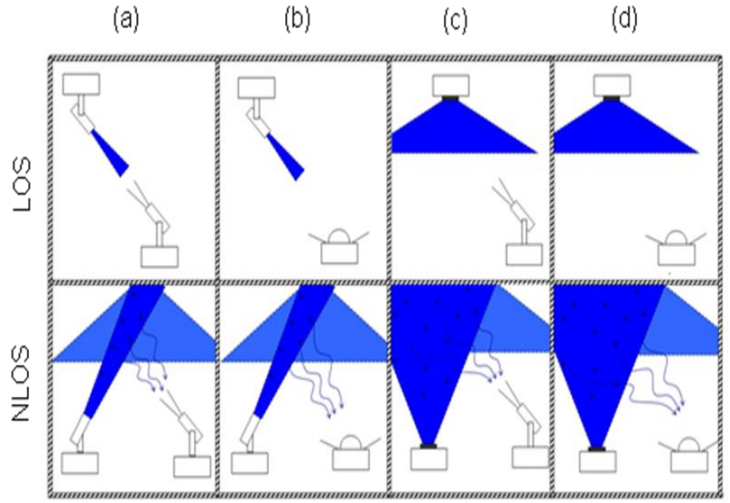
Wide Spectrum APDs

6

UV Commun. Applications

Outdoor Comm

Indoor Comm



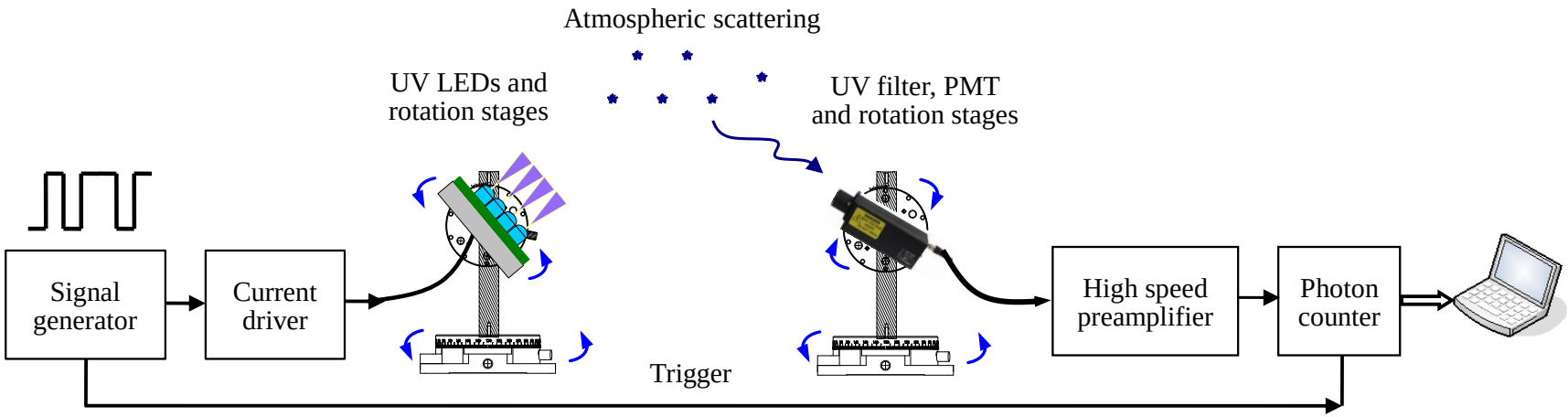
UGS

Chem/Bio Det

7

UV Commun. Technical Issues

Communication Diagram

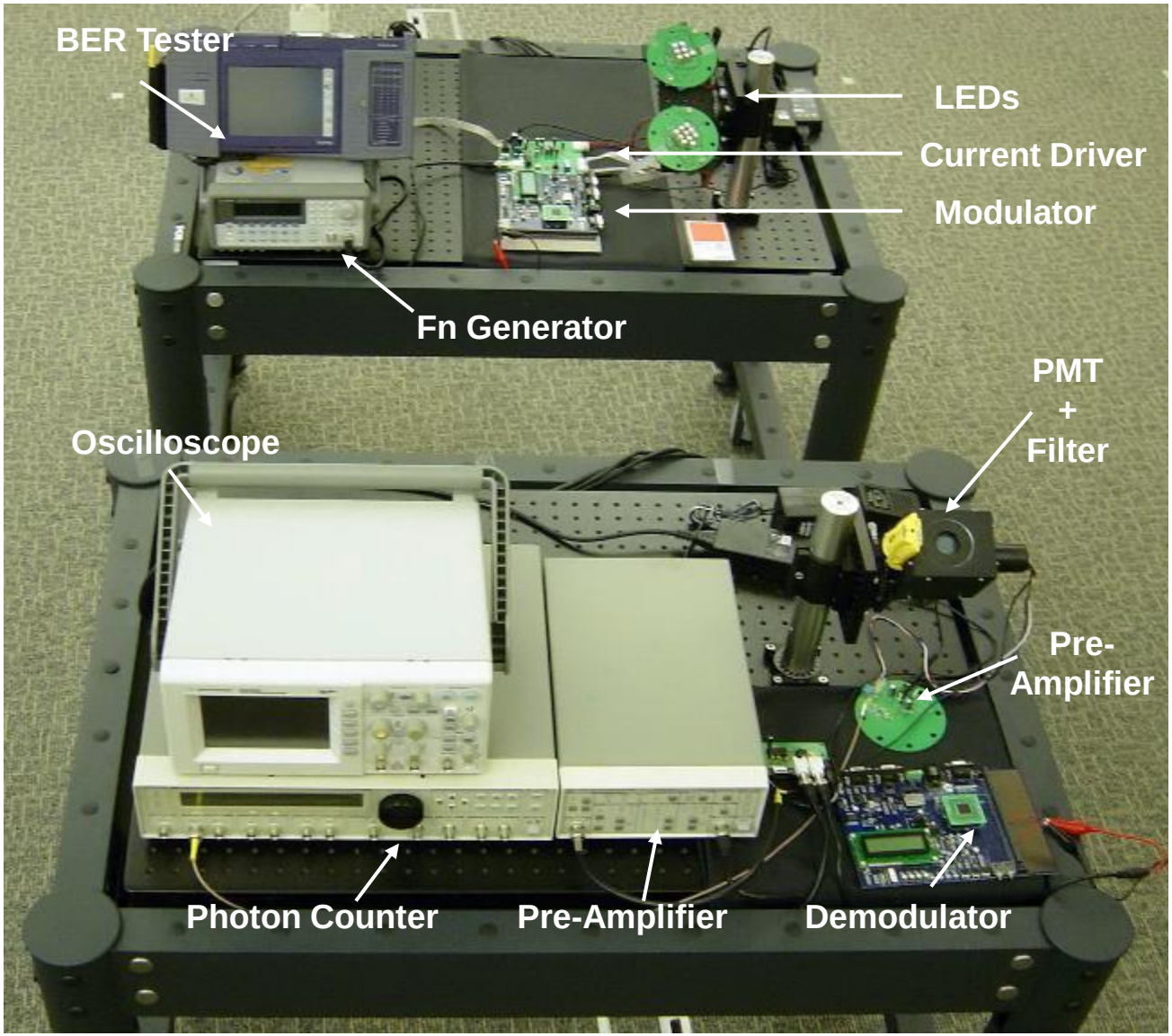


Issues

- Channel characterization, communication techniques, performance tradeoffs, system protocols
- Other commun. environments
- Beyond (imaging, sensing, geolocation)

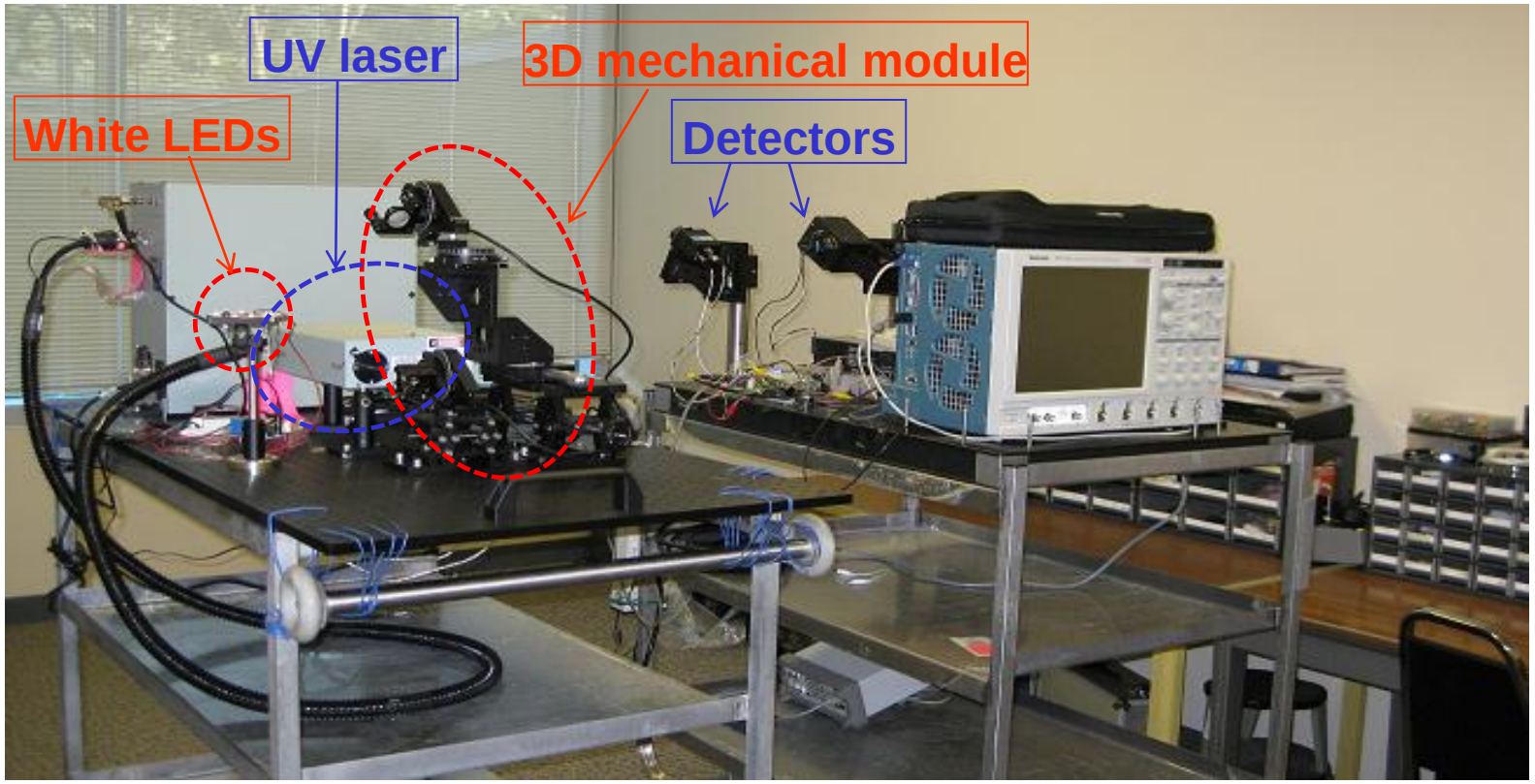
8

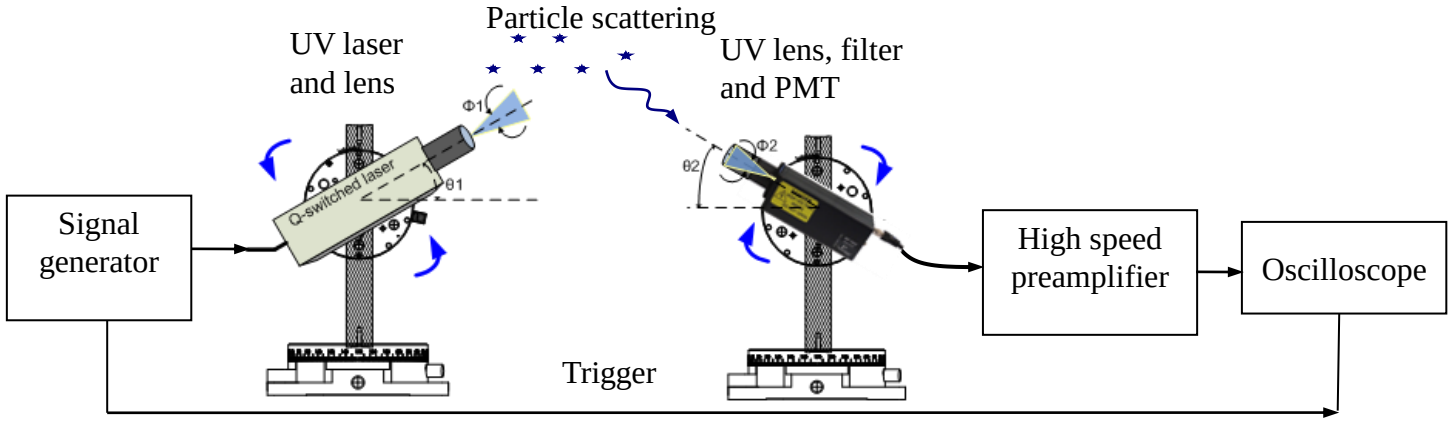
UV Commun. & Path Loss Test-bed



9

Pulse Broadening Test-bed

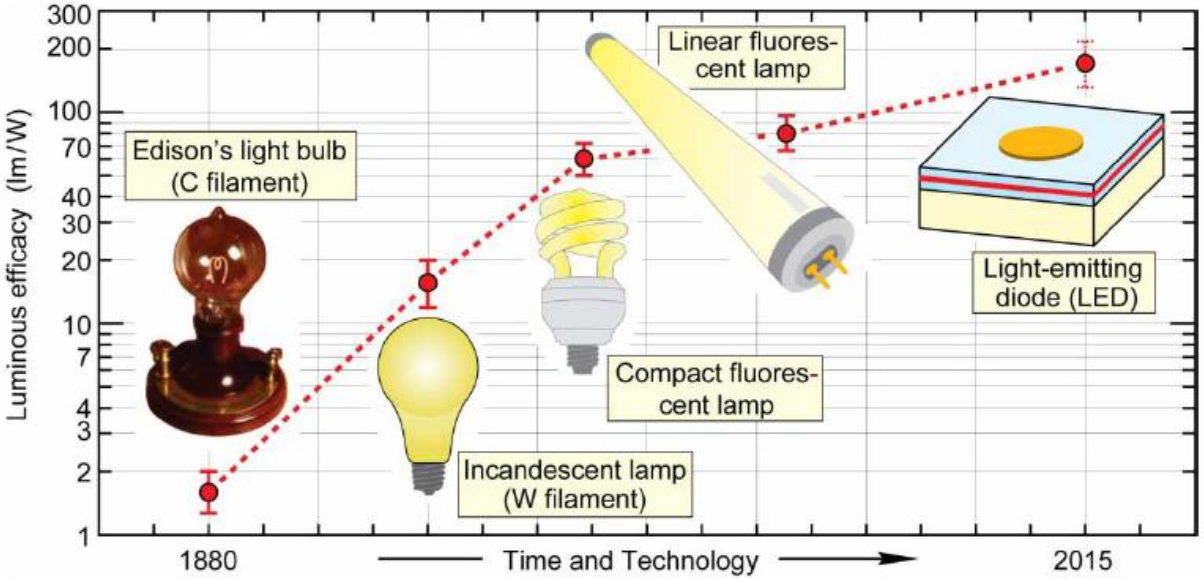




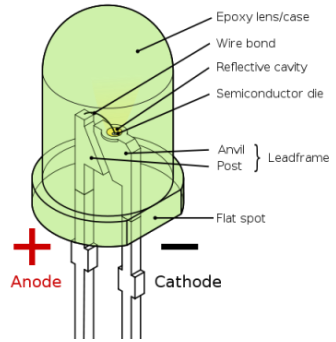
10

VLC Motivation

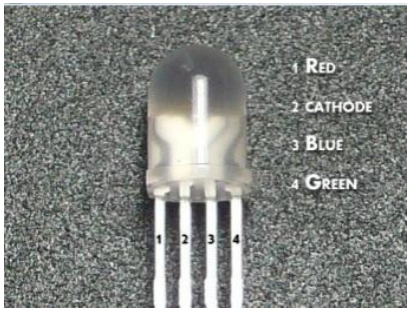
New Generation Lighting LEDs



J. K. Kim and E. F. Schubert, "Trancsending the replacement paradigm of solid-state lighting", Optics Express, vol. 16, no. 26, pp. 21835-21842, 2008



1-chip LED



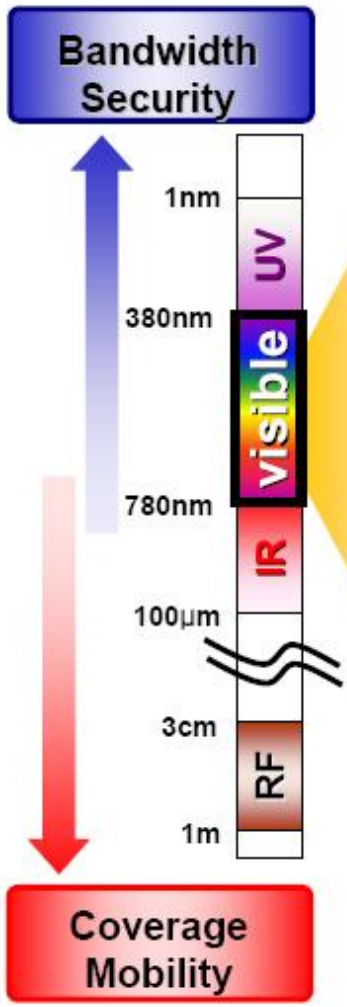
3-chip LED

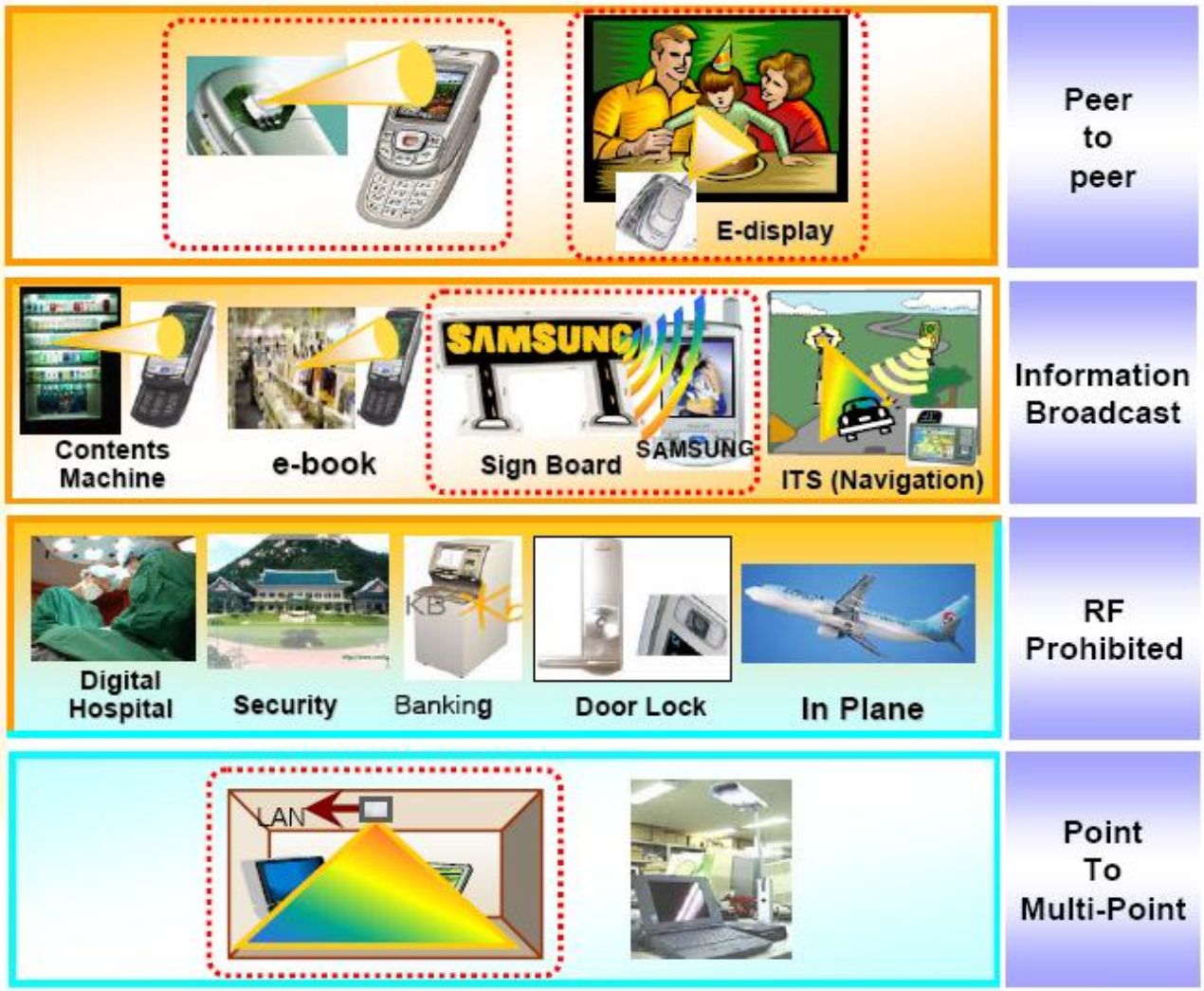
Potential Benefits of Lighting LEDs

- **High energy efficiency, long sustainability, low production and maintenance cost, green**
- **Ubiquitous and low cost piggybacking commun.**

11

VLC Applications





D. Shin, D. K. Jung, Y. J. Oh, T. Bae, H. C. Kwon, C. Cho, J. Son, "Visible light communication (VLC) motivation, application, and issue", IEEE802.15 TG7 document, doc.: IEEE802.15-<08/0015-00>

12

VLC Worldwide Research

Japan	➢First proposed by T. Komine and M. Nakagawa from Keio University in 2001 ➢The Visible Light Communications Consortium (VLCC) established in Japan in Nov. 2003 ➢Company participation: Casio, Toshiba, Sony, NEC, SHARP, etc.
Korea	➢Electronics and Telecommunications Research Institute (ETRI) ➢Samsung Electronics
Europe	➢UK: University of Oxford, Northumbria University ➢Germany: Fraunhofer institute for telecommunications, Jacobs University Bremen, Simens ➢Netherlands: Eindhoven University of Technology, Philips ➢Home Gigabit Access (OMEGA) project
US	➢Smart Lighting Center (Boston U, RPI, U of New Mexico) ➢UC-Light Center led by UCR ➢Intel, Interdigital, etc.

➢ **An IEEE task group (IEEE802.15 TG7) has been formed trying to set up a VLC standard (PHY and MAC layers in the network stack)**
http://www.ieee802.org/15/pub/TG7.html

13

VLC Focused Issues

- Source modeling
- Encoder/Decoder
- Modulation/Demod.
- Pre/Post -processing
- Channel modeling
- Filtering/Detection
- Multiple access
- Network interfacing
- Compatibility with lighting
- Navigation

14

More Preliminary Test-bed

15

News Report

UV work

- "Radios Broadcast into the Ultraviolet," *Photonics Spectra*, August 2009. (http://www.photonics.com/Content/ReadArticle.aspx?ArticleID=39191)
- "Ultraviolet Radios Beam to Life," *IEEE Spectrum*, May 2009. (http://www.spectrum.ieee.org/may09/8816)
- UV research by the WIT lab was regarded as a breakthrough at the Army Science and Technology Opportunities Conference, NC, 2008.

UC-Light funding

- More than 20 media/websites reported including:

  KABC-TV , PhysOrg.com, SolidStateLightingDesign.com, Press Enterprise, TechNews, ACM, LightingChina.com, ChinaFibre-on-Line, Green Solutions Magazine

16

Thank you!

17