Future of Wireless Communication

by Zack Dupuis

Contents

Basics of OWC

What is OWC?

Optical wireless communications is a form of optical communication in which unguided visible, infrared, or ultraviolet light is used to carry a signal.

Types

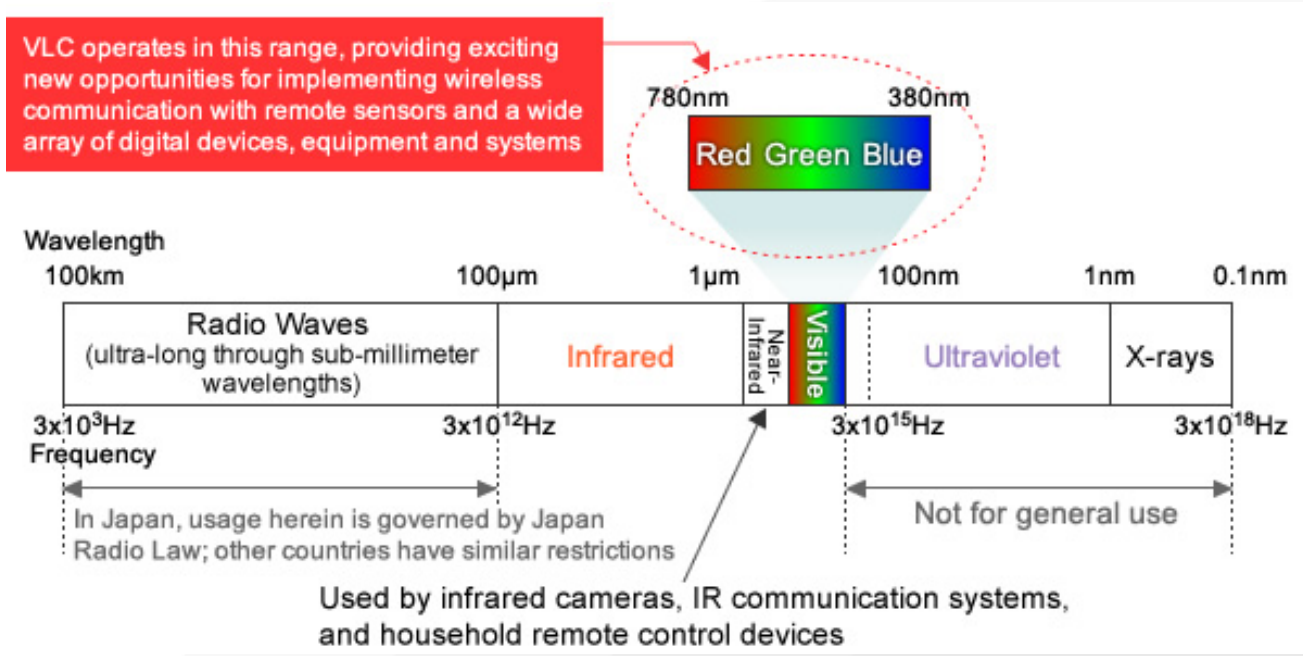
- IR
  - Free Space Optical communication
  - Laser source transmitters
  - 10Gbps per wavelength(latest version)
- VLC
  - LEDs
  - Smart Lighting
  - Li-Fi
- Ultraviolet communication
  - Solid state optical sources/detectors
  - Outdoor non-line-of-sight configurations

Why does RF need to be replaced?

- Capacity
- Efficiency
- Availability
- Security
- Simultaneous light and data
- More than 1.5 million cell towers and over 5 billion cell phones
- 600 TB of data per month (2012)

Why use OWC?

- Transmit data at lower light levels the eye cannot see(Li-Fi)
- Visible light spectrum is 10,000 x larger than RF spectrum
- Higher data rates
- Immune to electromagnetic forces
- Duplication of frequencies
- Low cost using LEDs
- Li-Fi alone is projected to grow at a compound annual rate of 82% from 2013 to 2018(Worth $6 Billion)



Challenges for OWC

VLC

- Slow modulations speeds of LEDs (on-off)
- Flicker
- Dimming
- LED rise-time
- LED nonlinearity
- Noise induced by natural and artificial light sources

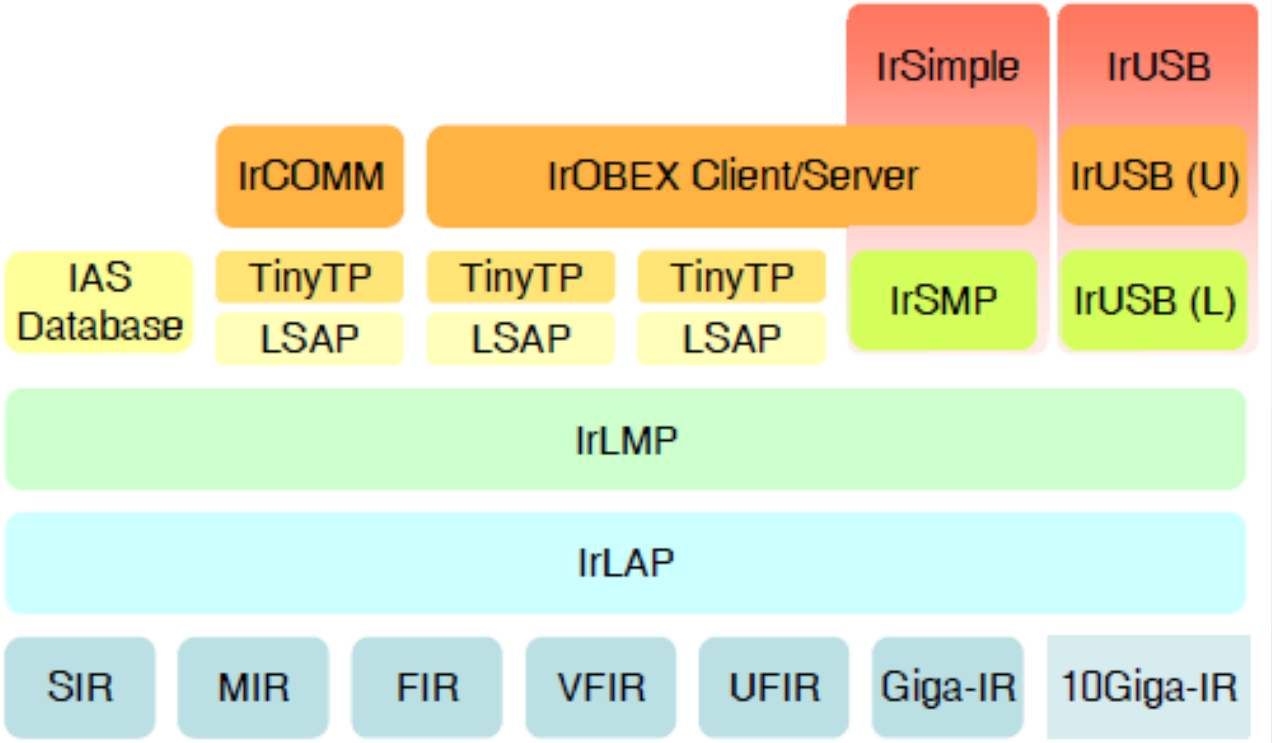
Infrared

- Low operating power to protect users eyes and skin
- Optoelectronic speed limitations
- High path loss
- Multipath dispersion
- Noise induced by natural and artificial light sources
- Direct LOS

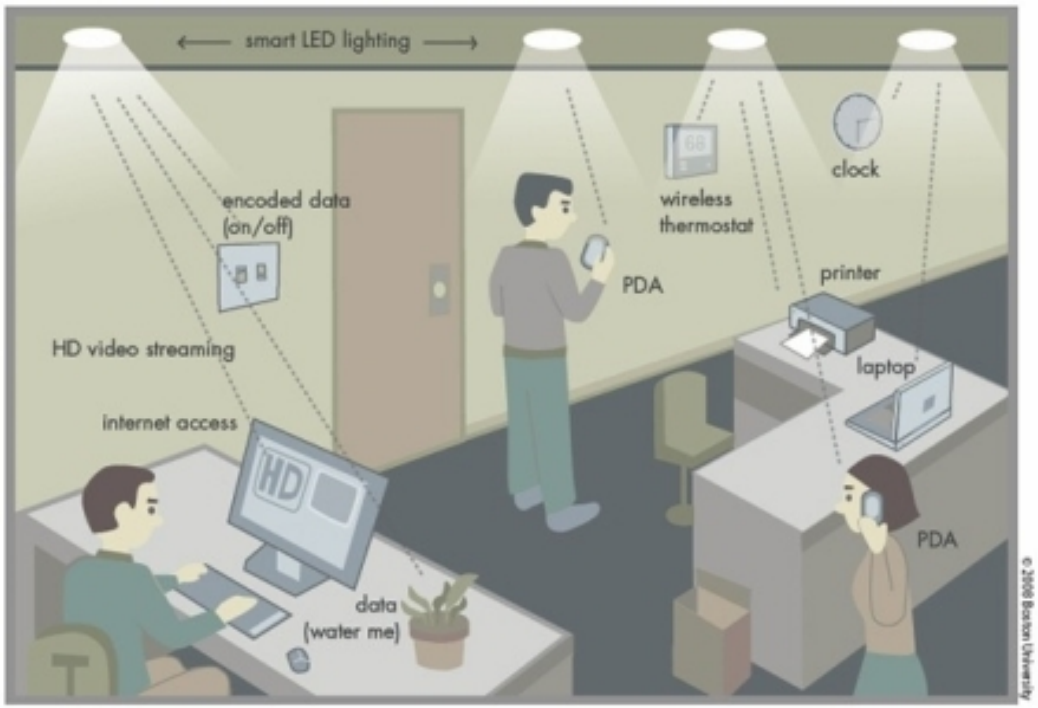
Progress of IR/VLC

Organisation/ Comm. Type	Target Application	Link Distance	Data Rate	Year[1]	Remarks
IrDA legacy	M2M, F2M	≤1 m	9.6 kbps -1 Gbps	2009	Half duplex, point-to-point
IrSimple/IrSS	M2M, I2M	several m	9.6 kbps -1 Gbps	2008	Bi-/uni-directional, point-to-point, point-to-multipoint
ISO/CALM	ITS	several m	1 - 128 Mbps	2006	Half duplex, point-to-point
ICSA	WLAN	several m	≤10 Mbps	n.a.	Half duplex, point-to-multipoint
VLCC	M2M, I2M	several m	≤10 Mbps	n.a.	Half duplex, point-to-multipoint
Samsung/IPMS	M2M	≤1 m	120 Mbps - 320 Mbps	2008	Full duplex, WYSIWYS, point-to-point
IEEE 802.15.7	M2M, I2M, F2M	several m	100 kbps - 96 Mbps	2011	Point-to-point, point-to-multipoint
OMEGA	I2M	several m	125 Mbps	2009	Uni-directional, only PHY, proprietary
Siemens/FhG	I2M	several m	500 Mbps	2010	Uni-directional, only PHY, proprietary
FhG IPMS	M2M	<10cm	3 Gbps	2012	Full Duplex, point-to-point, proprietary

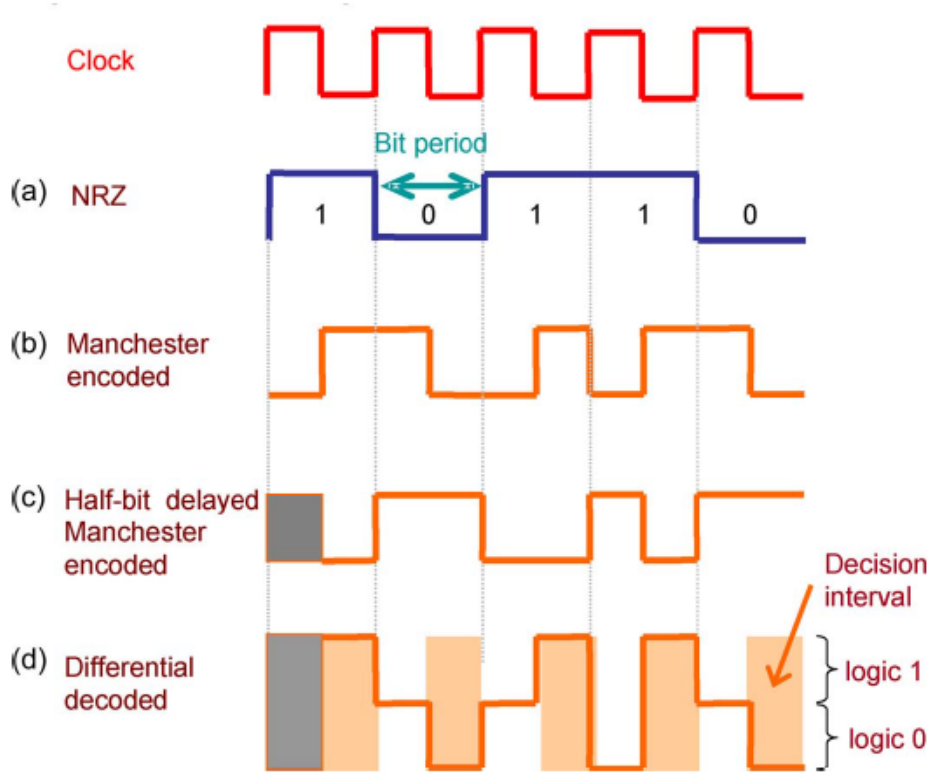
Layers of IrDA

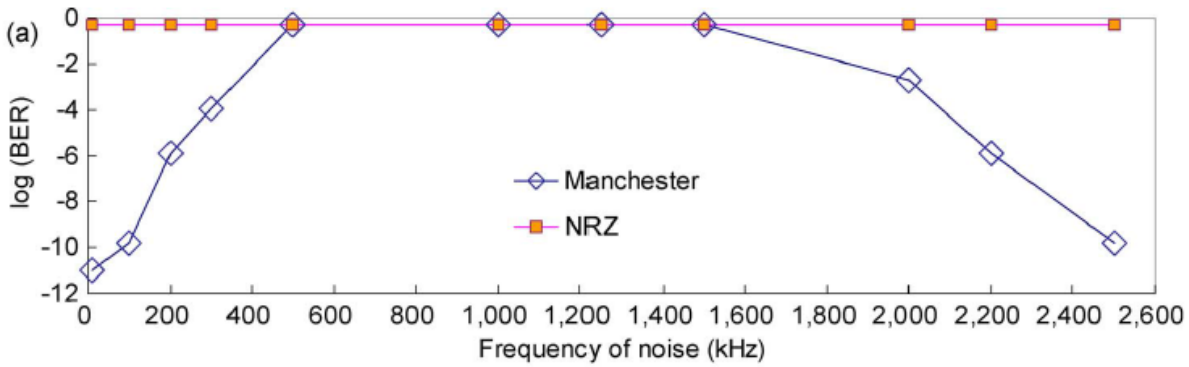


Smart LED Lighting Network



Noise Mitigation





Indoor VLC System

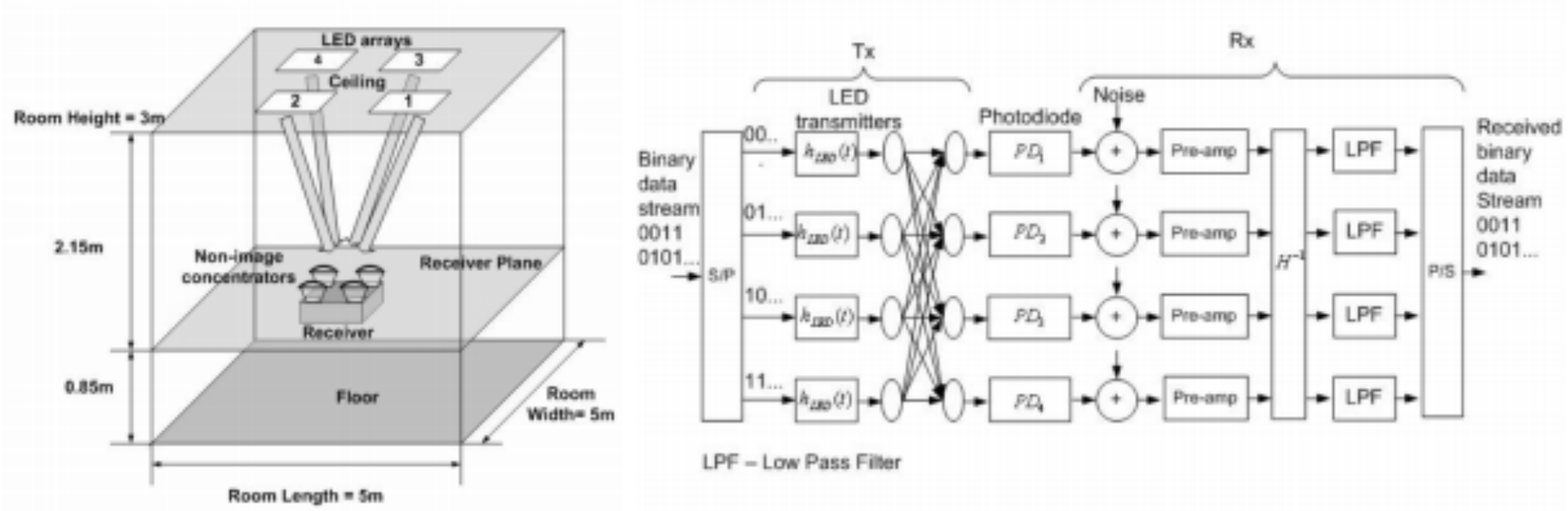
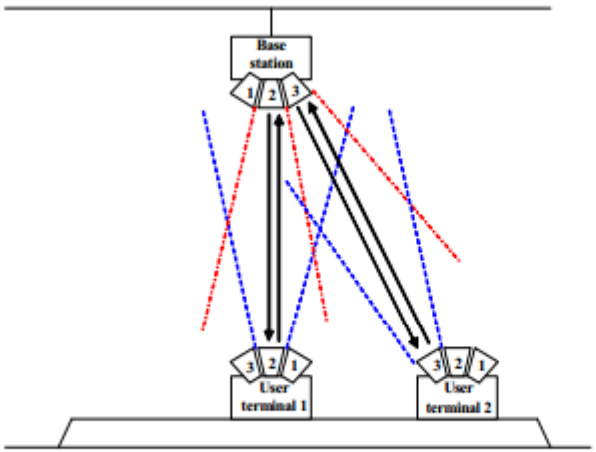


Figure 2: (a) VLC MIMO system; (b) Schematic of VLC MIMO model.

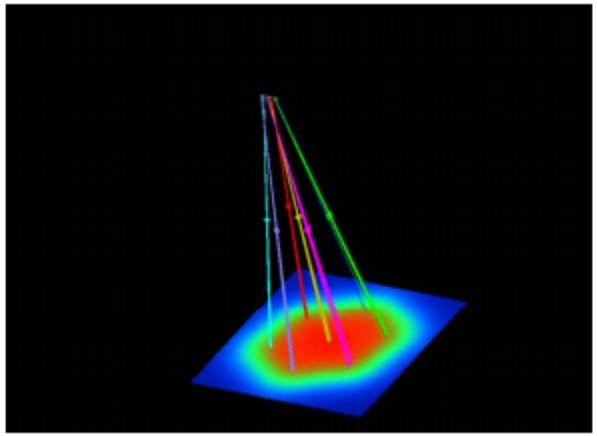
Table 2. Simulation results of VLC MIMO system

	White channel			White channel + equalisation			Blue channel		
Number of channels	4	16	36	4	16	36	4	16	36
Data rate (Mbit/s)	48	192	432	120	480	1080	160	640	1440
Lens diameter (cm)	0.2	0.44	0.71	0.44	0.8	1.38	1.6	3.6	7.14
Detector size (cm)	0.74×0.74	1.68×1.68	3.05×3.05	1.65×1.65	3.08×3.08	5.91×5.91	6.0×6.0	13.7×13.7	31.4×31.4

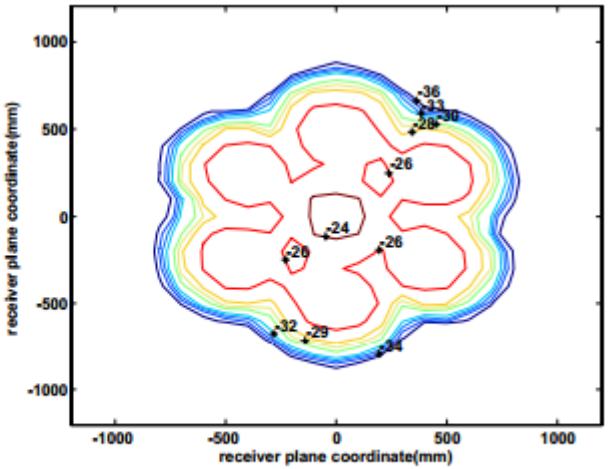
LOS Infrared Communication



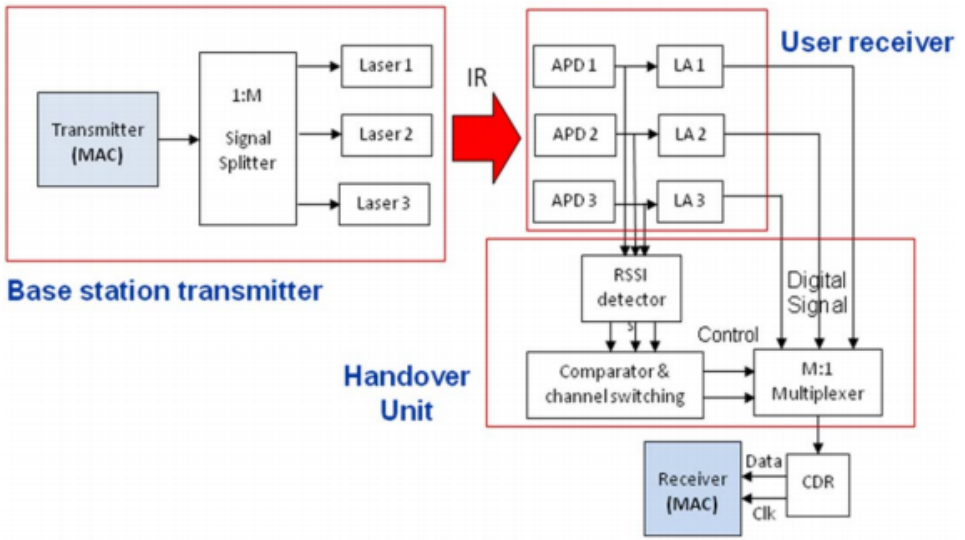
(a)



(b)



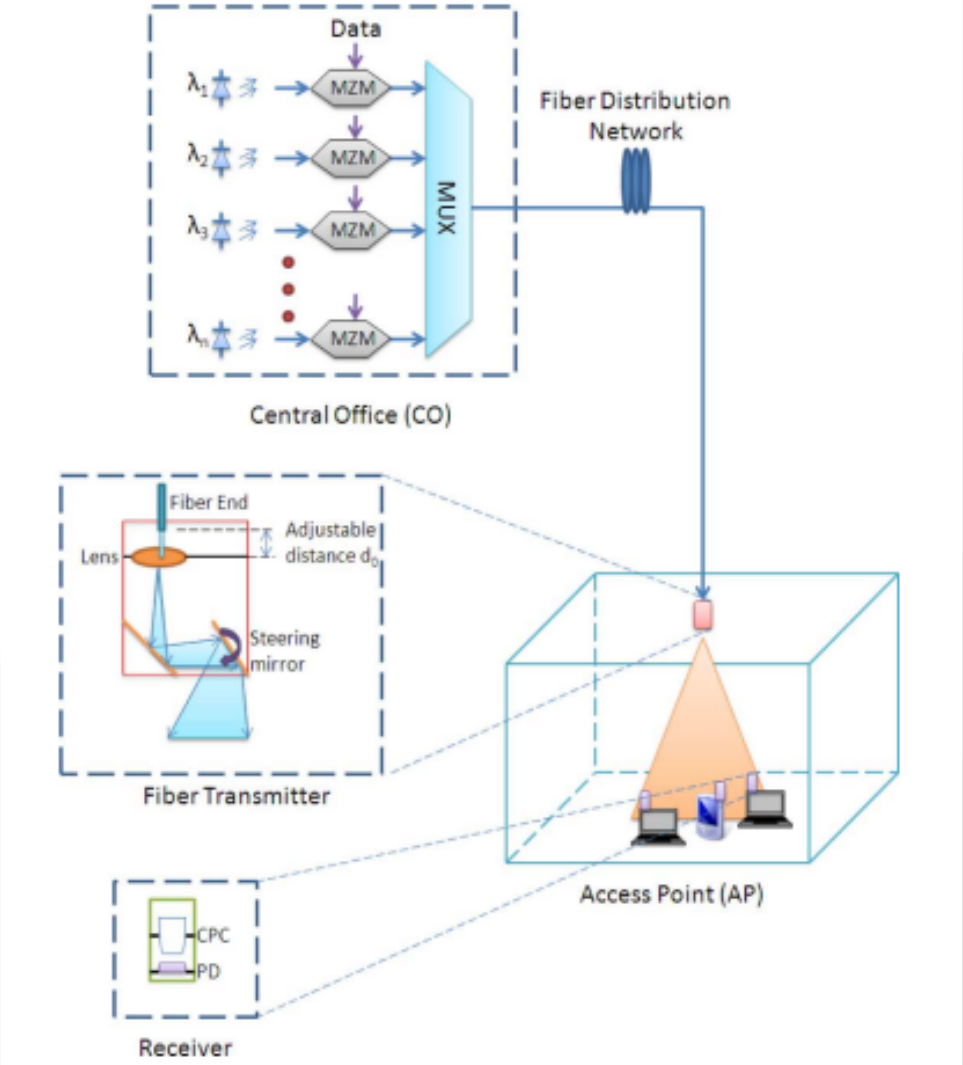
(c)



(d)

WDM optical wireless system

- One central office for multiple access points
- Ceiling mounted fiber end with a lens and steering mirror acting as transmitter
- Constant beam footprint maintained
- Compound parabolic concentrator used at receiver end



Advances in Li-Fi

- Harald Haas, chair of mobile communications at the University of Edinburgh
- Potential for wider bandwidth and quicker response time than Wi-Fi
- Bi-Directional system aggregate data rate of 110 Mbps(One direction 155Mbps)
- Custom LED reaching up to 4 Gbps on 5 mw optical output power
- 1.1Gbps communication up to 10 meters(Expect to increase to 15 Gbps soon)
- Using avalanche photodiodes for receivers
- “In 25 years, every light bulb in your home will have the processing power of your cellphone today”

  -Haas

References

[1] F. Deicke, W. Fisher, M. Faulwaber, "Optical Wireless Communication to Eco-System", Future Network Mobile Summit, pp1-7, 2012.

[2] H. Le Minh, Z. Ghassemlooy, D. O'Brien, G. Faulkner, "Indoor Optical Wireless Communications: Challenges and Possibilities", ICTON, pp1-5, 2010.

[3] C. W. Chow, C. H. Yeh, Y. F. Liu, P. Y. Huang, "Mitigation of Optical Background Noise in Light-Emitting Diode (LED) Optical Wireless Communication Systems", IEEE Photonics Journal, Vol. 5, No. 1, Feb 2013

[4] K. Wang, A. Nirmalathas, C. Lim, E. Skafidas, " Indoor Optical Wireless Localization System with Height Estimation for High-Speed Wireless Communications in Personal Areas", National ICT Australia, pp72-75, 2012.

[5] N. Savage, "Li-Fi Gets Ready to Compete With Wi-Fi", IEEE Spectrum, pp13, Dec 2014.