



Visible Light Communication

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0.0 - Biografi - Denny Darl x
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DIPLOMA OF TELECOMMUNICATION ENGINEERING – TELKOM UNIVERSITY

JADWAL 0.0 – BIOGRAFI 1.0 – PENGAJARAN 2.0 – RISET 3.0 – PENGABDIAN MASYARAKAT 4.0 – REFRAKSI 5.0 – IDEASHARING

0.0 – Biografi



Denny Darlis mendapatkan gelar Sarjana Sains (S.Si) dari Universitas Indonesia pada tahun 2000 pada bidang Fisika peminatan Instrumentasi. Setelah berkecimpung di dunia industri selama kurang lebih 5 tahun, melanjutkan studi Magister Teknik di Institut Teknologi Telkom hingga tahun 2010 untuk mendapatkan gelar MT di bidang Teknik Elektro peminatan Telekomunikasi. Minat penelitian yang sedang dikerjakan saat ini ialah Implementasi sistem telekomunikasi nirkabel, Visible Light Communication, Wireless Sensor Network, dan algoritma kriptografi yang diaplikasikan di FPGA dan Sistem Terbenam (Embedded System).

Resume

Pendidikan:

- 2010: Master Teknik (Elektro - Telekomunikasi), Institut Teknologi Telkom, Bandung, Indonesia
- 2000: Sarjana Sains (Fisika - Instrumentasi), Universitas Indonesia, Depok, Indonesia

Pengalaman Kerja:

- 2010 - Sekarang: Dosen, Program Studi D3 Teknik Telekomunikasi, Fakultas Ilmu Terapan, Universitas Telkom.

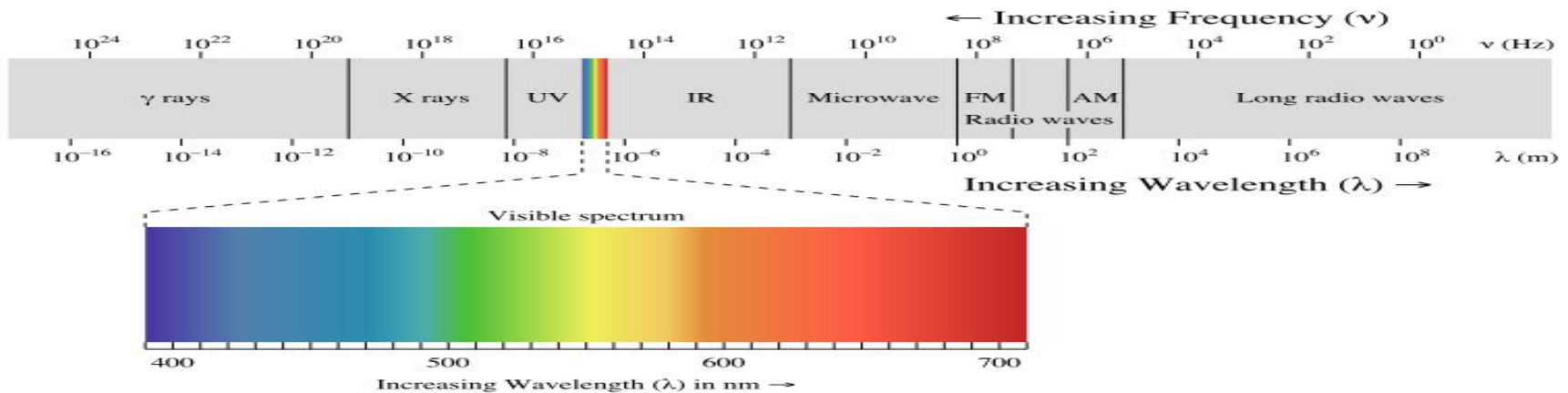
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Sumber : <http://shadowness.com/onfiksi/are-you-ready-to-rock-2>

Visible Light Communication

adalah **sistem komunikasi nirkabel*)** yang membawa informasi dengan cara memodulasi **cahaya tampak** yang aman bagi mata manusia

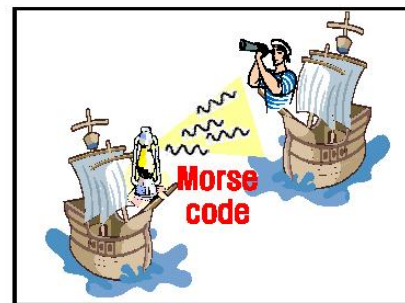
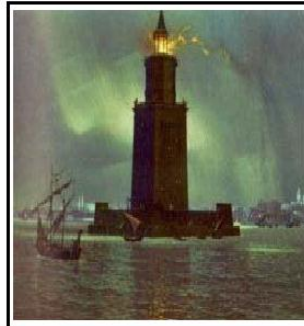
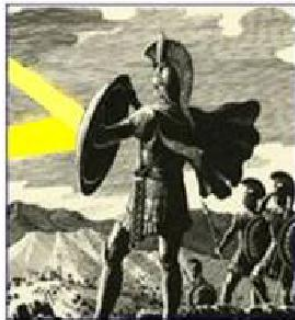


*) bagian dari Unguided-Optical Wireless Communication

- Cahaya Tampak = Gelombang EM dengan spektrum $\sim 400 - 800 \text{ THz}$ ($750-375 \text{ nm}$)*,
*) ± 10000 spektrum frekuensi dapat digunakan
- Karakteristik umum :
 - Visibility : secara estetika ramah
 - Aman : apa yang dilihat adalah apa yang dikirim
 - Kesehatan : aman bagi tubuh manusia (terutama mata)
 - Tidak berlisensi : tidak ada regulasi terkait frekuensi optik
 - Digunakan di daerah umum hingga terlarang (pesawat, rumah sakit, pesawat luar angkasa, pabrik petrokimia dll)

VLC history – Low speed

- ❖ Information delivery using mirror reflection (Heliograph)
- ❖ The use of fire or lamp
 - Beacon fire, lighthouse, ship-to-ship comm. by Morse code
- ❖ Traffic light : R/G/B color multiplexing (Walk/Stop)



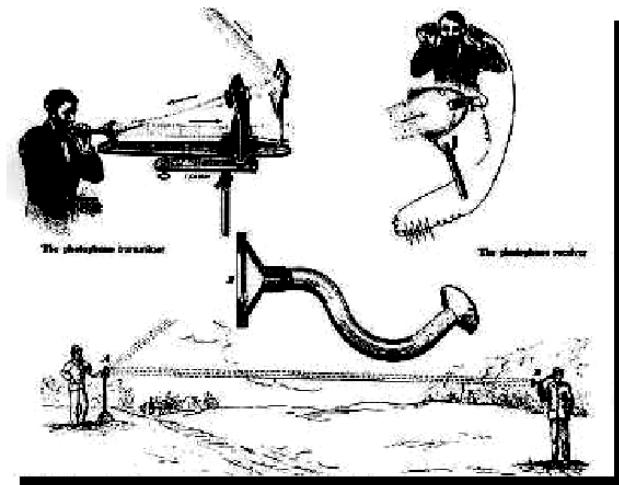
VLC history – Photophone

❖ Bell's Photophone (1880)

- Optical source : sunlight
- Modulation : vibrating mirror
- Receiver : parabolic mirror
- Distance : 700 ft (213m)

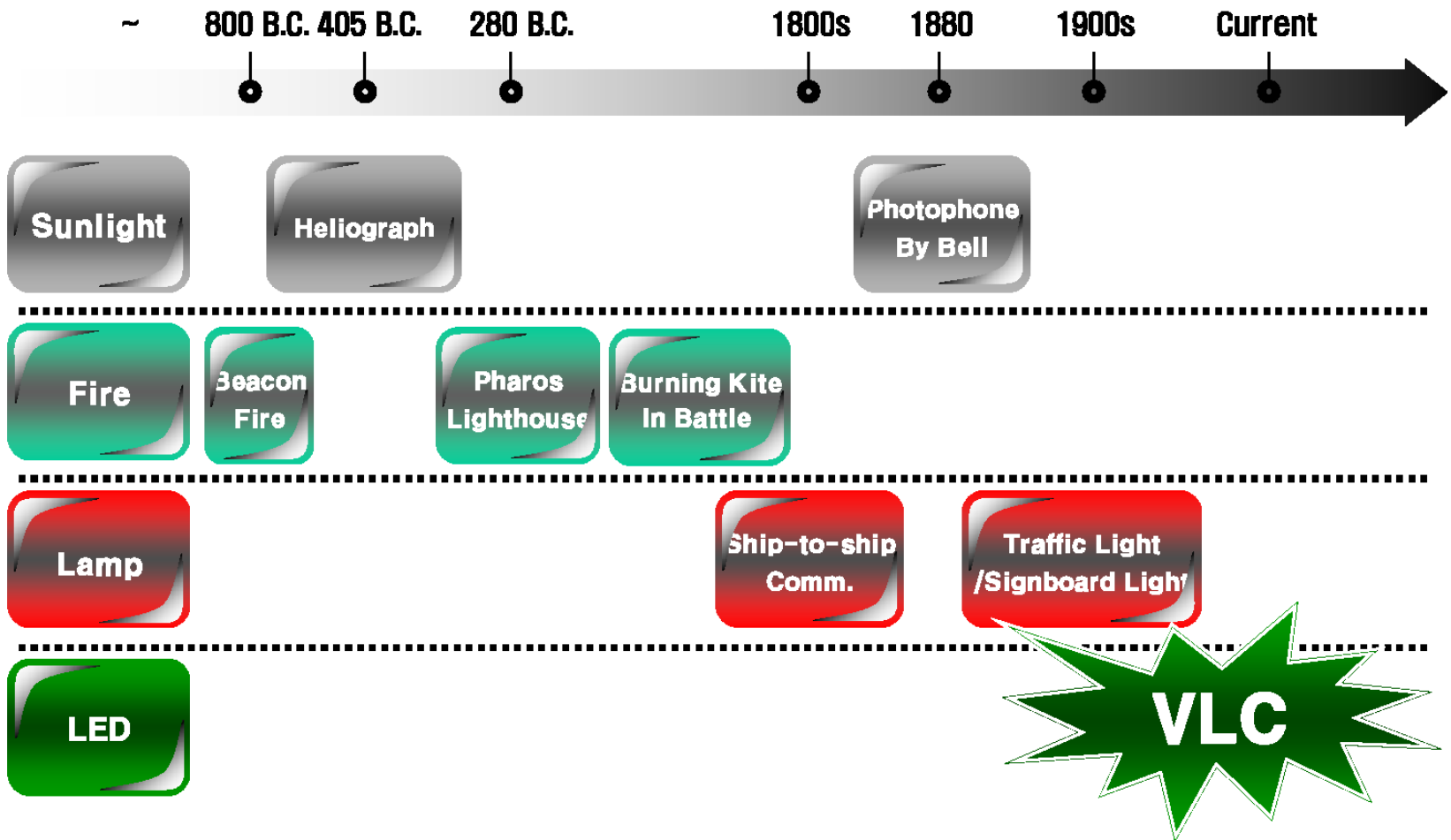


<http://www.freespaceoptic.com/>

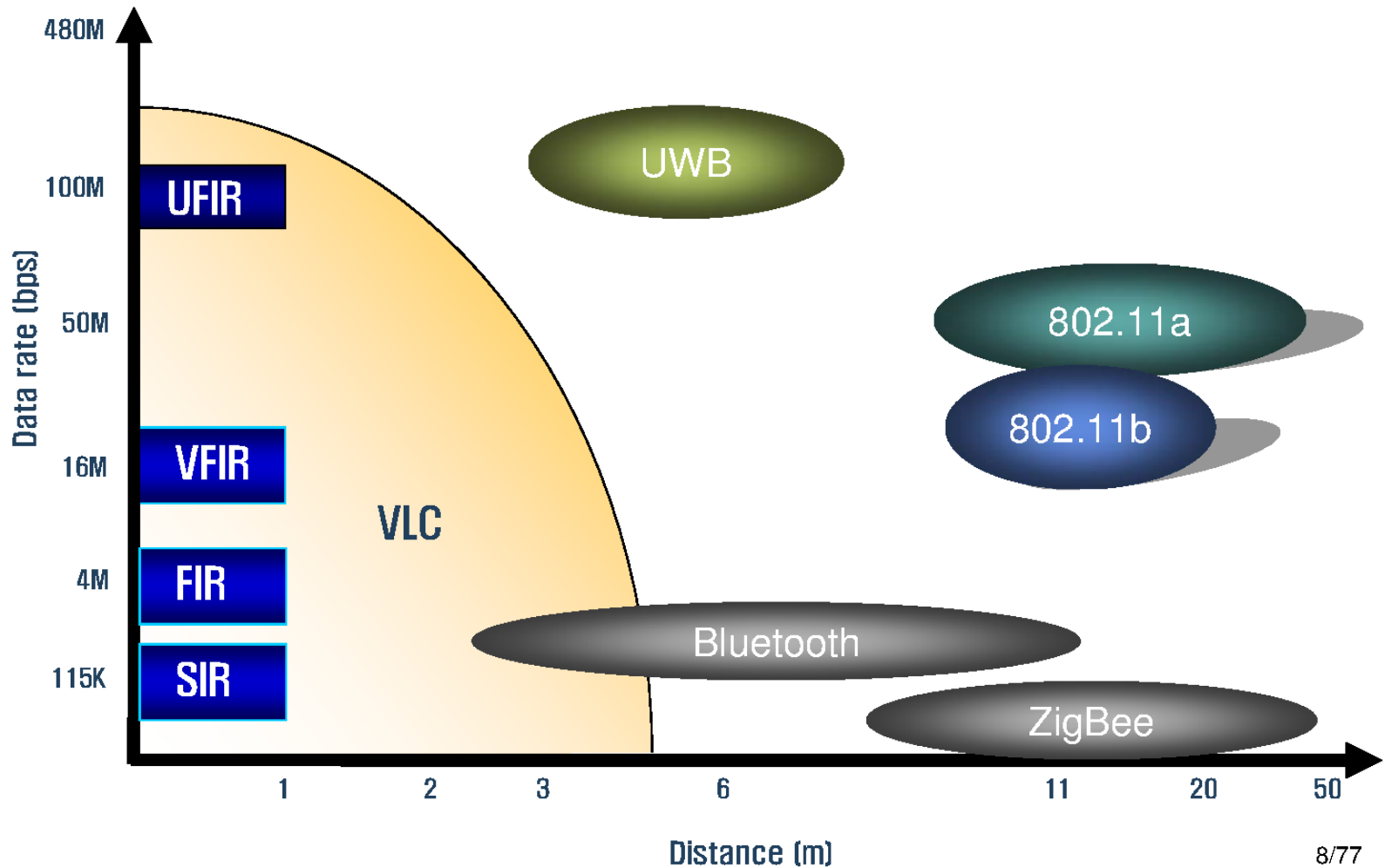


Excerpted from: The New Idea Self-Instructor edited by Ferdinand Ellsworth Cary, A. M. (Monarch Book Company, Chicago & Philadelphia, 1904)

VLC history



VLC Characteristics

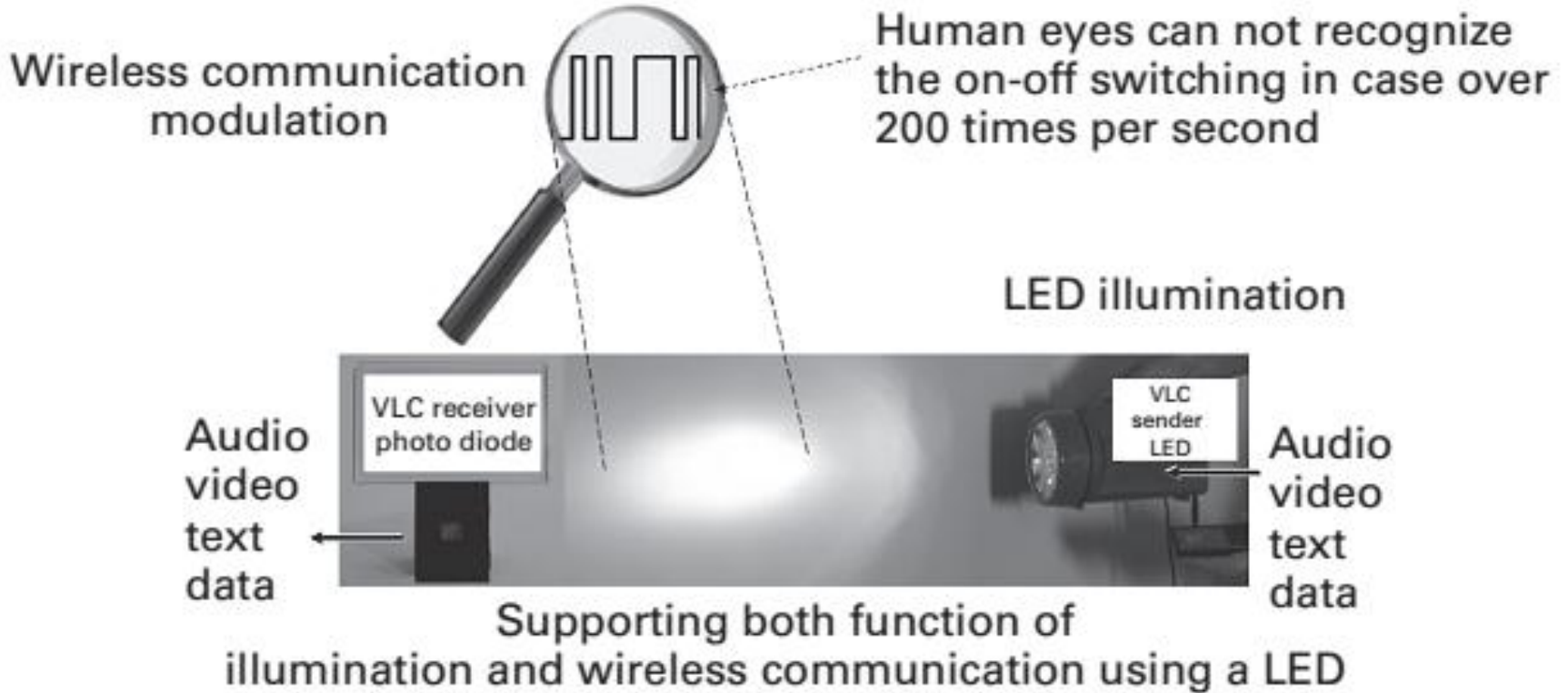


VLC vs. RF Characteristics

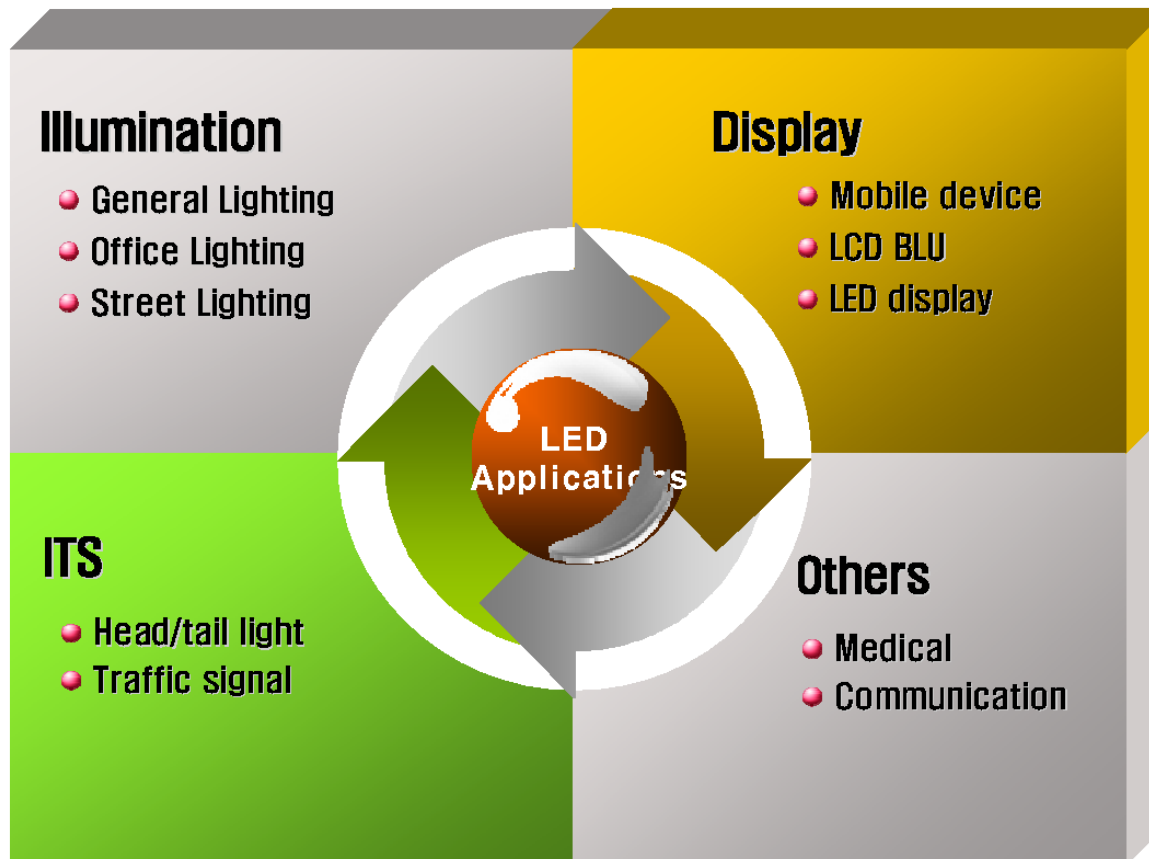


Property		VLC	RF
Bandwidth		Unlimited, 400nm~700nm	Regulatory, BW Limited
EMI		No	High
Line of Sight Standard		Yes Beginning (IG-VLC)	No Matured
Hazard		No	Yes
Mobile To Mobile	Visibility (Security)	Yes	No
	Power Consumption	Relatively low	Medium
	Distance	Short	Medium
Infra to Mobile	Visibility (Security)	Yes	No
	Infra	LED Illumination	Access Point
	Mobility	Limited	Yes
	Coverage	Narrow	Wide

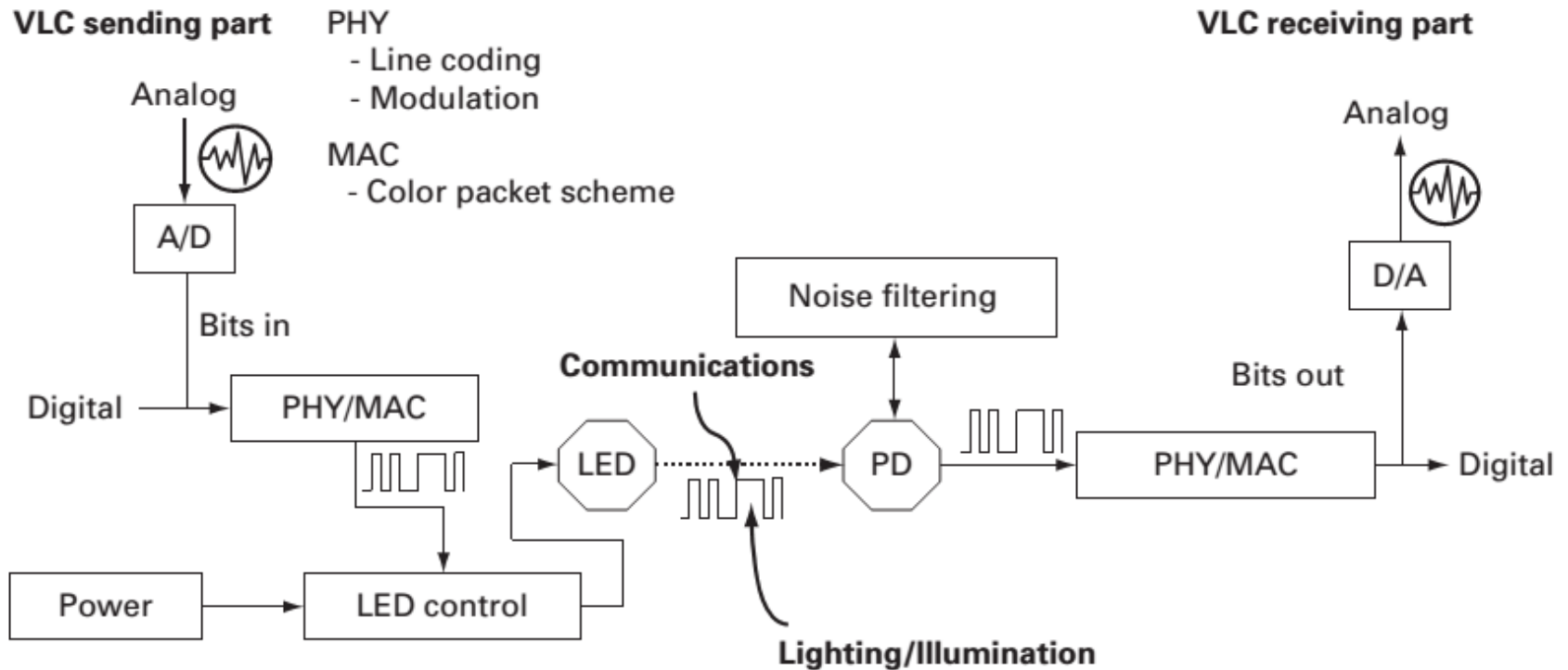
Prinsip Kerja VLC



LED application



Arsitektur VLC PHY



IEEE 802.15.7

- Short-range wireless optical communication using visible light dipublikasikan pada 6 September 2011
- IEEE 802.15.7 Visible Light Communication Task Group telah mengembangkan standar VLC untuk PHY dan MAC pada tahun 2009; Study Group pada tahun 2008, dan Interest Group pada tahun 2007
- IEEE 802.15.7 VLC memiliki tiga jenis PHY yang bergantung pada penerapannya, yaitu PHY I, PHY II, and PHY III.

PHY I

Modulation	RLL code	Optical clock rate	FEC		Data rate
			Outer code (RS)	Inner code (CC)	

PHY II

Modulation	RLL code	Optical clock rate	FEC	Data rate
VPPM	4B6B	3.75 MHz	RS(64,32)	1.25 Mb/s
			RS(160,128)	2 Mb/s
		7.5 MHz	RS(64,32)	2.5 Mb/s
			RS(160,128)	4 Mb/s
OOK	8B10B	15 MHz	none	5 Mb/s
			RS(64,32)	6 Mb/s
		30 MHz	RS(160,128)	9.6 Mb/s
			RS(64,32)	12 Mb/s
			RS(160,128)	19.2 Mb/s

PHY III

4-CSK	none	12 MHz	RS(64,32)	12 Mb/s
8-CSK	none		RS(64,32)	18 Mb/s
4-CSK	none		RS(64,32)	24 Mb/s
8-CSK	none	24 MHz	RS(64,32)	36 Mb/s
16-CSK	none		RS(64,32)	48 Mb/s
8-CSK	none		none	72 Mb/s
16-CSK	none		none	96 Mb/s

“LiFi”

high-speed, bidirectional, networked and mobile wireless communications using light.

- **High speed**
 - Data rates of at least 10 Mbps per access point
- **Bidirectional**
 - Light spectrum (190 nm – 10,000 nm wavelength) used for uplink and downlink
- **Networked**
 - Facilitate network connectivity and management
- **Mobile**
 - Support roaming users and multiple users per access point (hand-over and multiple access)

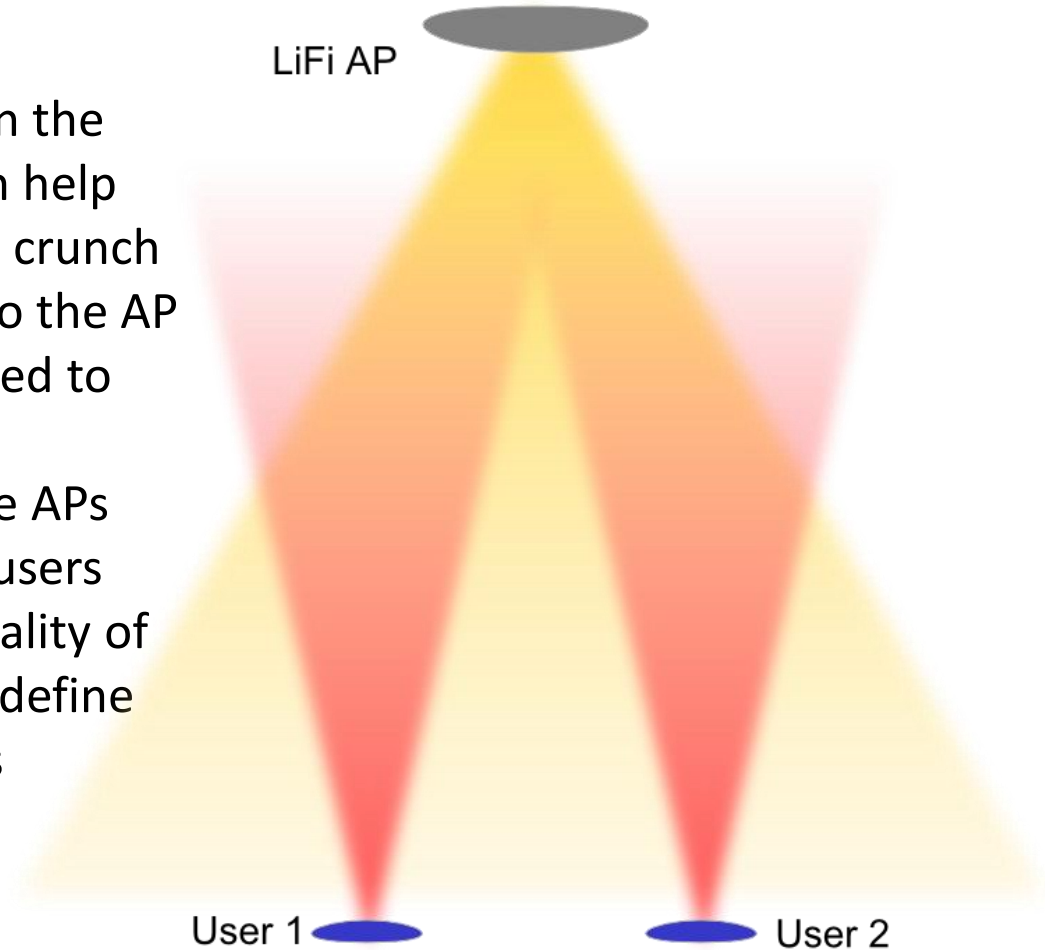
LiFi: High Level Concepts

- High speed
 - Efficient use of optical bandwidth
- Bidirectional
 - Support full uplink and downlink communications without additional RF resources
- Networked & Mobile
 - User expectations of wireless technology
- Secure & Safe
 - Privacy, cybersecurity and EMI concerns

LiFi: bidirectional and multiple access support

- **Bidirectional**

- LiFi operates entirely in the light spectrum and can help alleviate the spectrum crunch
- Users request access to the AP which may be connected to the network
- Users may see multiple APs
- APs may see multiple users
- The inherent directionality of light beams is used to define strict coverage regions



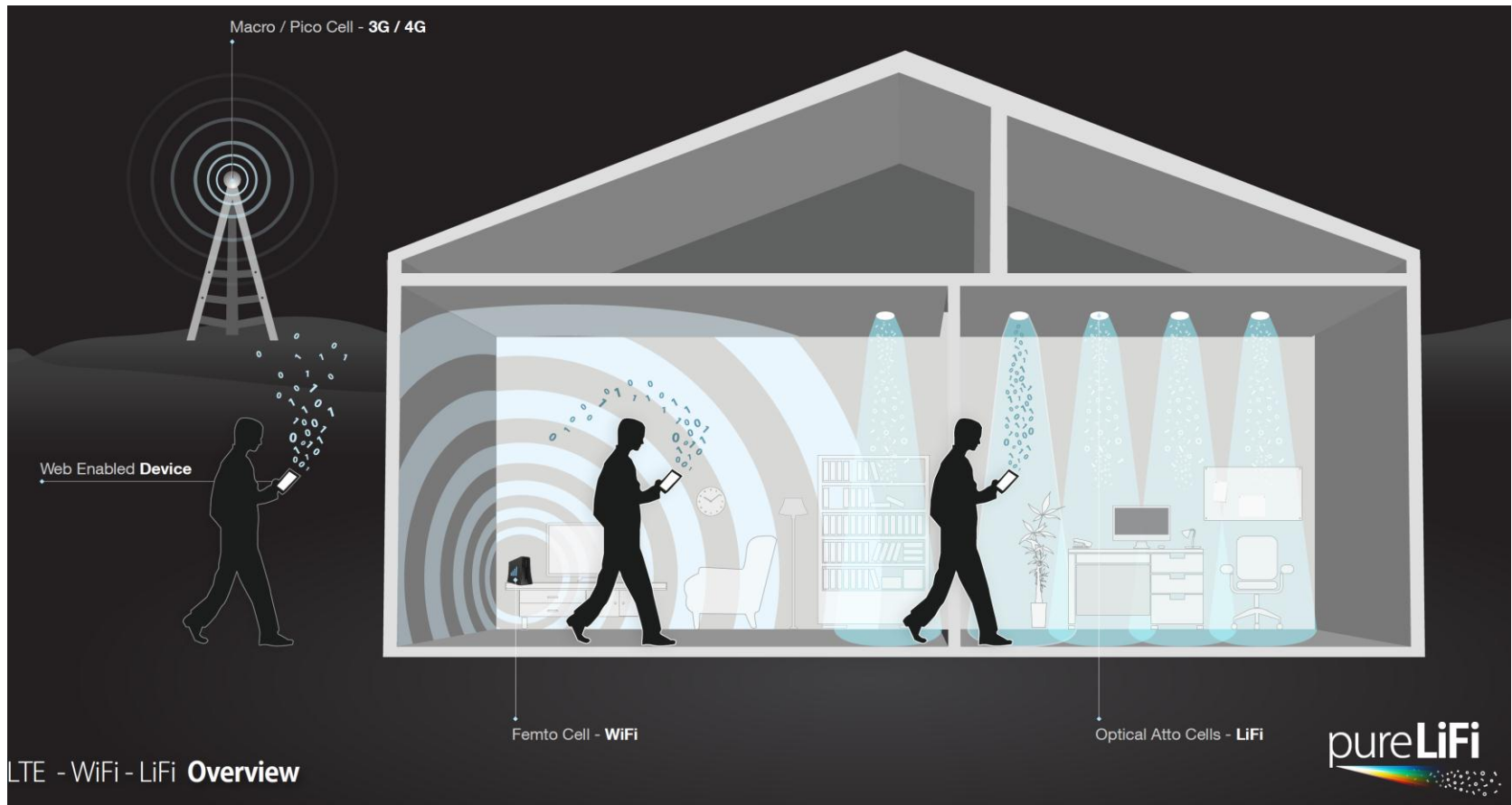
LiFi: mobility and hand-over support

- **Networked & Mobile**

- Users can move from one light source to another and retain their session
- Users do not need to be aligned with the light source and may connect to the strongest light source
- The signal may be detected from reflections as well as direct line of sight



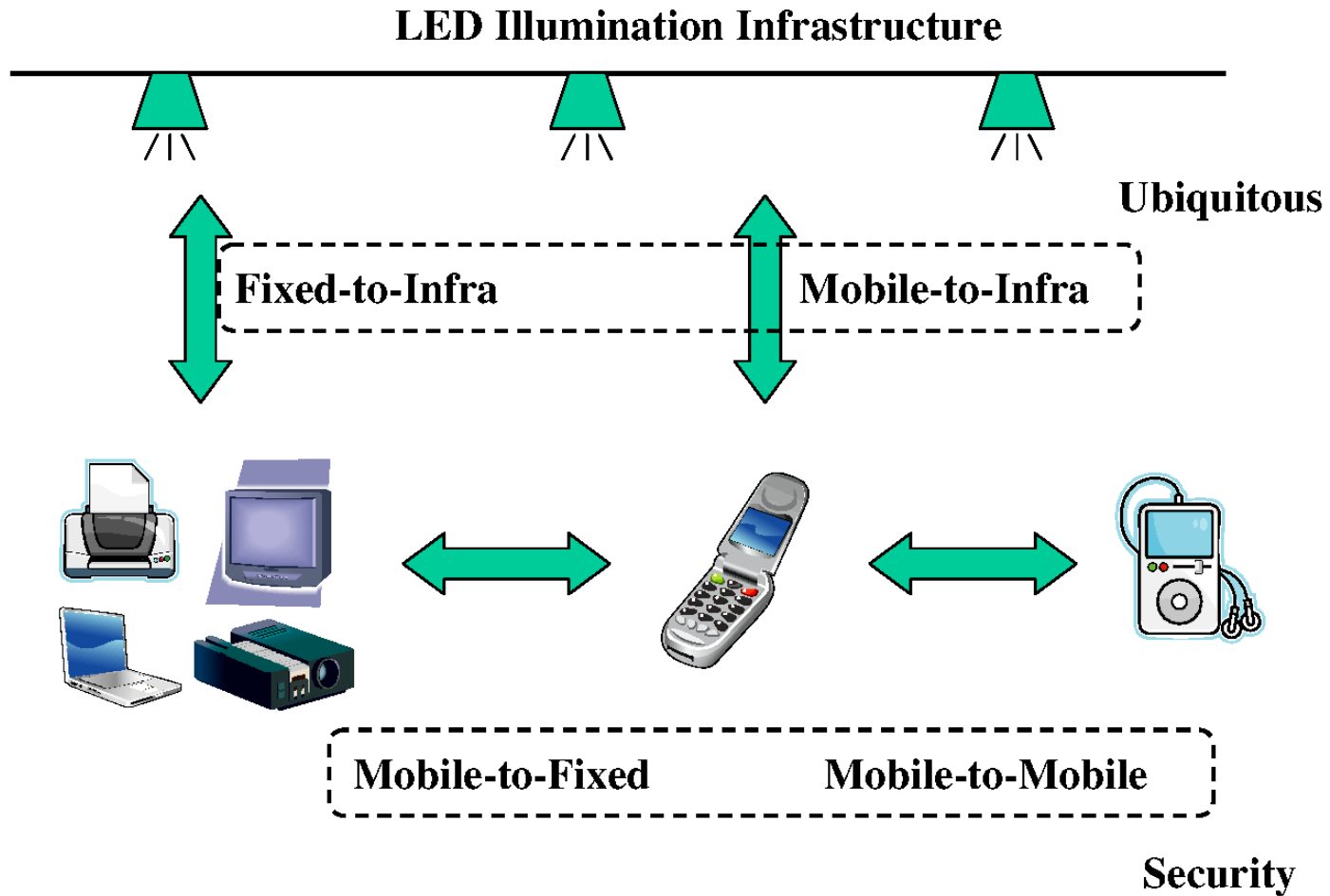
LiFi: Complementary to existing RF



LiFi: Competitive Advantages

- Security
 - If no photons escape, there is no external network intrusion
- Localization
 - Strictly defined illumination area, sharp SINR cut-off, enables geofencing and asset tracking
- Safety
 - No RF radiation alleviating health and EMI concerns
- Data Density
 - Smaller Li-Fi cells allow significantly greater spatial reuse of bandwidth

Indoor application

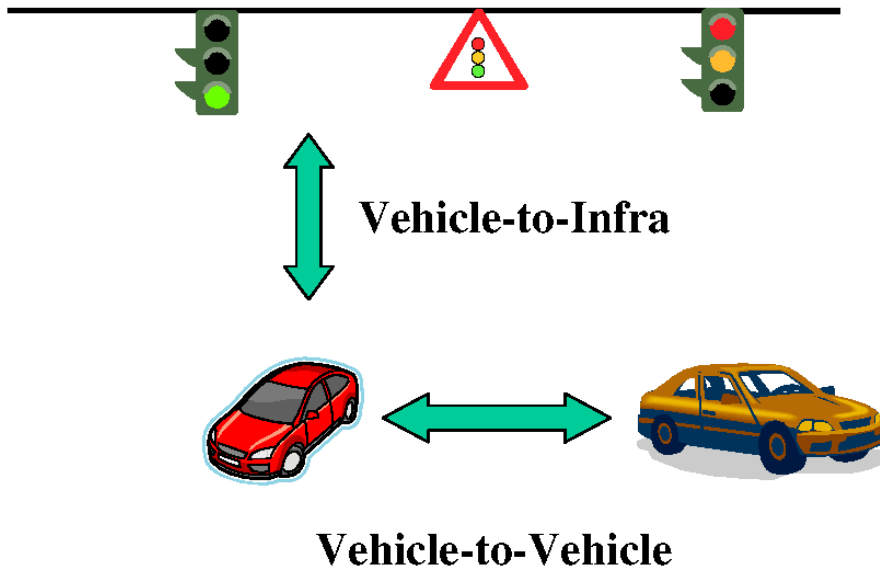


Requirements (Indoor application)

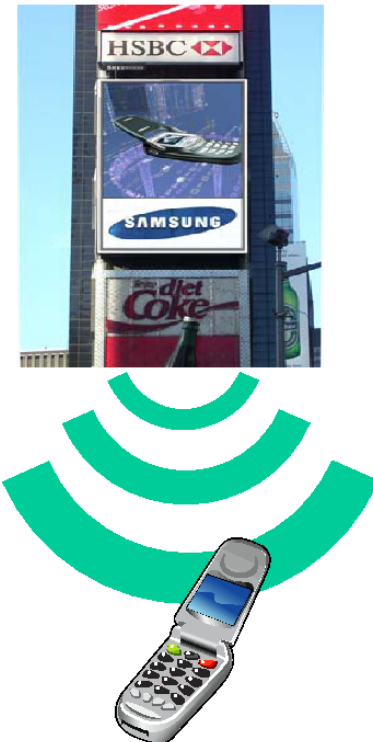
	Mobile to Mobile	Mobile to Fixed	Mobile to Infra	Fixed to Infra
Link	Bi-direction	Bi-direction	Bi or Uni	Bi or Uni
Reach	~1m	~1m	~3m	~3m
Rate	~100Mbps	~100Mbps	~10Mbps	~10Mbps
Application	Contents sharing	File transfer Video streaming M-commerce	Indoor navigation LBS Networked robot	Data broadcast
Alternative	IrDA, Bluetooth, UWB	IrDA, Bluetooth, UWB		WLAN

Outdoor application

Traffic control Infrastructure

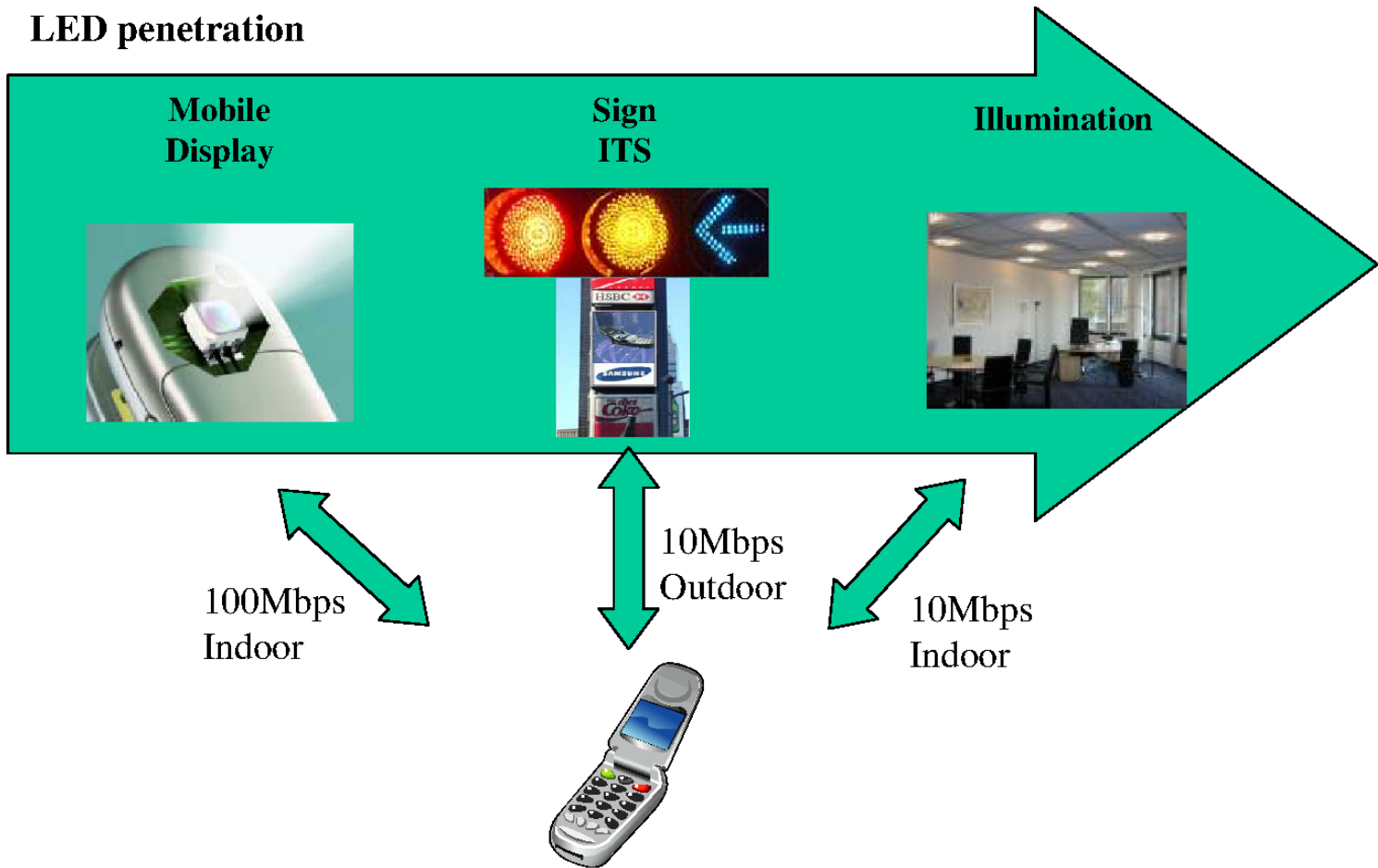


Outdoor advertising



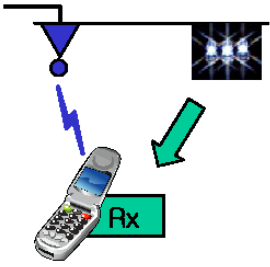
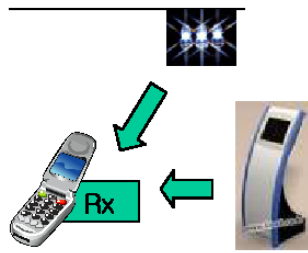


VLC application evolution

LED penetration



Indoor navigation scheme

	Uni-direction	Bi-direction	Hybrid	Hot spot
Link				
Rate	<ul style="list-style-type: none"> Down : ~10kbps 	<ul style="list-style-type: none"> Down : ~10Mbps Up : ~100Mbps 	<ul style="list-style-type: none"> Down : ~10kbps Up : ~10Mbps 	<ul style="list-style-type: none"> Down(light) : ~10kbps Down(HS) : ~100Mbps
Infra	<ul style="list-style-type: none"> Lighting with optical ID 	<ul style="list-style-type: none"> Lighting with optical ID Receiver In-building network Routing server 	<ul style="list-style-type: none"> Lighting with optical ID RF access point In-building network Routing server 	<ul style="list-style-type: none"> Lighting with optical ID Hot spot
Mobile	<ul style="list-style-type: none"> Receiver Large storage Map info Routing software 	<ul style="list-style-type: none"> Receiver Transmitter 	<ul style="list-style-type: none"> Receiver RF connectivity 	<ul style="list-style-type: none"> Receiver Large storage Routing software
Other service		LBS Ad-hoc connection	LBS	

Demonstrations



High speed



Mobile to Mobile
(100Mbps, Samsung)



Tx, Rx
(~30Mbps, Univ. of Oxford)



LED array
(~1Gbps, Keio Univ.)



Music broadcasting
(6Mbps, Univ. of Oxford)



Infra to Mobile
(10Mbps, Tamura Inc.)



Sign board
(10Mbps, Samsung)



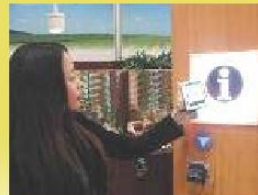
Infra to Mobile (LAN)
(4Mbps, Samsung)



Audio transmission
(100kbps, Hongkong Univ.)



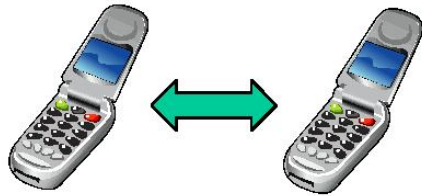
Infra to Mobile, VLCC (Keio Univ., NEC, Toshiba, Sony, Matsushita, Casio etc.)
(4.8kbps, illuminations, visible light ID, sign board, applications based on JEITA)



Low speed

VLC Demonstrations

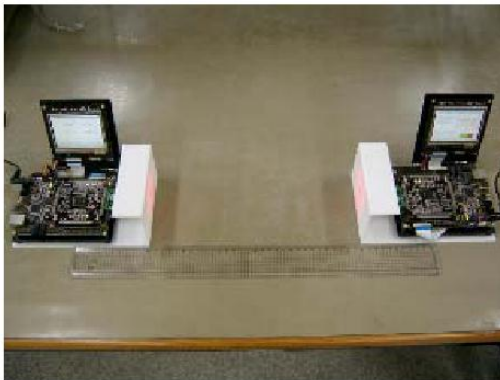
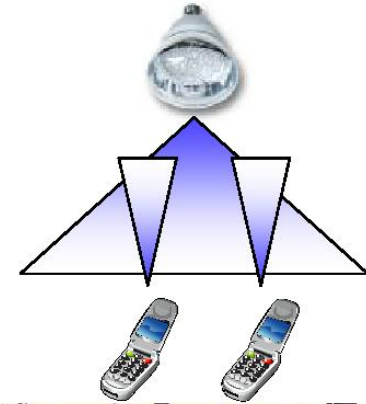
Mobile to mobile



Infra to mobile



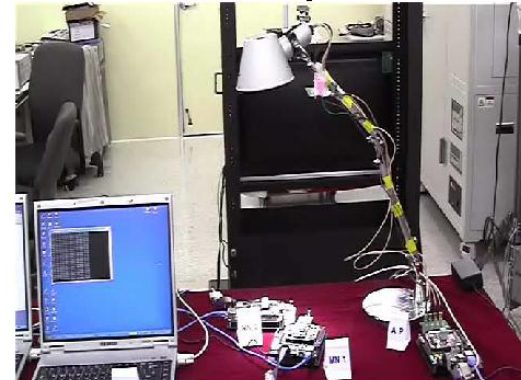
Infra to mobile



100 Mbps, 1m
Bidirection



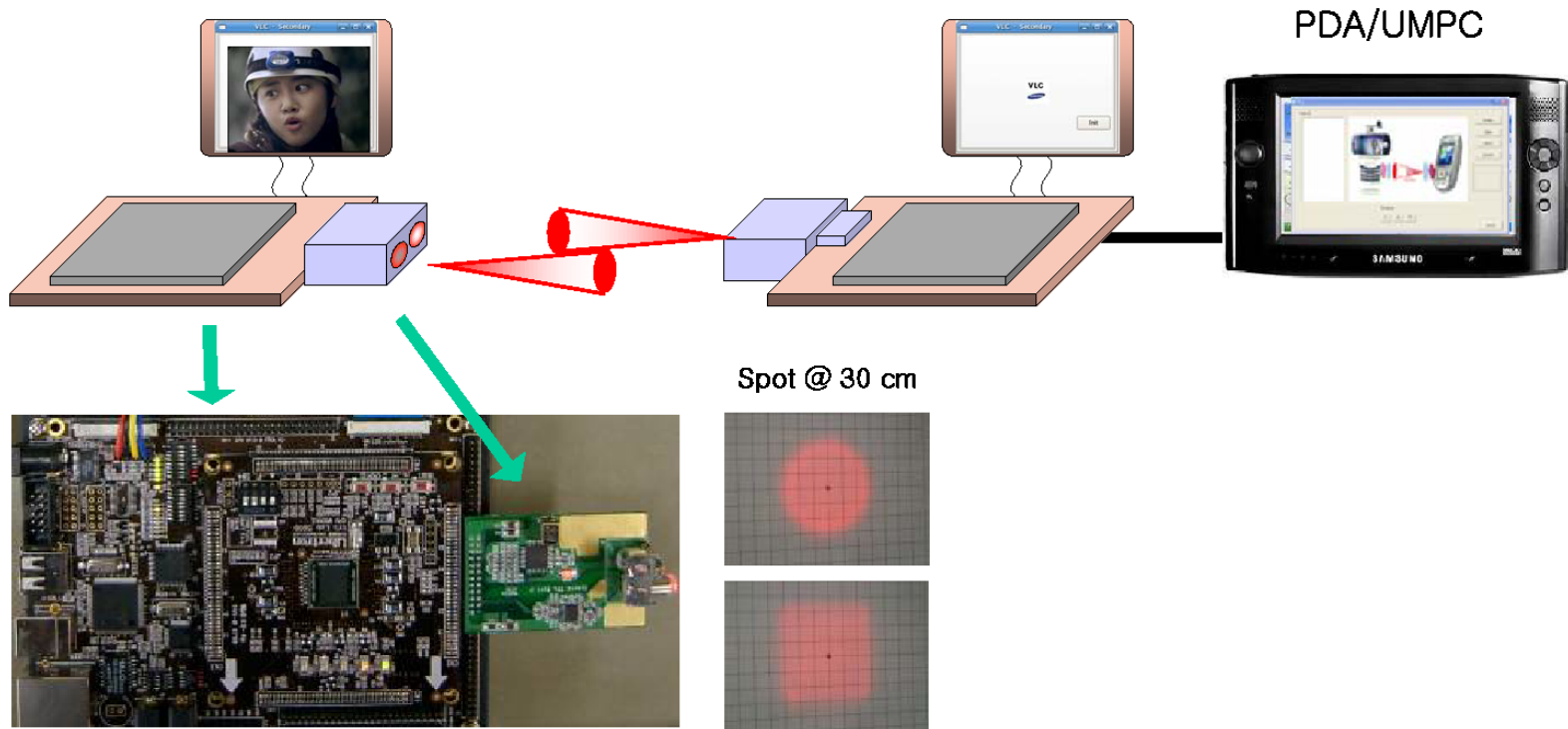
20 Mbps, 3m
Unidirection



4 Mbps, 3m
Bidirection

Mobile-to-mobile demo

- What You See Is What You Send (WYSIWYS)
- 120 Mbps, 1m, Full duplex
- File transfer and video streaming



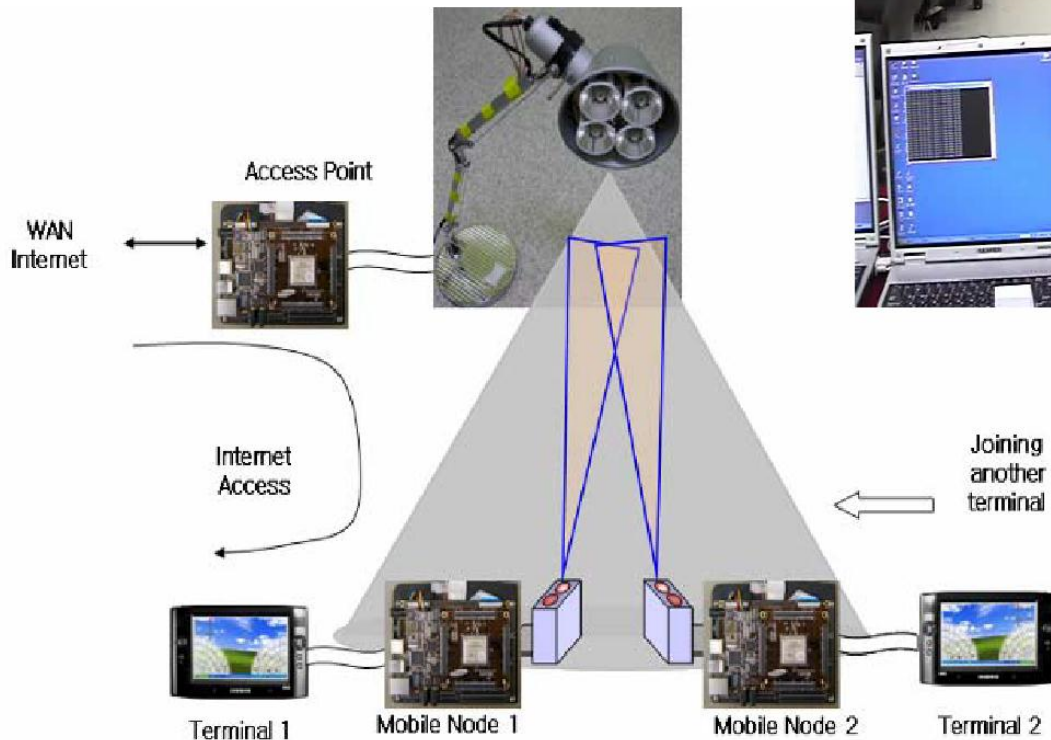
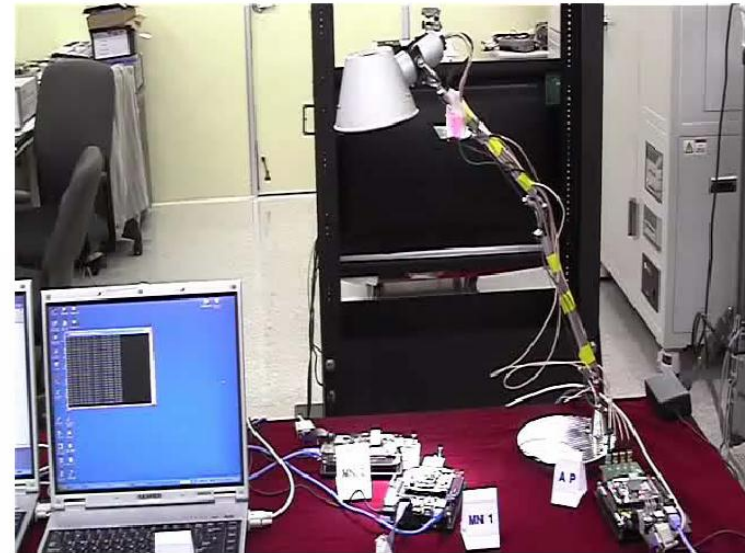
Infra-to-mobile (uni-direction)

- RGB WDM transmission
- 20 Mbps, 3m, Uni-direction
- Information broadcast from sign board



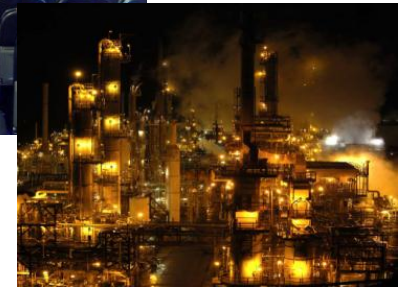
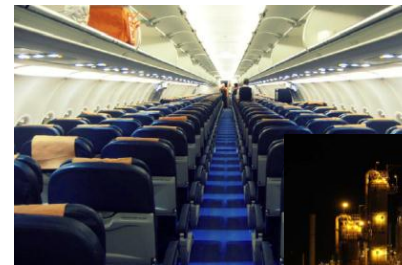
Infra-to-mobile (bi-direction)

- TDMA-based P2MP
- 4 Mbps, 3 m, bi-direction
- Secure indoor LAN



LiFi: use-cases

- Security Conference rooms
- Hangers and storage depots
- Airplanes and Airports
- EMI sensitive environments
 - Hospitals, Petrochemical plants, Nuclear facilities, etc.

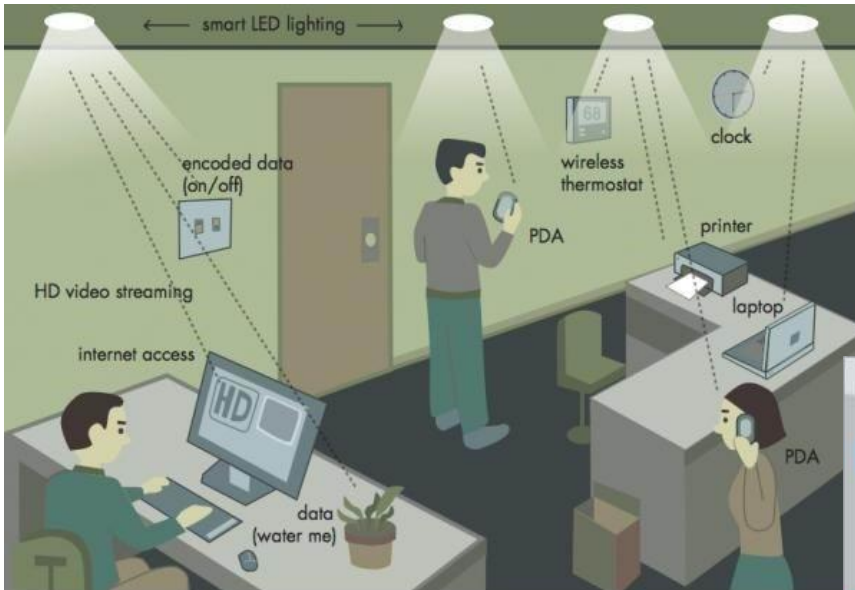


LiFi: use-cases

- Spectrum relief
 - Every-day mobile communications
- Open plan offices
- Hotels
- Research Institutions

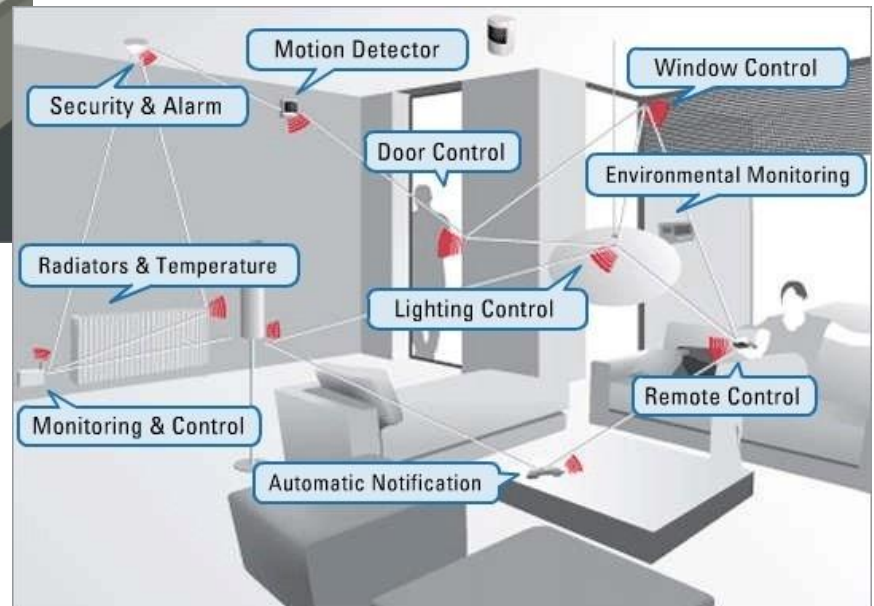


LiFi: use-cases



Smart Office

Smart Home



Future Challenge

- Automatic Focus and Optic Antenna Design for VLC Systems
- Channel Modeling and Characterization of VLC Systems
- Coding for VLC systems
- Computing with Light
- Efficient Signal Processing Algorithms for VLC systems
- Indoor Communication
- Information Display and Communications
- Integration of VLC with other Wireless Technologies
- Inter-vehicle Communication
- Intra-vehicle Communication
- Vehicle to Infrastructure Communication
- Visual Signaling and Communication
- Visible Light Communication Networks
- Localization using Visible Lighting
- Interference Mitigation, Multiuser Access, and Duplexing Techniques
- MIMO Technologies in VLC Systems
- Mobility Management
- Network Protocol and Network Architecture for VLC
- New Modulation Methods for VLC Systems
- Novel Designs for VLC Systems
- Positioning and Communications
- Security Issues in VLC
- Specific Integrated Chip for VLC Systems
- System Designs and Architectures Coupling VLC Capabilities with RF
- Practical Applications with VLC System
- Standardization Activities Related to VLC
- Challenges in VLC commercialization Activities

Proof of Concept



Produk VLC



Tim RG VLC Indonesia



K... voice? Ah, sudah biasa. Aliran tetap, bagaimana kalau kirim data dan berbicara lewat cahaya? Ini yang luar biasa! Visible light communication (VLC)...

...mikro kontroler dan bengkel komunikasi nirkabel. Tim VLC Indonesia dibentuk sesuai dengan masa akhir perkuliahan di mana mahasiswa harus membuat alat...

Informasi video listrik... berfungsi untuk mengubah informasi cahaya menjadi listrik. Satu lagi alat adalah ViLan. Alat ini masih dalam progres pembuatan, yaitu suatu perangkat yang...

Referensi

- Toshihiko Komine, “Visible Light Wireless Communications and Its Fundamental Study”, 2005
- http://en.wikipedia.org/wiki/Visible_light_communication
- Nikola Serafimovski, pureLiFi, IEEE 802.15-15-0107-01-007a-lifi-definition, 2015
- http://www.ted.com/talks/harald_haas_wireless_data_from_every_light_bulb
- Kang Tae Gyu, “Advanced Optical Wireless Communication System : Chapter 14 Visible Light Communication”, Cambridge University Press, 2012

Video Demo

- [LightMessage from pureVLC](#)
- [AudioStreamLifi](#)
- [TEDx VLC](#)
- [LiFi Wireless Comm System](#)



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<http://dennydarlis.staff.telkomuniversity.ac.id/lima-point-nol/vlc/>

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