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

Submission Title: [VLC application trials]
Date Submitted: [17 March, 2008]
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Re: []

Abstract: [Some visible light communication (VLC) application trials are described in this document. The VLC applications are categorized. Some demonstrations and the feature of each categorized application are also presented.]

Purpose: [Contribution to IEEE 802.15 IG-VLC]

VLC application trials

2008.03.18

Samsung Electronics

Contents

VLC introduction

- **VLC (Visible Light Communication)**

  : **New communication technology using “Visible Light”.**

- **Visible Light**

  : **Wavelength between ~400nm (750THz) and ~700nm (428THz)**

- **General Characteristic**

  - Visibility : Aesthetically pleasing
  - Security : What You See Is What You Send.
  - Health : Harmless for human body
  - Unregulated : no regulation in optical frequency
  - Using in the restricted area : aircraft, spaceship, hospital
  - Eye safety

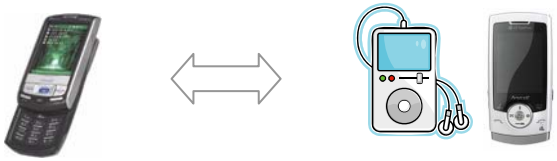
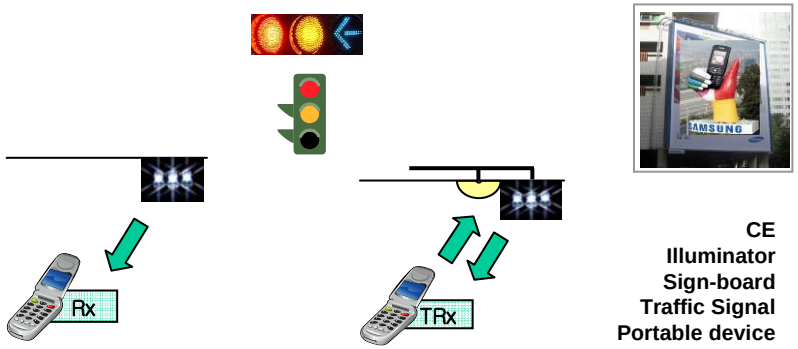
VLC motivation

- **Communication community trend**
  - Ubiquitous (Connect each other everywhere, every time)
  - Security
- **LED trend**
  - LED technology (efficiency, brightness)
  - LED Cost
- **Environmental trend**
  - Health
  - Energy saving
- **Intrinsic characteristic of VLC**
  - Visibility
  - No interference / No regulation

VLC vs. RF Characteristic

Property		VLC	RF
	Bandwidth	Unlimited, 400nm~700nm	Regulatory, BW Limited
	EMI	No	High
	Line of Sight (LOS)	Yes	No
	Standard	Beginning (IG-VLC)	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

VLC Applications

	Application	
Mobile to Mobile	 **Handheld device** **Portable device**	• Contents-sharing • Data transfer
Mobile to Fixed	 **CE** **Kiosk** **Portable device** **Handheld device**	• File transfer • Video streaming • M-commerce
Infra to Mobile	 **CE** **Illuminator** **Sign-board** **Traffic Signal** **Portable device** **Handheld device**	• Information-broadcast • ITS • Indoor LBS • Indoor Navigation • Networked Robot 

Demonstrations

High speed

Mobile to Mobile
(100Mbps,Samsung)

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

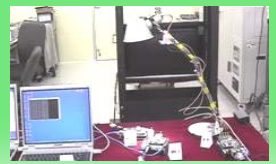
LED array
(~1Gbps, Keio Univ.)

Music broadcasting
(6Mbps, Univ. of Oxford)

Infra to Mobile
(10Mbps, Tamura Inc.)

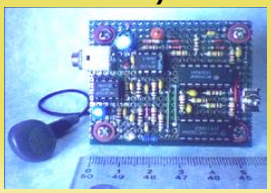
Sign board
(10Mbps, Samsung)

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



Low speed

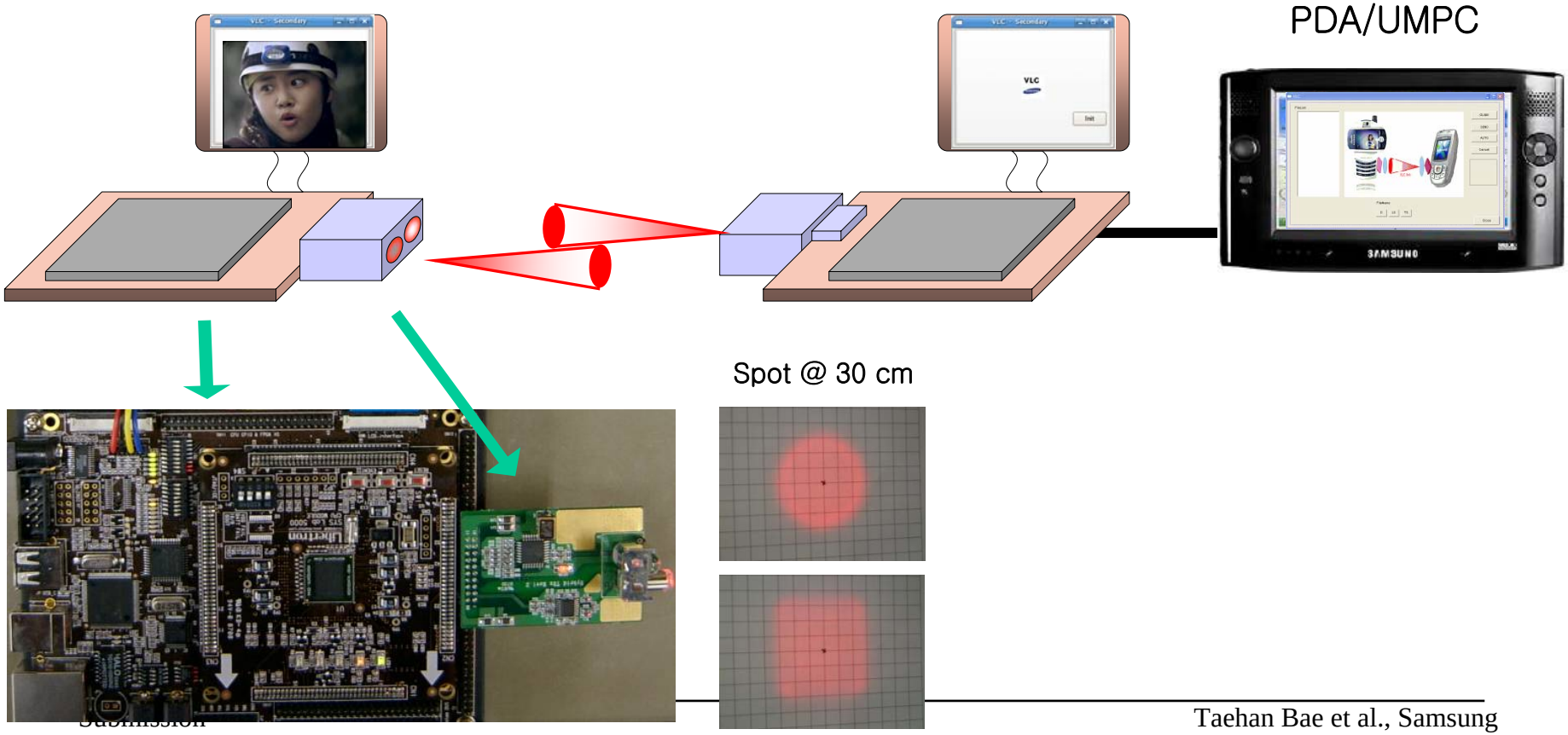
Audio system
(100kbps, Hongkong Univ.)



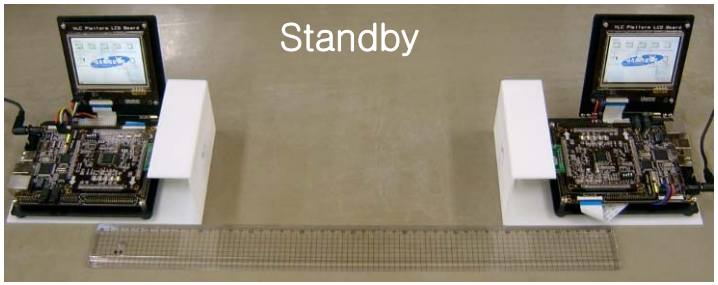
Infra to Mobile, VLCC (Keio Univ., NEC, Toshiba, Sony, Matsushita, Casio etc.)
(4.8kbps, illuminations, visible light ID, sign board, applications)

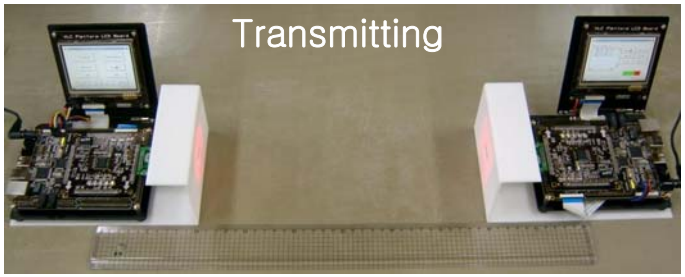
Mobile-to-mobile

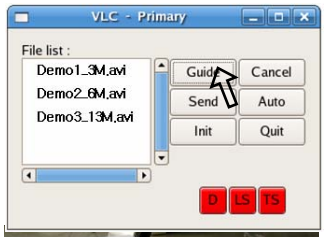
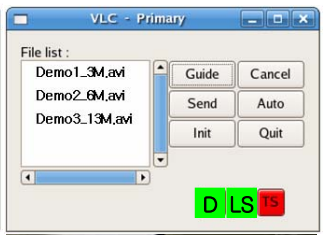
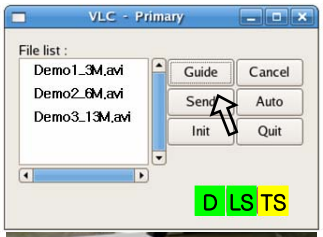
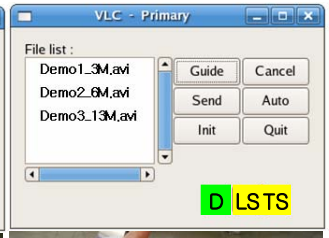
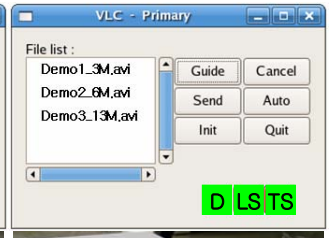
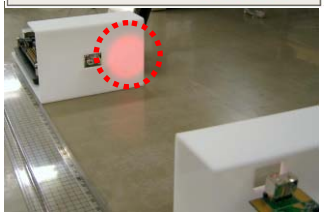
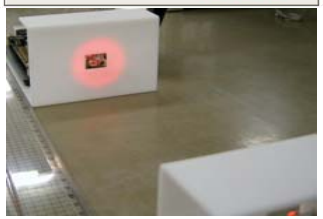
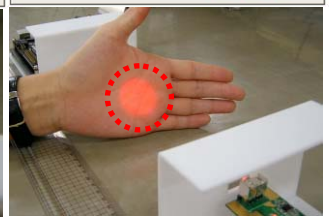
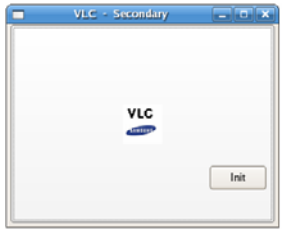
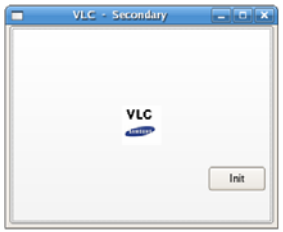
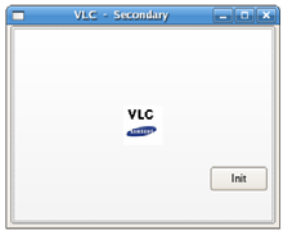
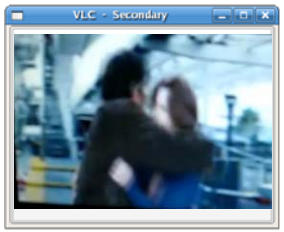
- What You See Is What You Send (WYSIWYS)
- 120 Mbps, 1m, Full duplex
- File transfer and video streaming



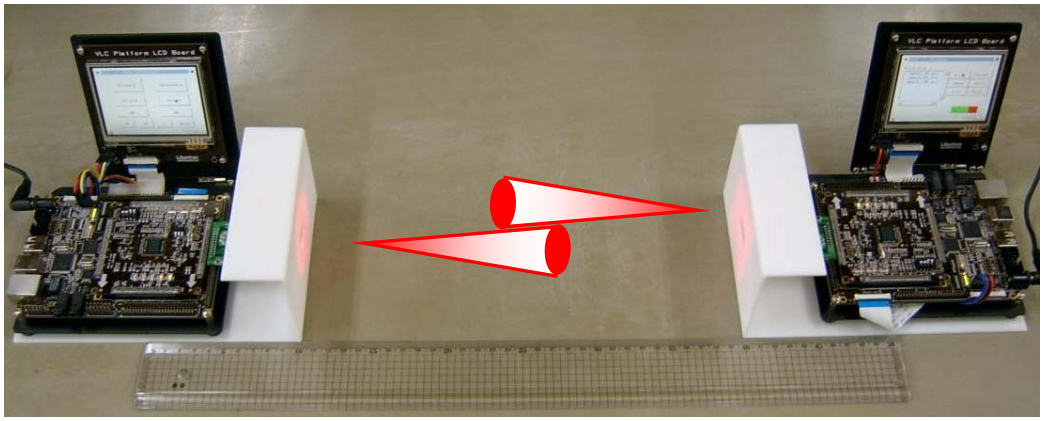
Mobile-to-mobile (protocol)

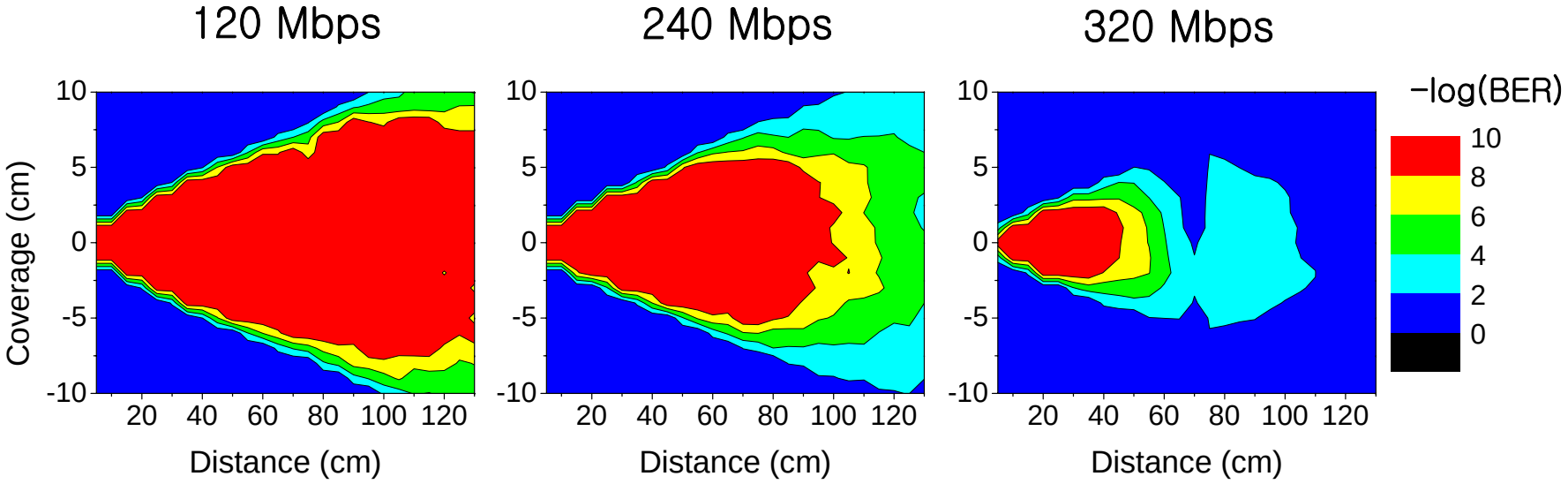




	Beam guiding	User alignment Device discovery	Start steaming	Temporal blocking (< 8 sec.)	Streaming end
Primary Screen					
Link					
Secondary Screen					

Mobile-to-mobile (Link performance)

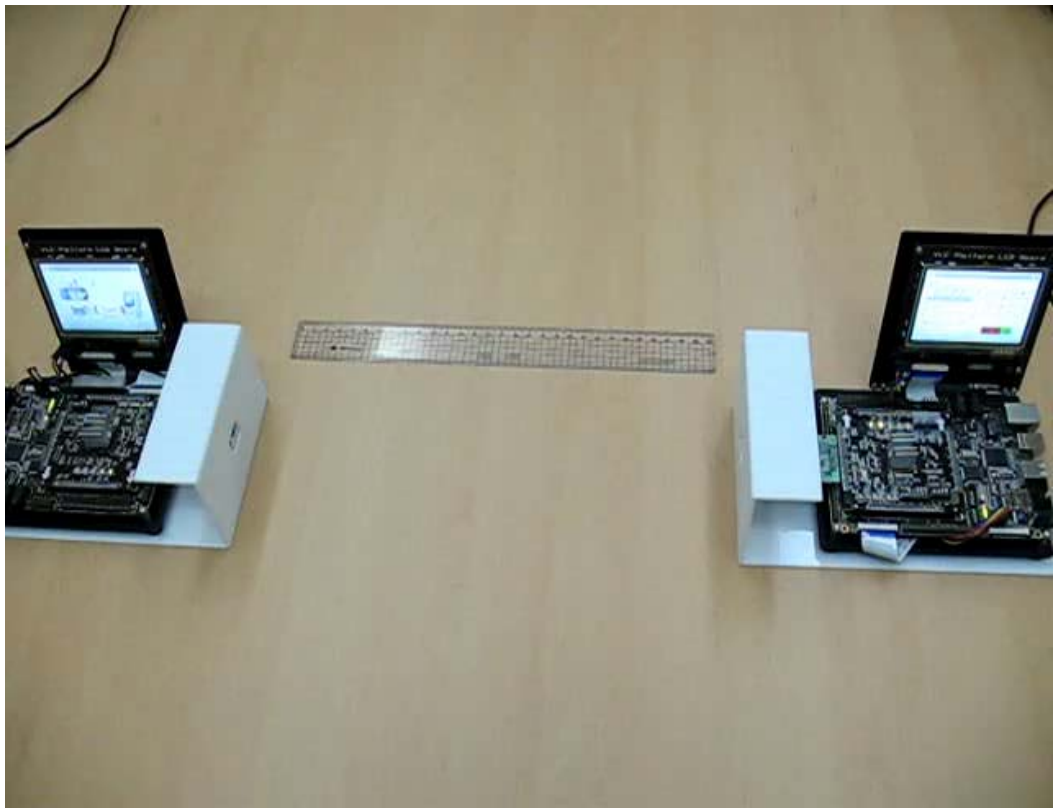




Mobile-to-mobile feature

- Modulation : NRZ
- Encoding : 8B/10B
- Optical Source : LD, LED
- Wavelength : 630nm
- PD : Silicon
- Protocol :
  - Visibility support
  - Beam Guiding& Discovery
  - Alarm for Miss alignment
  - Self Restoration

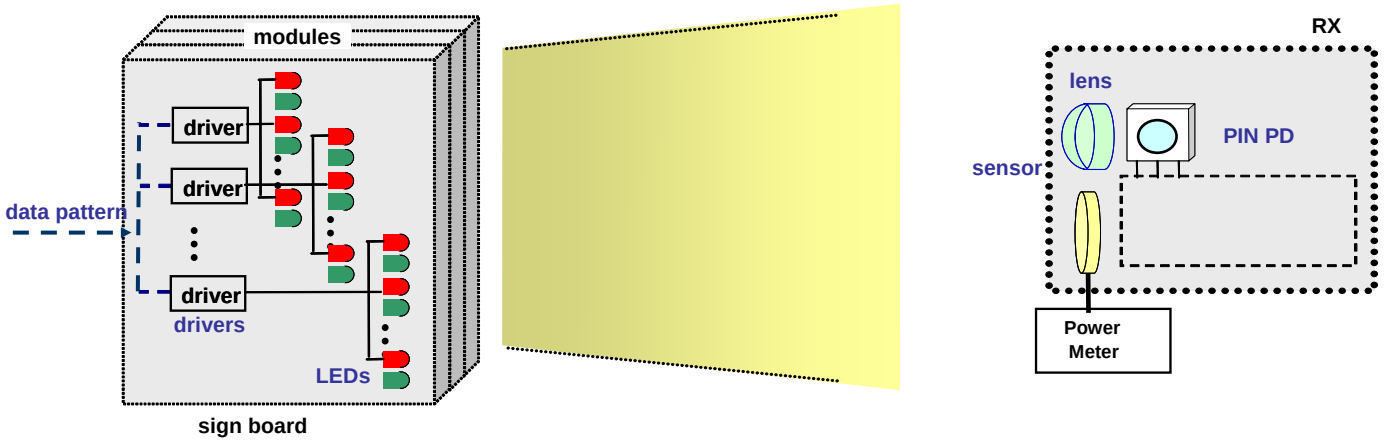
Mobile-to-mobile



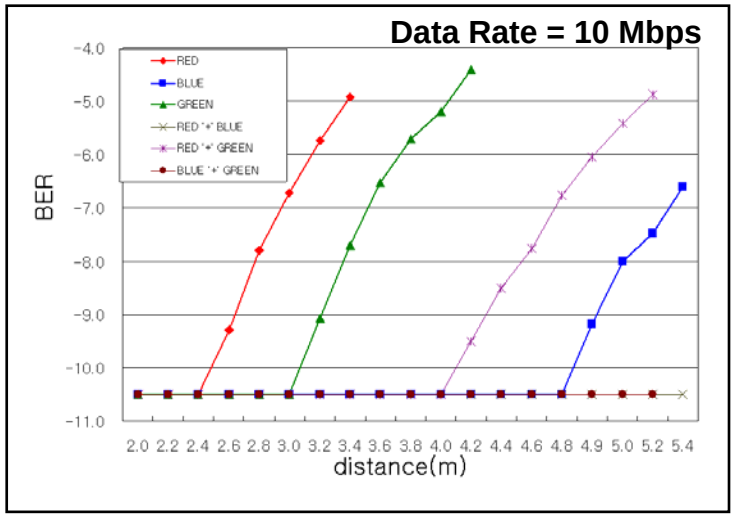
Infra-to-mobile (bi-direction)

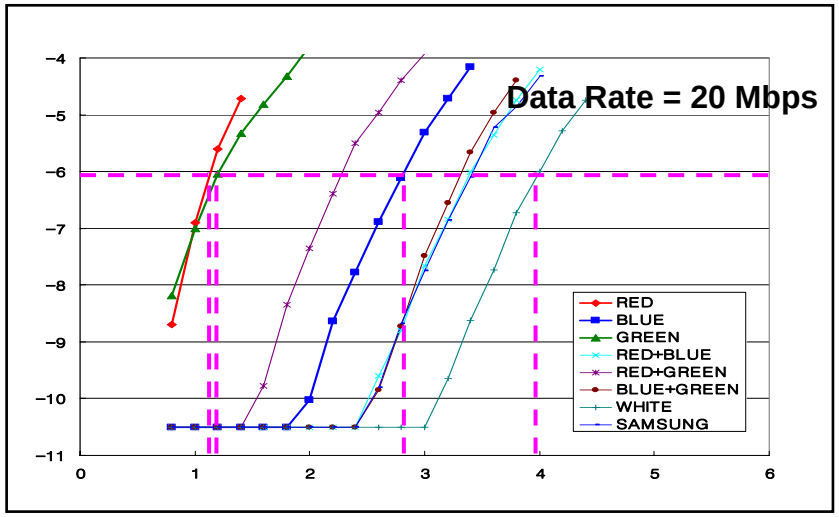
- Information broadcasting from signboard
  - Main function : Display, Indication, Text, Graphic
  - Additional function : Broadcast additional information
  - Public / commercial information
  - Unspecified individuals
- RGB WDM transmission
- 20 Mbps, 3m, Uni-direction

Infra-to-mobile (Link performance)



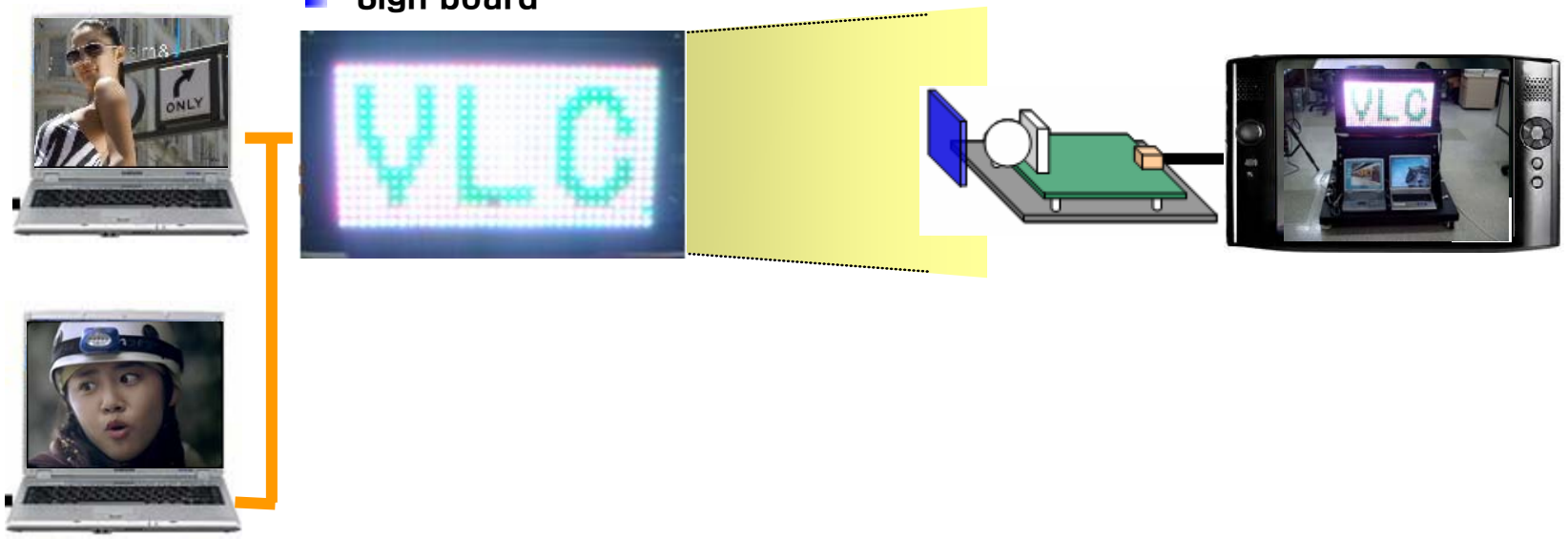
❖ **Experimental setup**





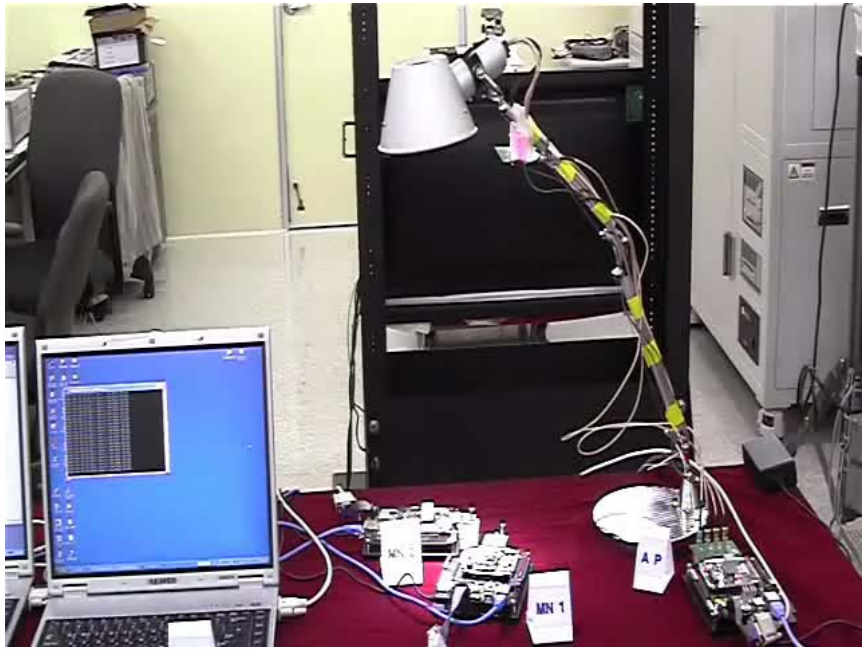
Infra-to-mobile (Uni-direction)

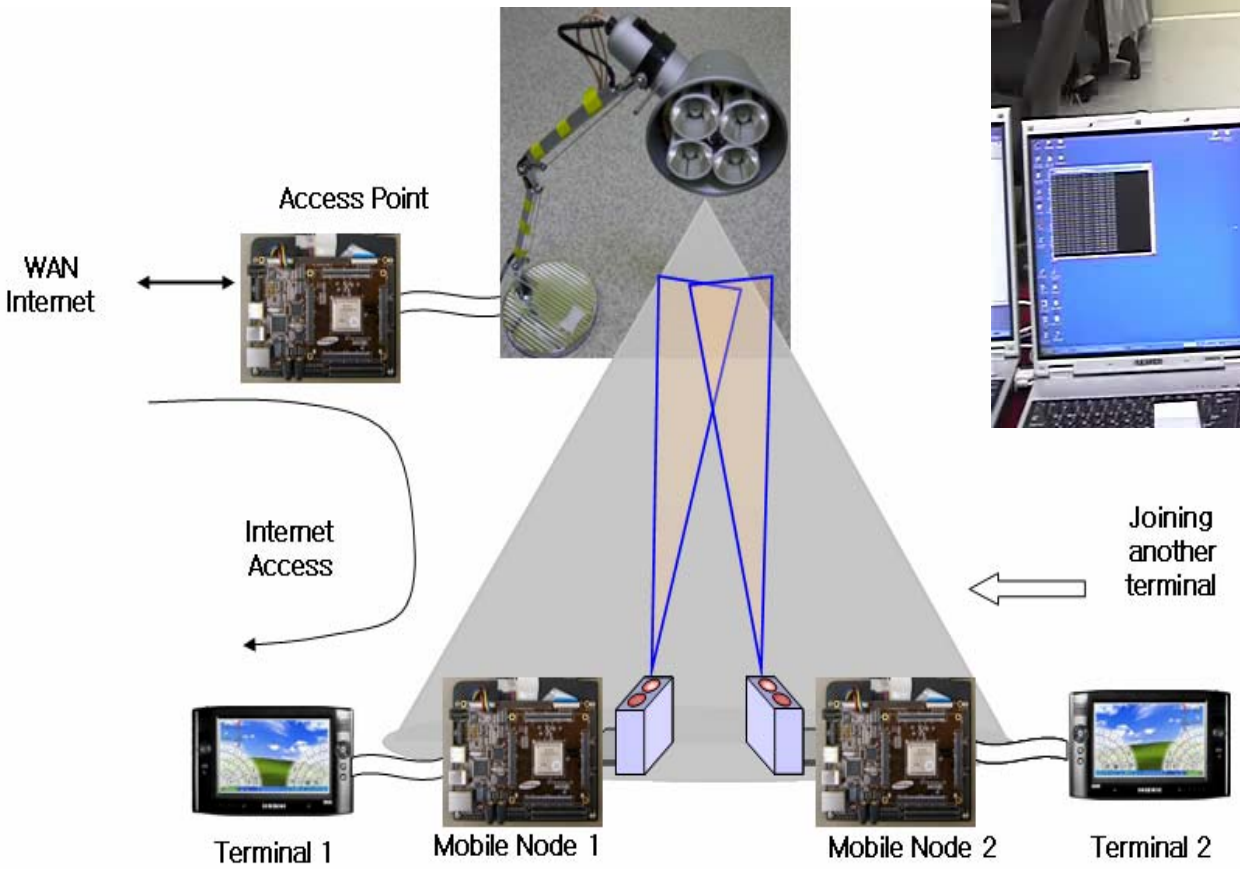
- Sign board



Infra-to-mobile (bi-direction)

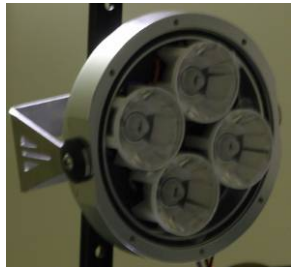
- 4 Mbps, 3 m, bi-direction
- Secure indoor LAN



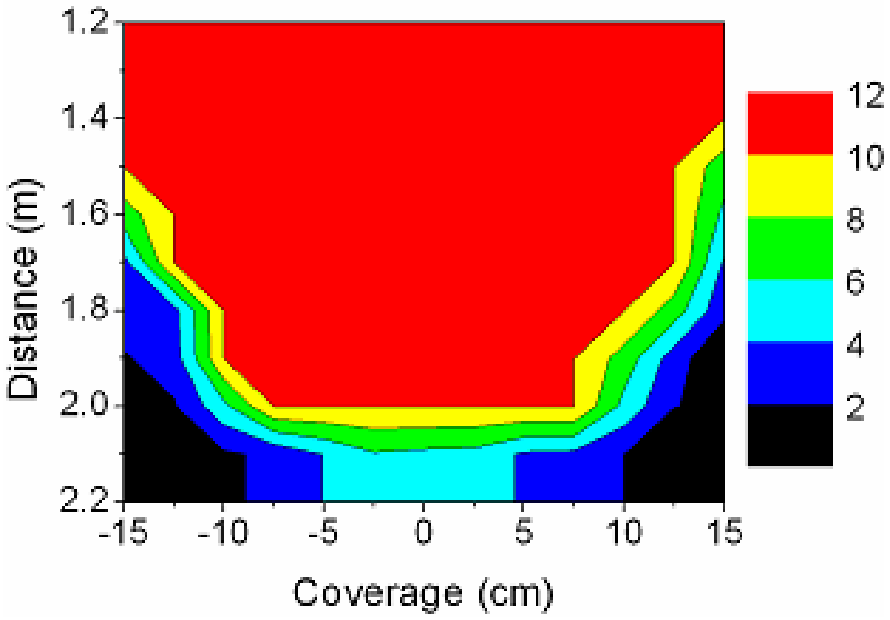


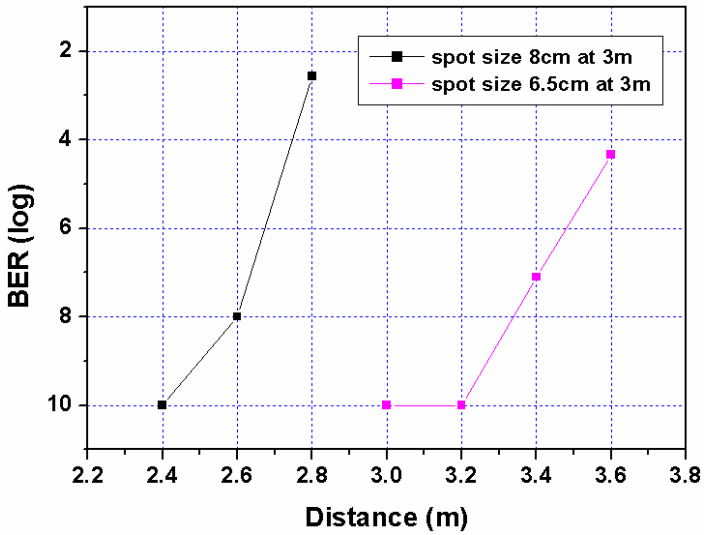
Infra-to-mobile (Link performance)

- Downstream : White LED

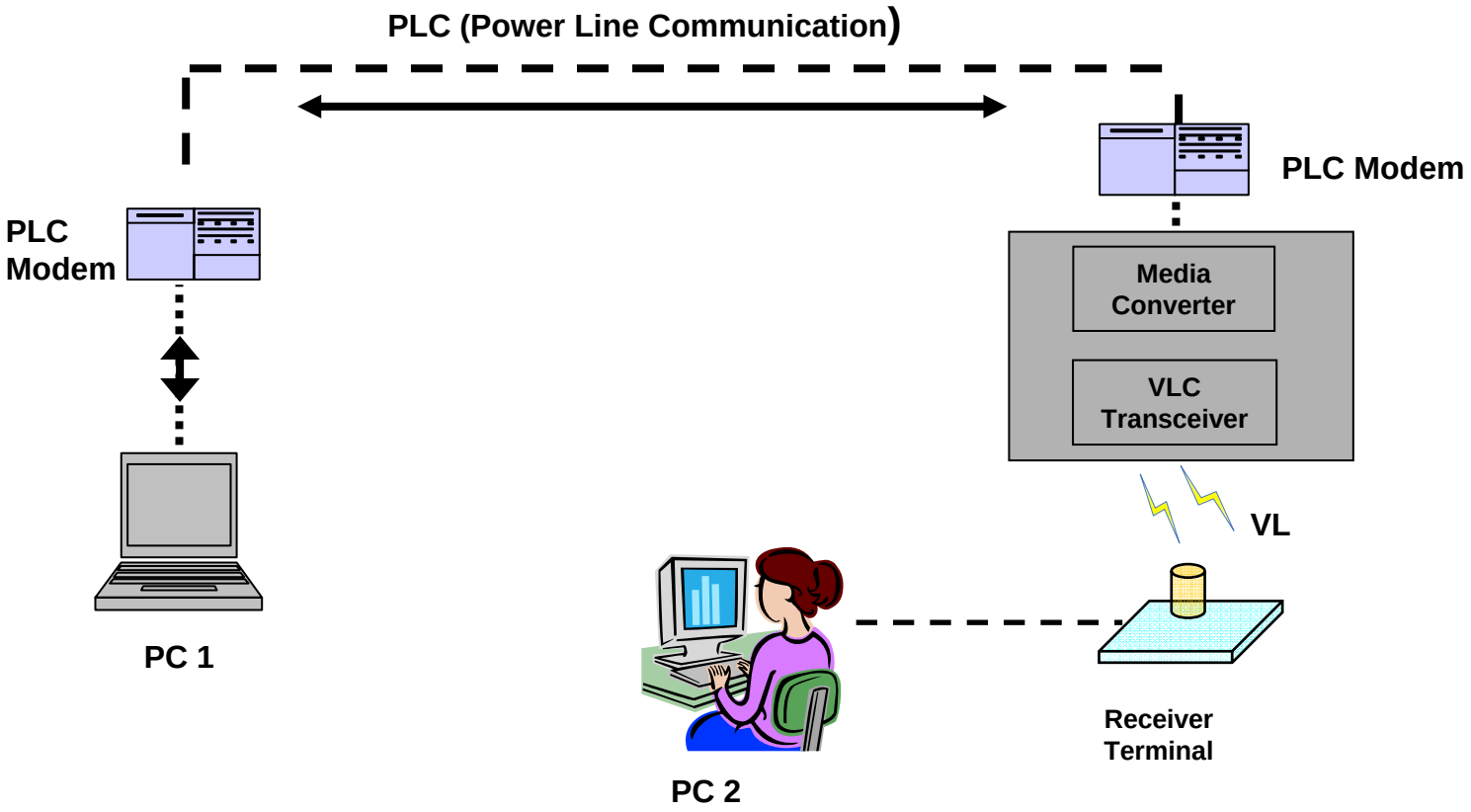


- Upstream : LD



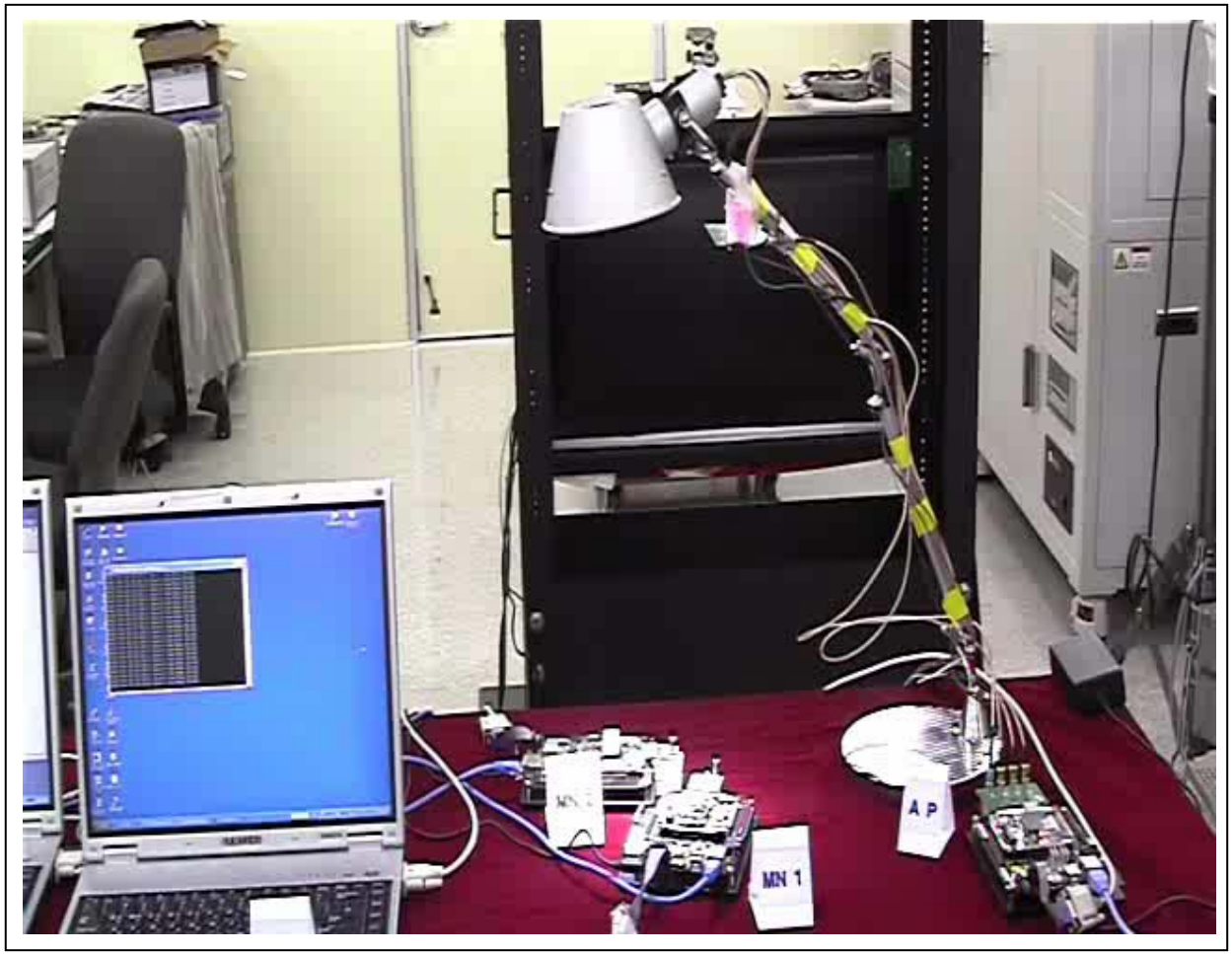


Infra-to-mobile (Network Access)



- The configuration of the PLC connection

Infra-to-mobile (Bi-direction)



Summary

- The VLC is new communication technology using “Visible Light”.
- Motivation
  - Communication community trend
  - LED trend
  - Environmental trend
  - Intrinsic characteristic of VLC
- Characteristic
- Applications
- Demonstrations
  - Mobile-to-mobile
  - Infra-to-mobile (uni-direction / bi-direction)

Thank you