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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]

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VLC application trials

2008.03.18

Samsung Electronics

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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

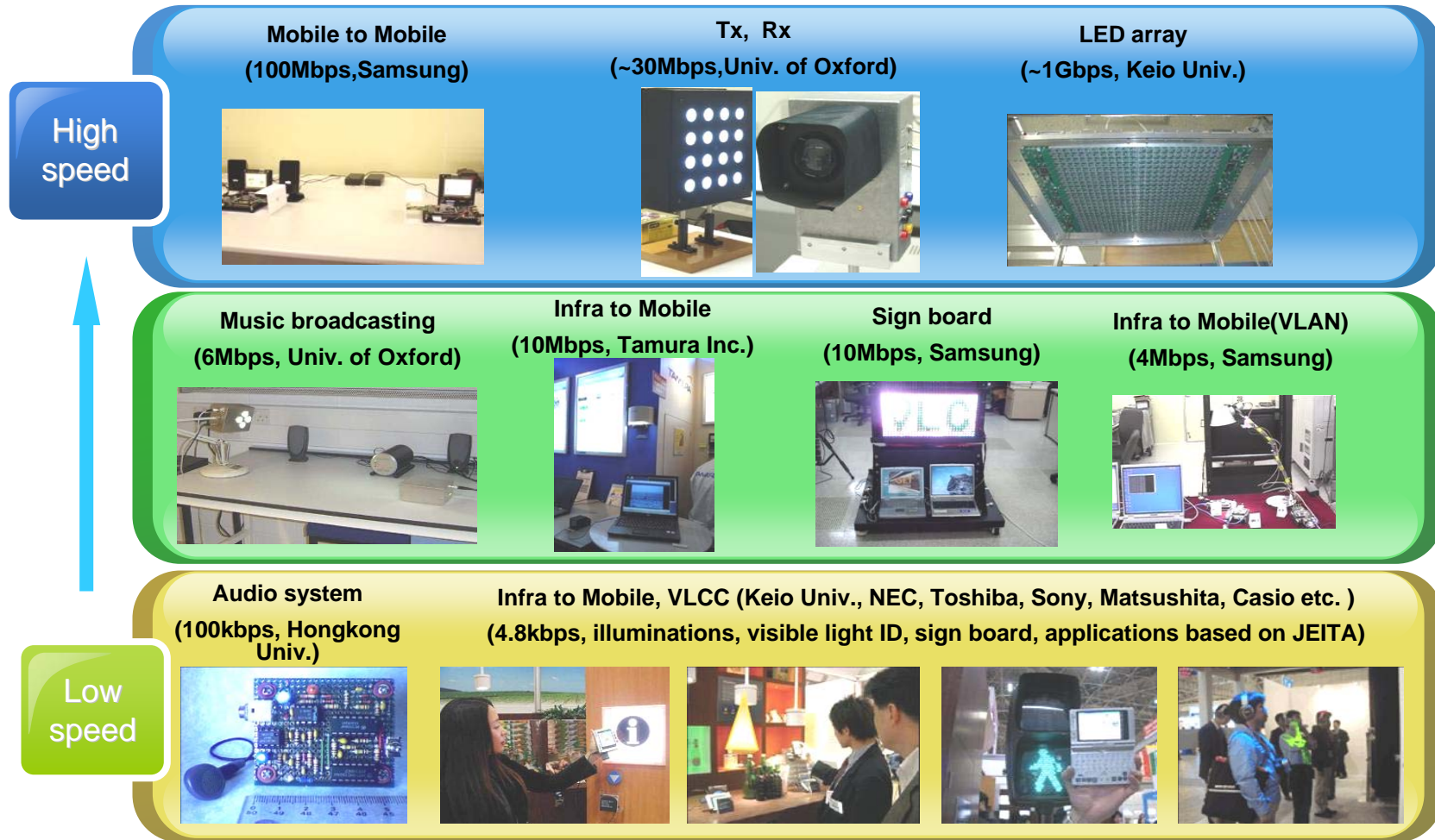
- **Environmental trend**
 - Health
 - Energy saving

- **Intrinsic characteristic of VLC**
 - Visibility
 - No interference / No regulation

VLC vs. RF Characteristic

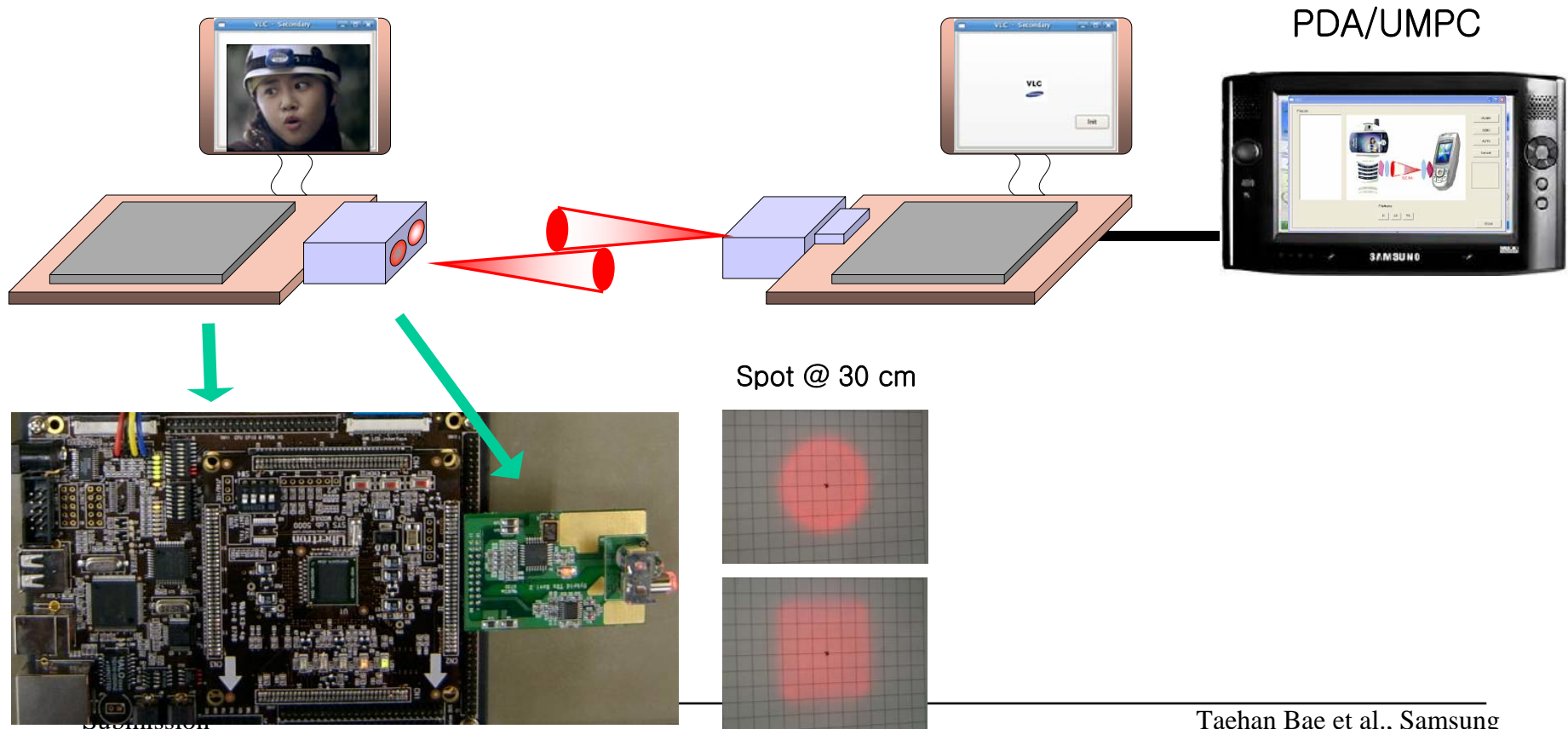
Property		VLC	RF
Bandwidth		Unlimited, 400nm~700nm	Regulatory, BW Limited
EMI		No	High
Line of Sight (LOS)		Yes	No
Standard		Beginning (IG-VLC)	Matured
Hazard		No	Yes
Mobile To Mobile	Visibility (Security)	Yes	No
	Power Consumption	Relatively low	Medium
	Distance	Short	Medium
Infra to Mobile	Visibility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

Demonstrations

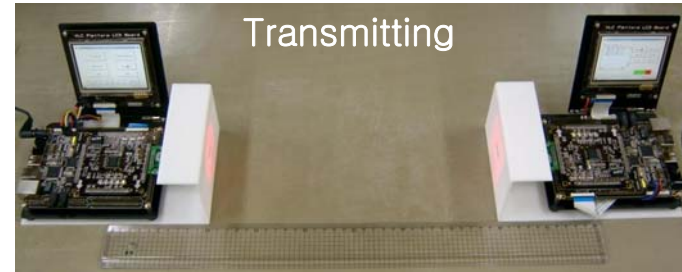
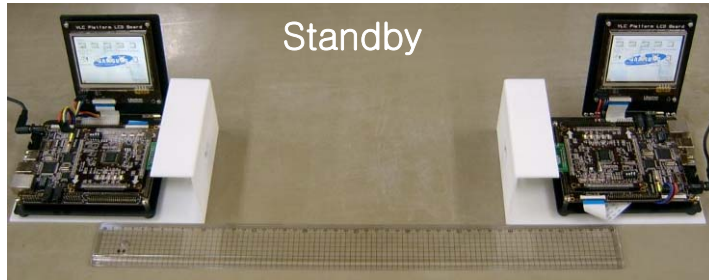


Mobile-to-mobile

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



Mobile-to-mobile (protocol)



Beam guiding

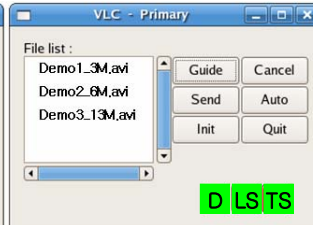
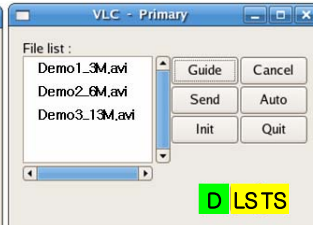
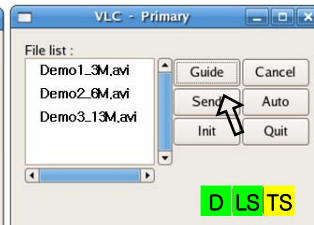
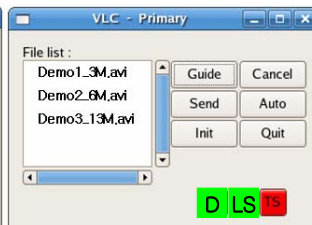
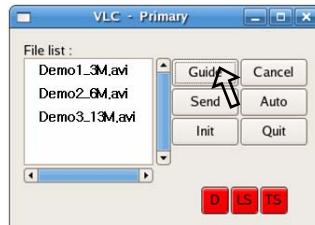
User alignment
Device discovery

Start steaming

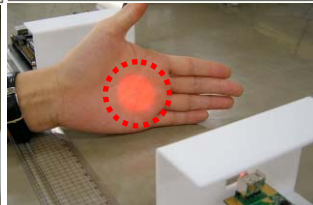
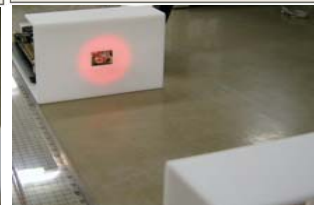
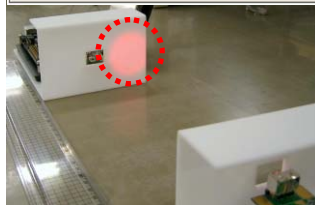
Temporal blocking
(< 8 sec.)

Streaming end

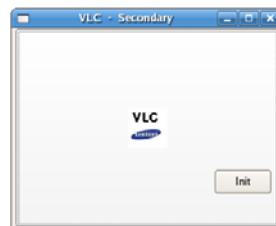
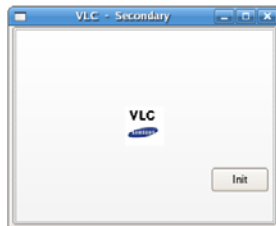
Primary
Screen



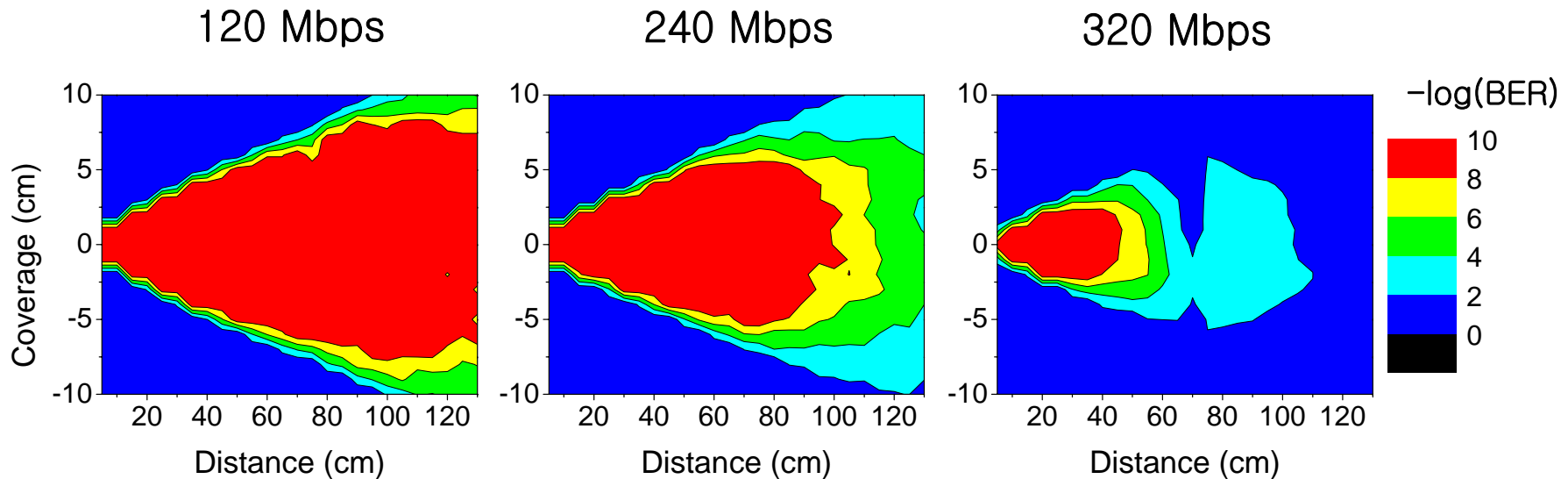
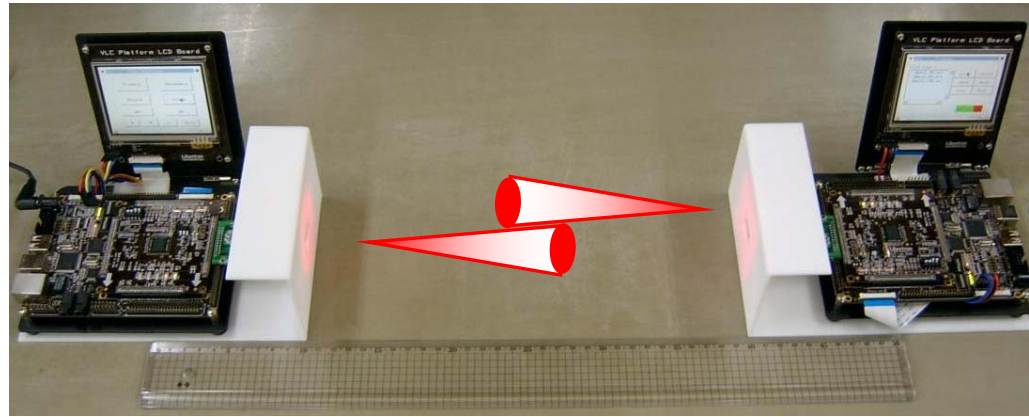
Link



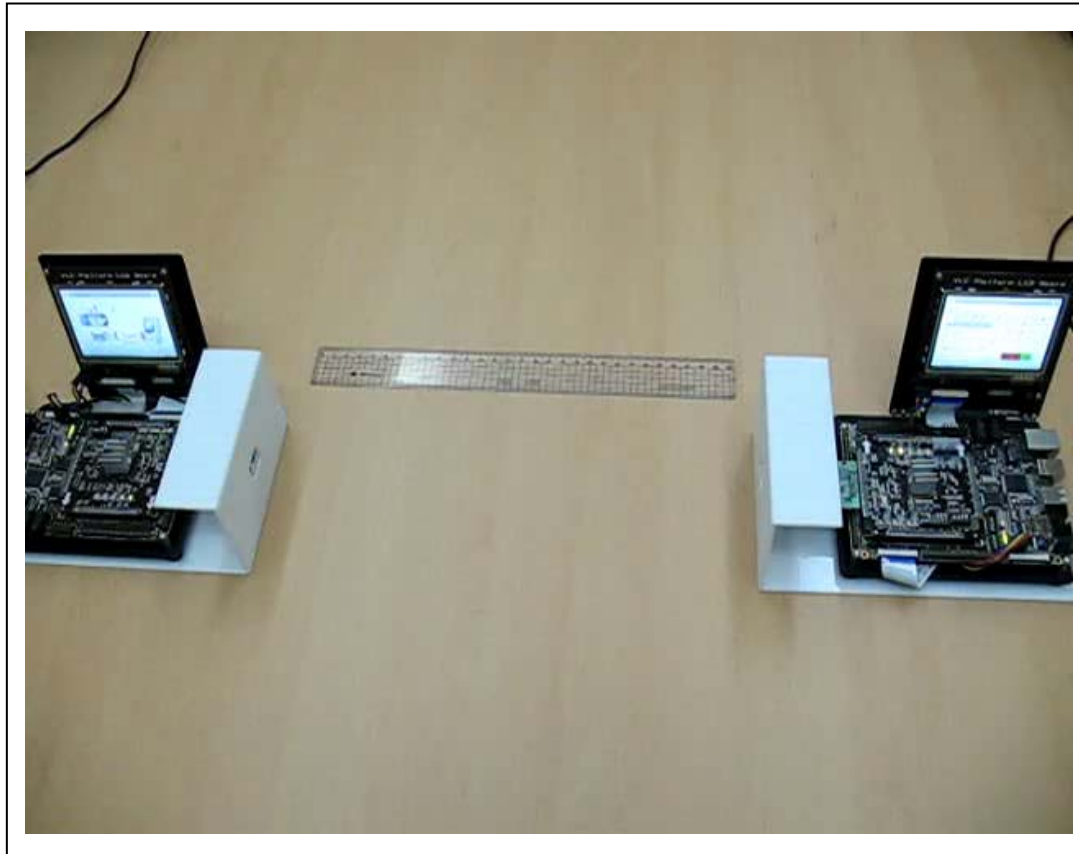
Secondary
Screen



Mobile-to-mobile (Link performance)



Mobile-to-mobile



Mobile-to-mobile feature

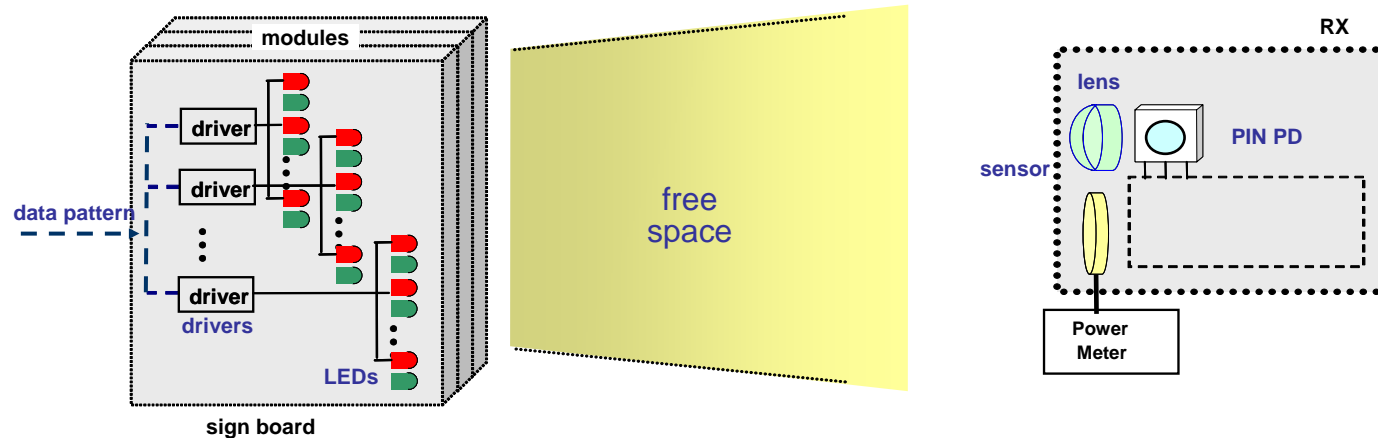
- Modulation : NRZ
- Encoding : 8B/10B
- Optical Source : LD, LED
- Wavelength : 630nm
- PD : Silicon
- Protocol :
 - Visibility support
 - Beam Guiding& Discovery
 - Alarm for Miss alignment
 - Self Restoration

Infra-to-mobile (bi-direction)

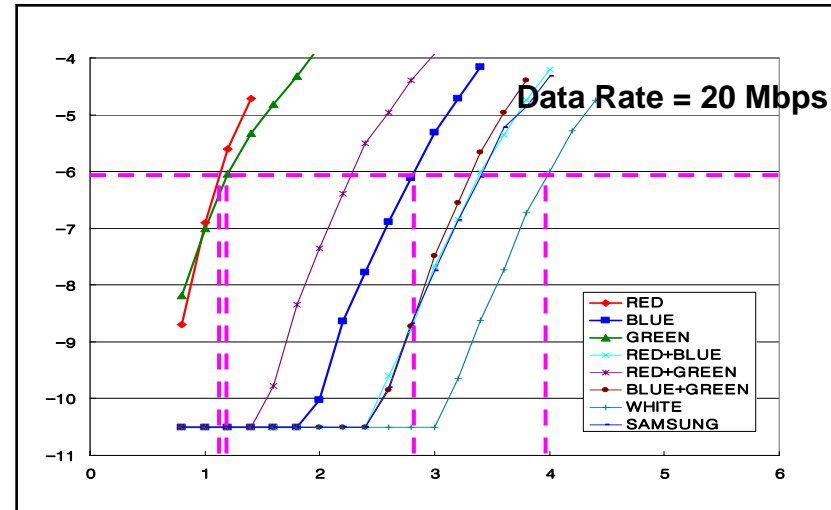
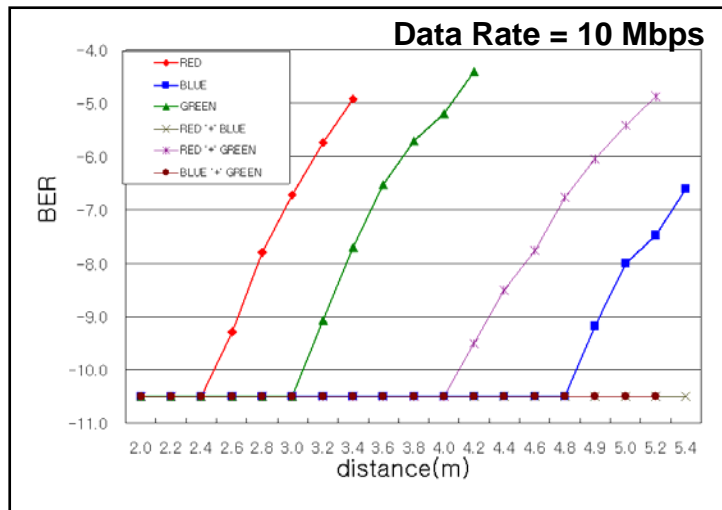
- Information broadcasting from signboard
 - Main function : Display, Indication, Text, Graphic
 - Additional function : Broadcast additional information
 - Public / commercial information
 - Unspecified individuals
- RGB WDM transmission
- 20 Mbps, 3m, Uni-direction



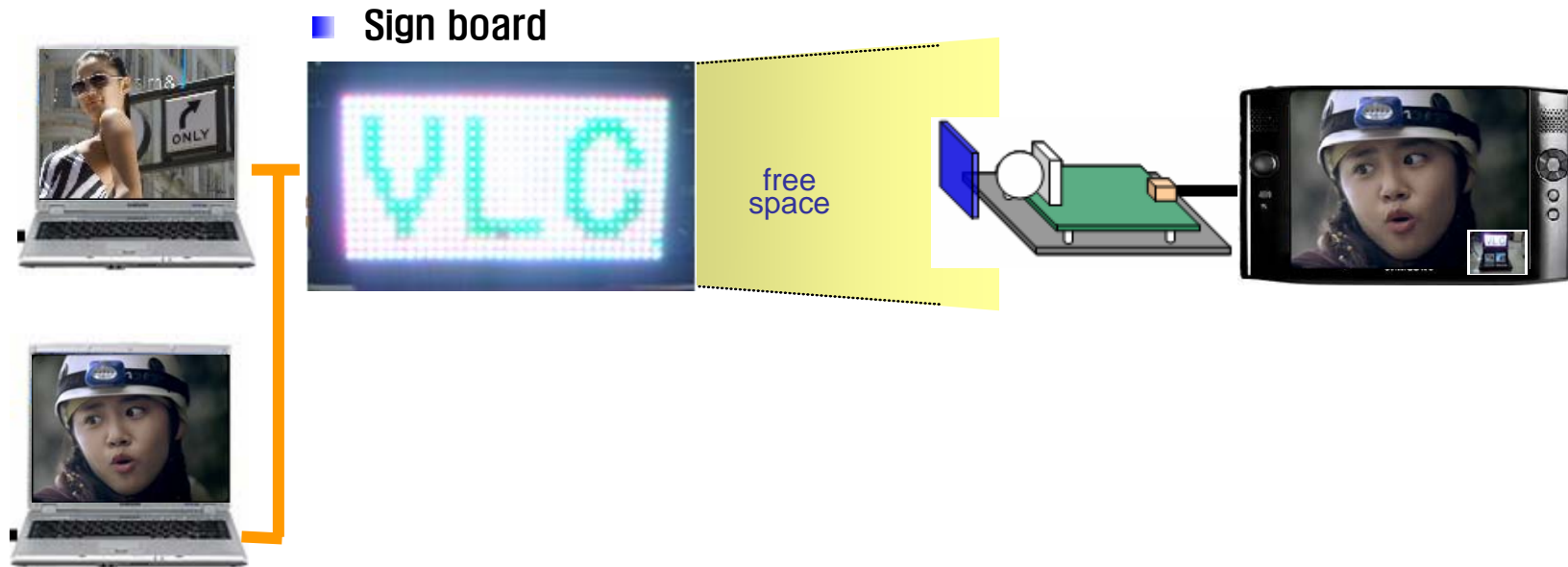
Infra-to-mobile (Link performance)



❖ Experimental setup

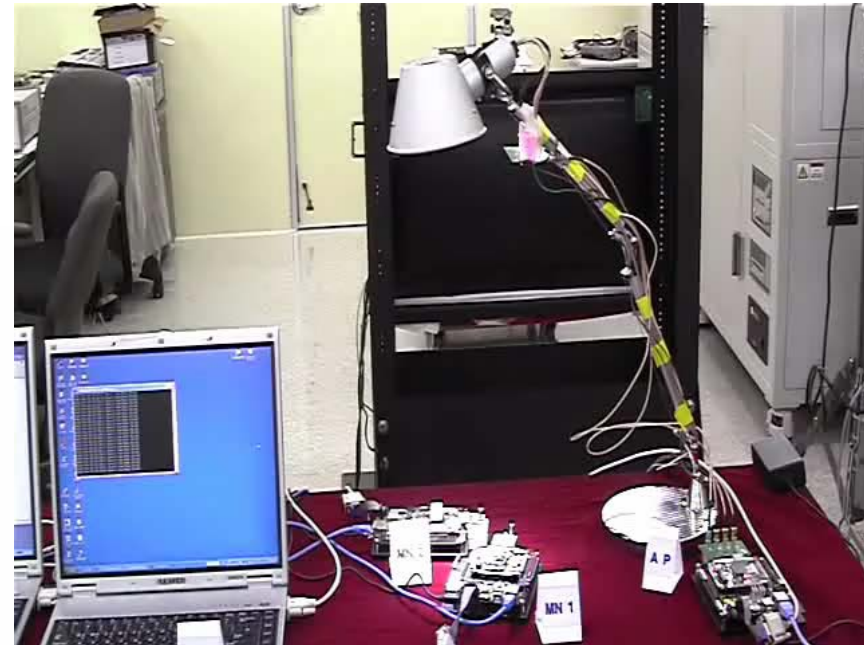
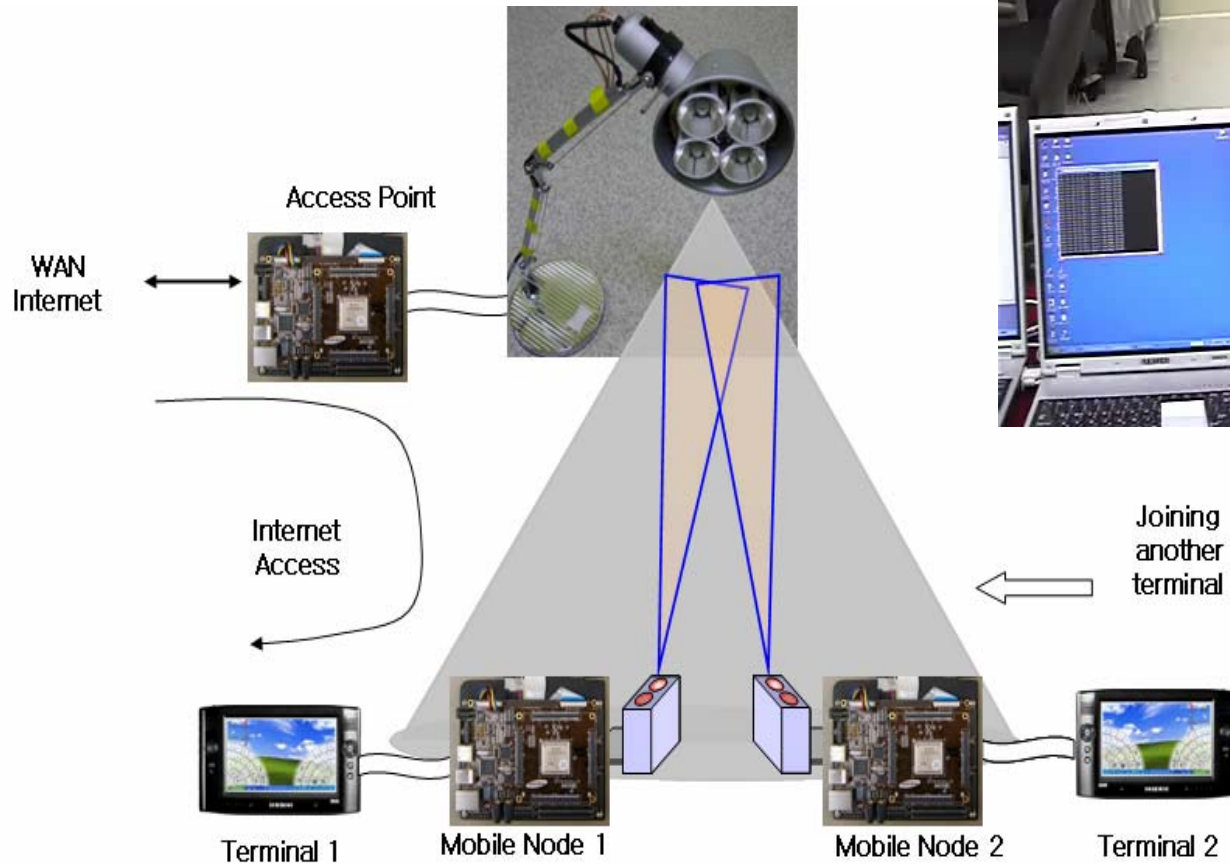


Infra-to-mobile (Uni-direction)



Infra-to-mobile (bi-direction)

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

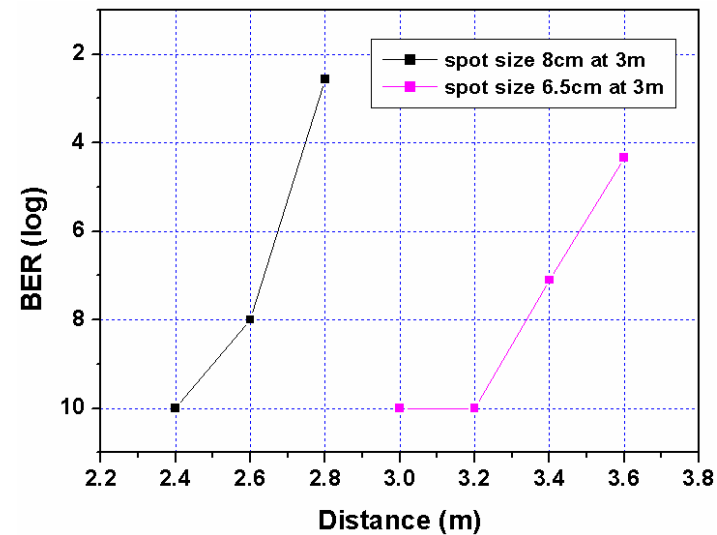
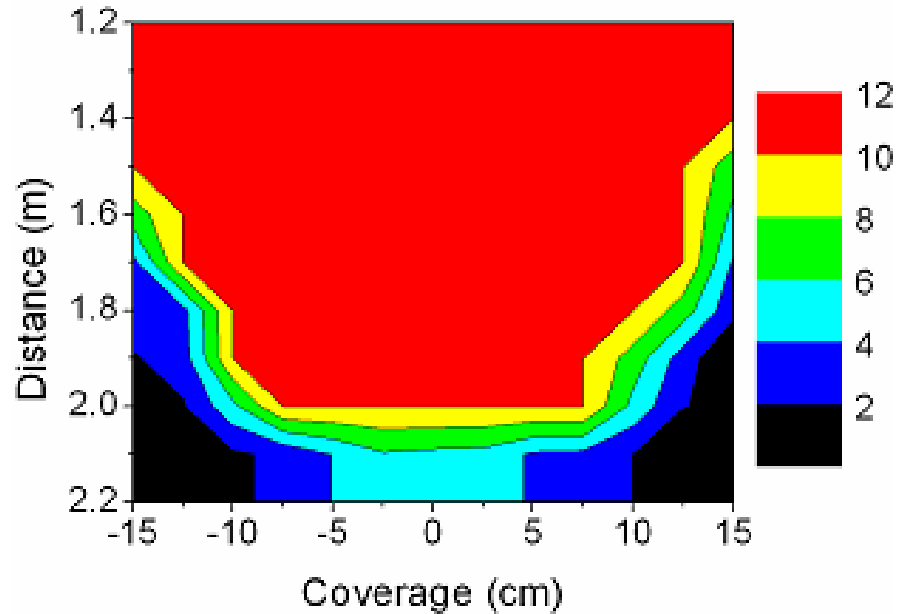


Infra-to-mobile (Link performance)

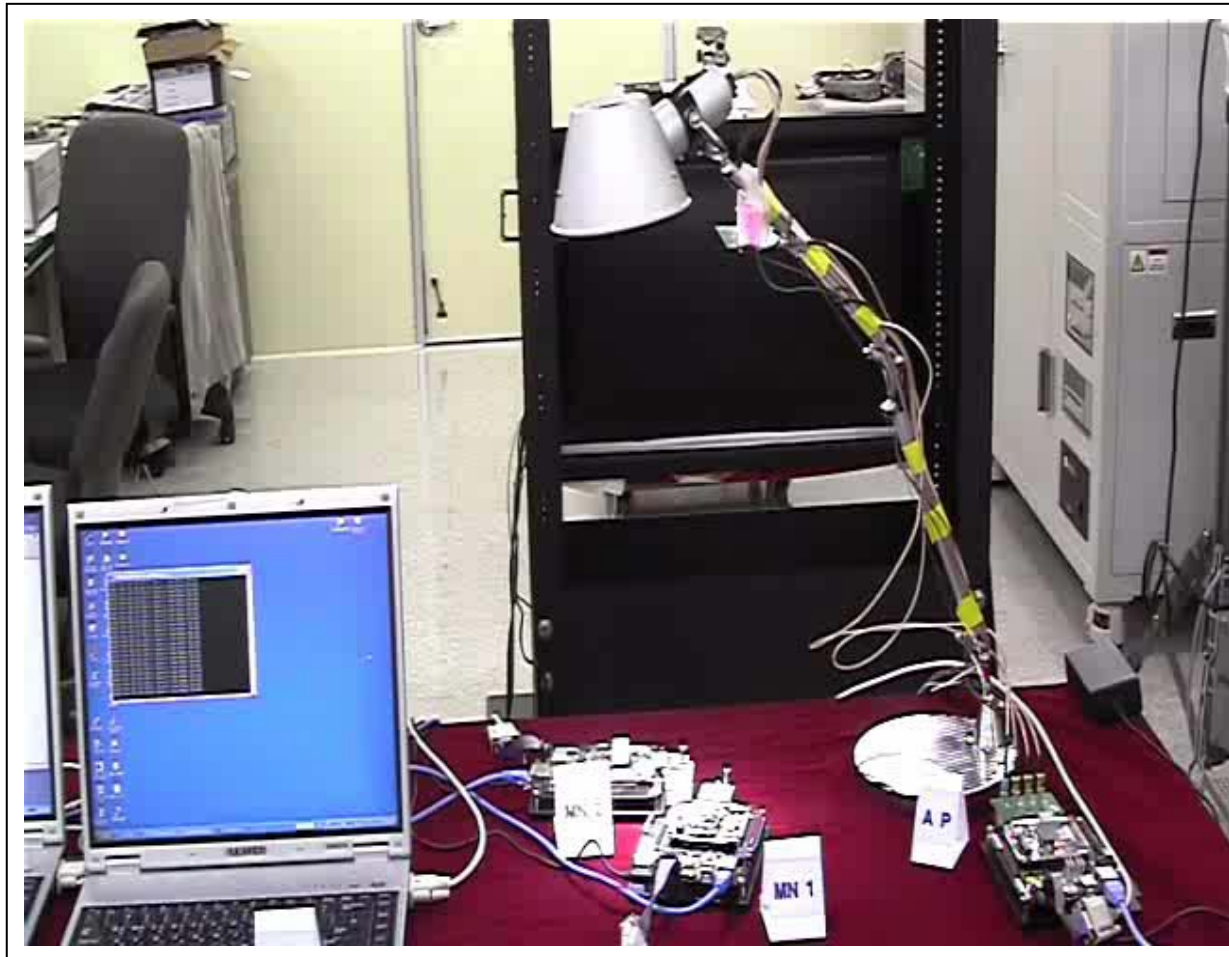
■ Downstream : White LED



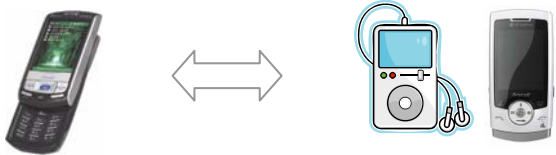
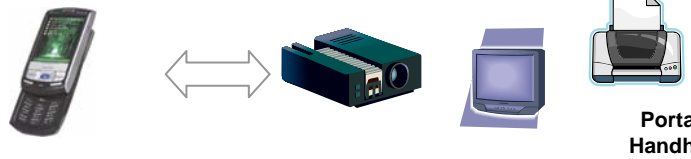
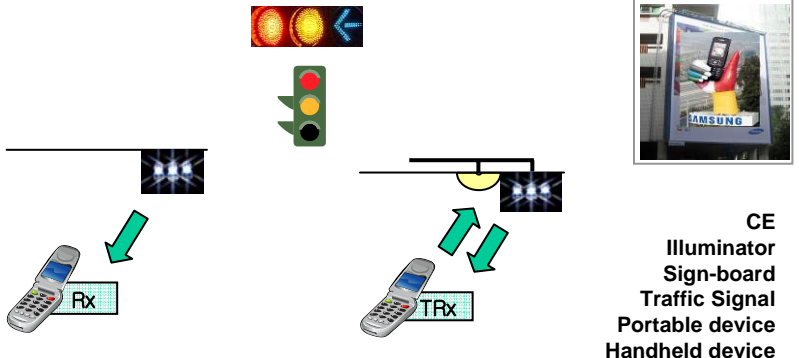

■ Upstream : LD



Infra-to-mobile (Bi-direction)



VLC Applications

	Application	
<p>Mobile to Mobile</p>	 <p>Handheld device Portable device</p>	<ul style="list-style-type: none"> • Contents-sharing • Data transfer
<p>Mobile to Fixed</p>	 <p>CE Kiosk Portable device Handheld device</p>	<ul style="list-style-type: none"> • File transfer • Video streaming • M-commerce
<p>Infra to Mobile</p>	 <p>CE Illuminator Sign-board Traffic Signal Portable device Handheld device</p>	<ul style="list-style-type: none"> • Information-broadcast • ITS • Indoor LBS • Indoor Navigation • Networked Robot 

Technical Requirement of Applications

	Link	Distance	Rate	Need to be considered	
Mobile to Mobile	Bi-direction	~50cm	~100Mbps	<ul style="list-style-type: none"> • FOV (Field of View) • Short range 	
Mobile to Fixed	Uni-direction	~1m	~100Mbps	<ul style="list-style-type: none"> • Asymmetric high speed data rate • High security • Rx diffuser 	
Infra to Mobile	Uni-direction	~3m	~10Mbps	<ul style="list-style-type: none"> • High security • Multi-path 	<ul style="list-style-type: none"> • Cell planning • Sync between light
	Bi-direction			<ul style="list-style-type: none"> • Mobility • Uplink mobility • Define / Design the light ID 	<ul style="list-style-type: none"> • Multiple access • Infra network access • Color Balancing (works as illuminator)

Summary

■ The VLC is new communication technology using “Visible Light”.

■ Motivation

- Communication community trend
- LED trend
- Environmental trend
- Intrinsic characteristic of VLC

■ Characteristic

■ Demonstrations

- Mobile-to-mobile
- Infra-to-mobile (uni-direction / bi-direction)

■ Applications

■ Technical Requirement of Applications