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

Submission Title: [Visible Light Communication (VLC) motivation, application, and issue]
Date Submitted: [11 January 2008]
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Abstract: [The overview of the visible light communication (VLC) and application scenarios in the various are presented in this document. The visibility is the key feature of this communication system. The VLC is going to be the best candidate for the various communication applications which are needed the secured-environment. The research issues, which should be discussed in the near future, also are presented.]

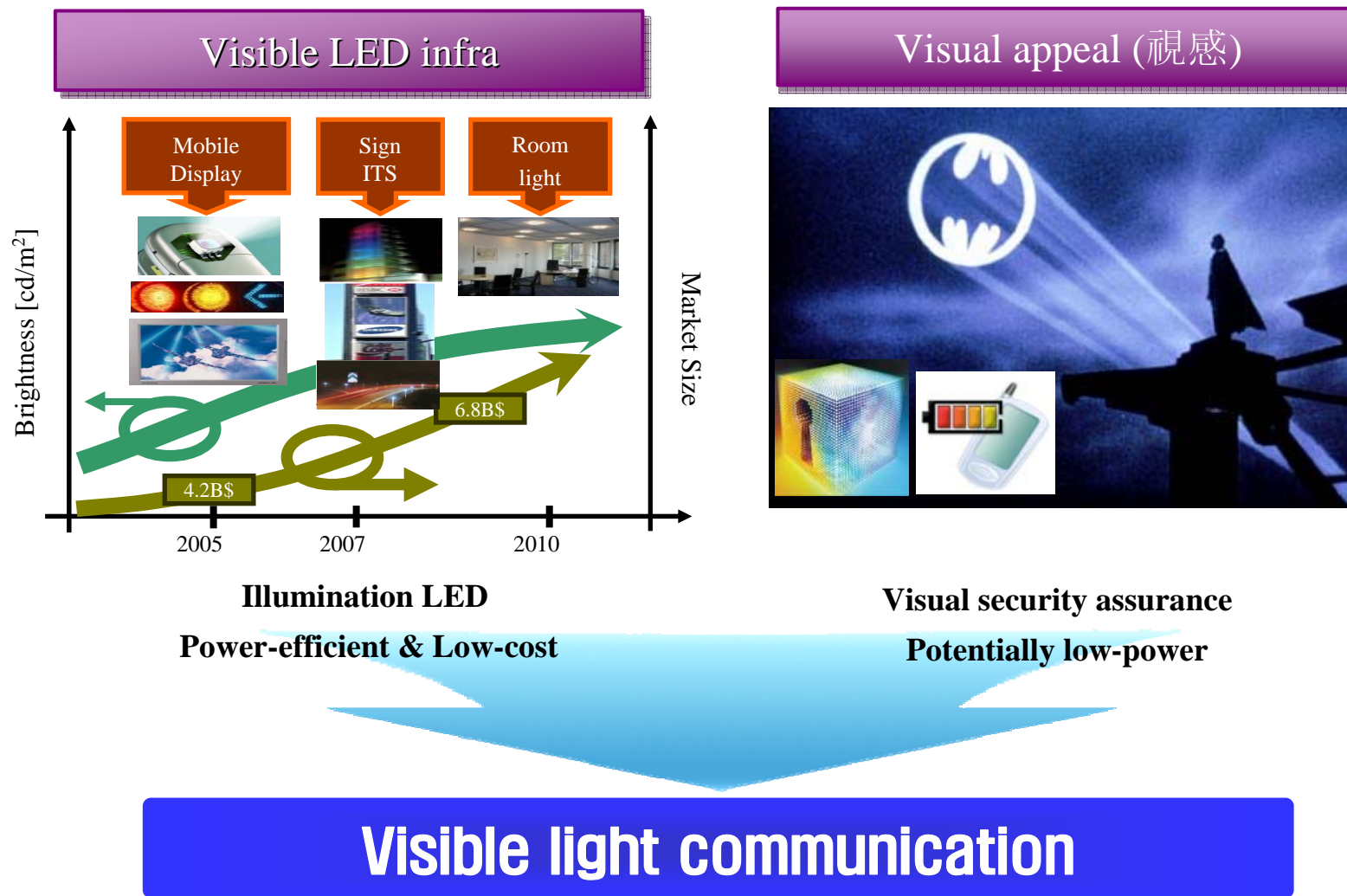**Purpose:** [Contribution to IEEE 802.15 IG-VLC]

Visible Light Communication (VLC) motivation, application and issue

2008. 1.
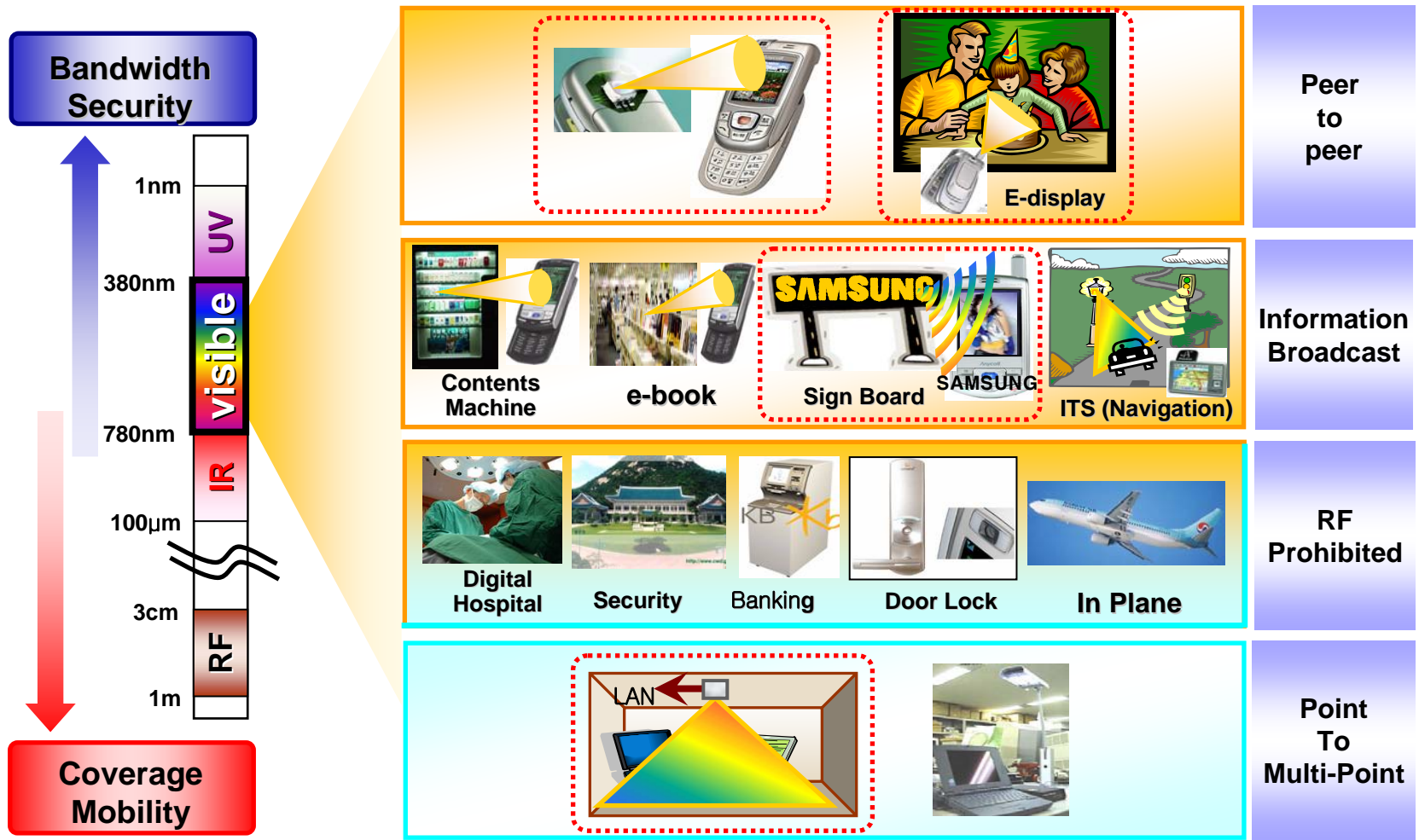## Samsung Electronics

Outline

- **VLC motivation**

- **VLC application**

  - Indoor

  - Outdoor

  - Demonstration

- **VLC research issue**

- **Summary**

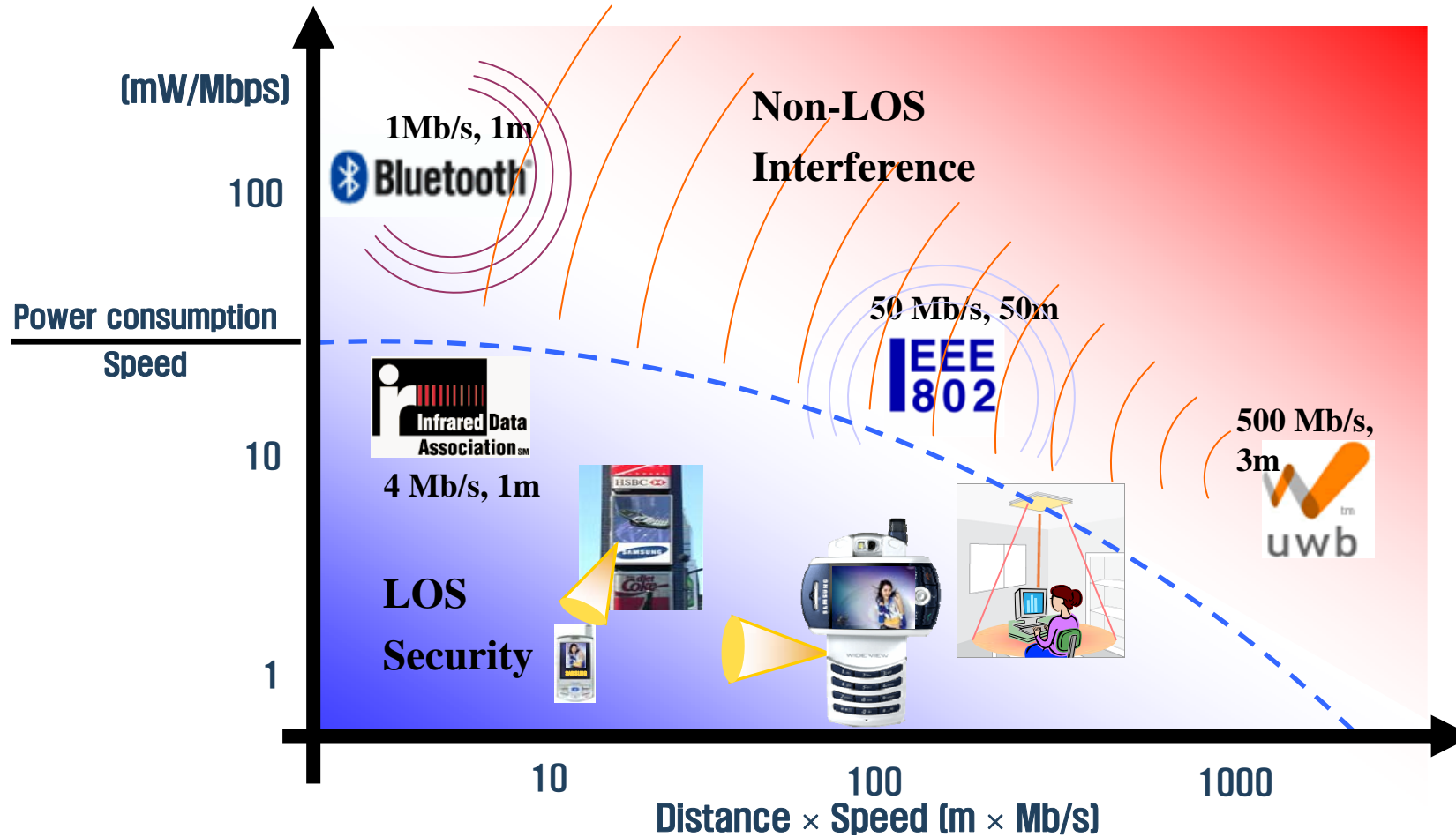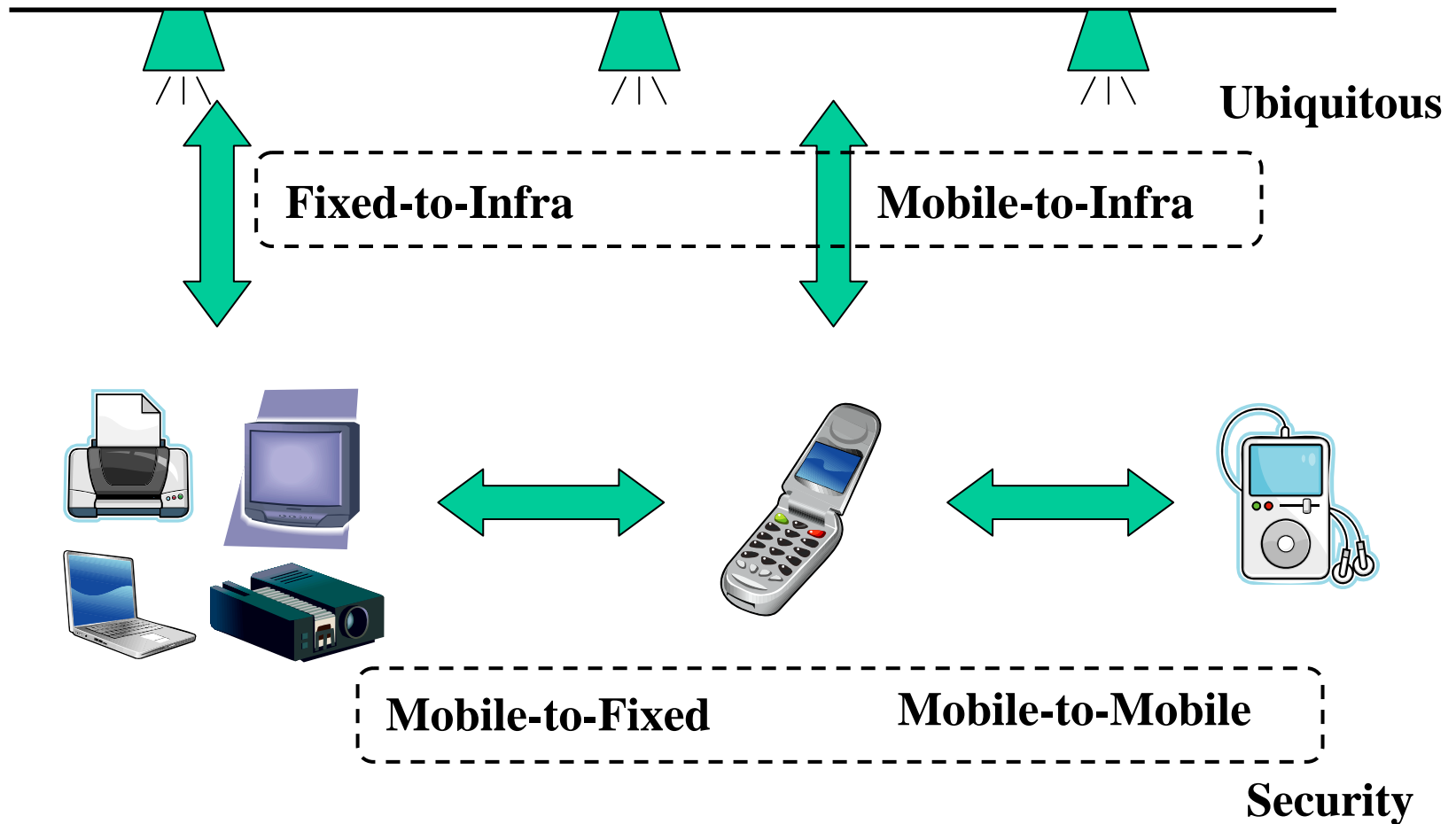- **Appendix**

  - LED modulation bandwidth

VLC motivation

Visible LED infra

Mobile Display

Sign ITS

Room light

Brightness [cd/m²]

Market Size

6.8B$

4.2B$

2005　2007　2010

Illumination LED

Power-efficient & Low-cost

Visual appeal (視感)

Visual security assurance

Potentially low-power

Visible light communication

VLC Application

Bandwidth
Security

1nm

uv

380nm

visible

780nm

IR

100μm

3cm

RF

1m

Coverage
Mobility

E-display

**Peer
to
peer**

Contents
Machine

e-book

Sign Board

SAMSUNG

ITS (Navigation)

**Information
Broadcast**

Digital
Hospital

Security

Banking

KB

Door Lock

In Plane

**RF
Prohibited**

LAN

**Point
To
Multi-Point**

VLC Positioning

(mW/Mbps)

Power consumption / **Speed**

1Mb/s, 1m

Non-LOS Interference

50 Mb/s, 50m

500 Mb/s, 3m

4 Mb/s, 1m

LOS Security

100

10

1

10

100

1000

Distance × Speed (m × Mb/s)

Directivity + Simplicity ⟶ Optical connectivity saves power

Indoor Application

LED Illumination Infrastructure

Ubiquitous

Fixed-to-Infra   **Mobile-to-Infra**

Mobile-to-Fixed   **Mobile-to-Mobile**

Security

Requirement (Indoor Application)

	Mobile to Mobile	Mobile to Fixed	Mobile to Infra	Fixed to Infra
Link	Bi-direction	Bi-direction	Bi or Uni direction	Bi or Uni direction
Distance	~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

Outdoor advertising

Traffic control Infrastructure

Vehicle-to-Infra

Vehicle-to-Vehicle
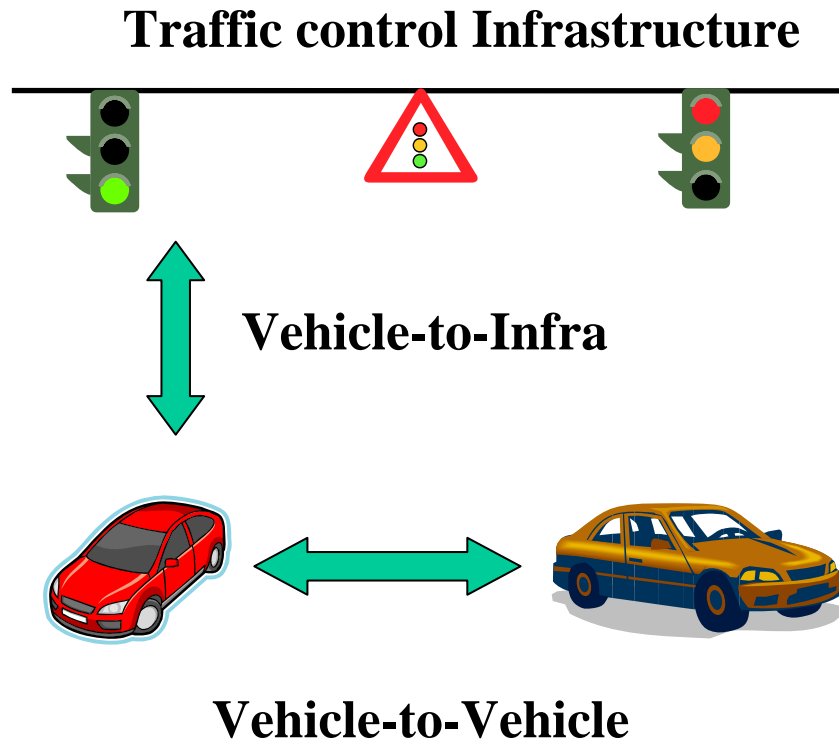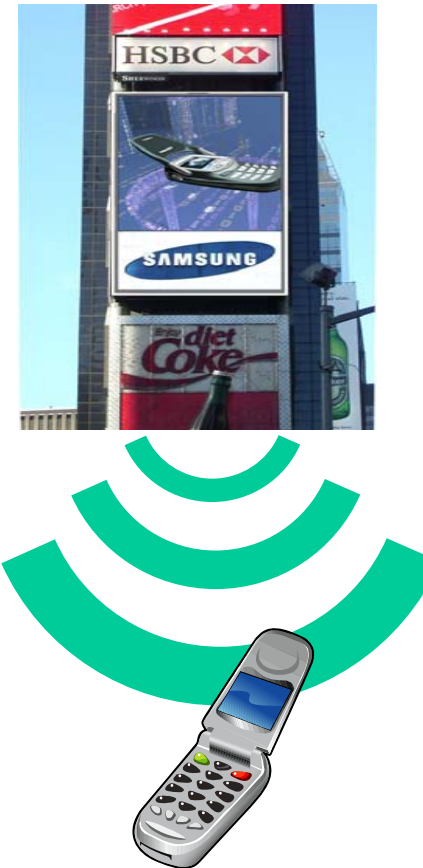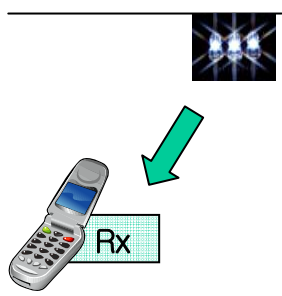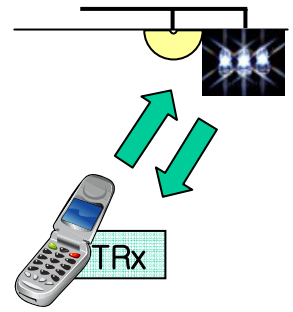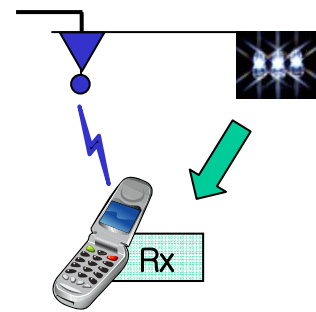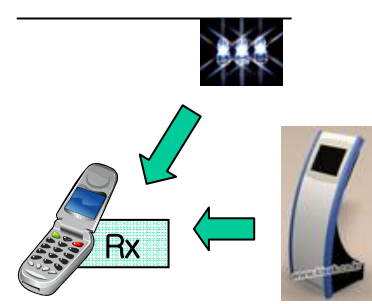
VLC Application Evolution

LED penetration

**Mobile Display**

**Sign
ITS**

Illumination

100Mbps
Indoor

10Mbps
Outdoor

10Mbps
Indoor
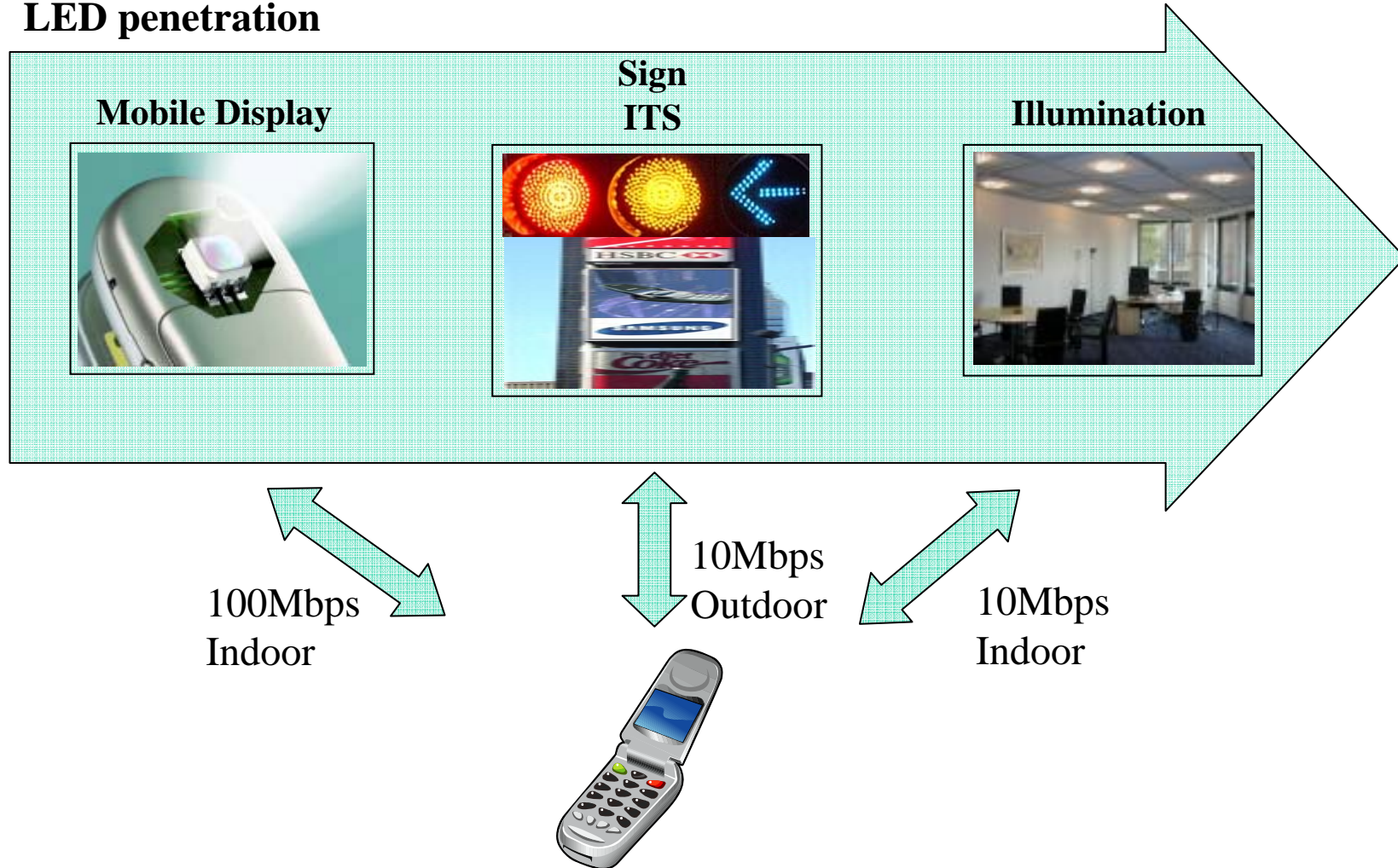
Indoor Navigation Scheme

|	Uni-direction	Bi-direction	Hybrid	Hot spot
Link				
Rate	• Down : ~10kbps	• Down : ~10Mbps • Up : ~100Mbps	• Down : ~10kbps • Up : ~10Mbps	• Down (light) : ~10kbps • Down (HS) : ~100Mbps
Infra	• Lighting with optical ID	• Lighting with optical ID • Receiver • In-building network • Routing server	• Lighting with optical ID • RF access point • In-building network • Routing server	• Lighting with optical ID • Hot spot
Mobile	• Receiver • Large storage • Map info • Routing software	• Receiver • Transmitter	• Receiver • RF connectivity	• Receiver • Large storage • Routing software
Other service		LBS Ad-hoc connection	LBS	

High-Speed High-Security Connectivity

What You See Is What You Send (WYSIWYS)
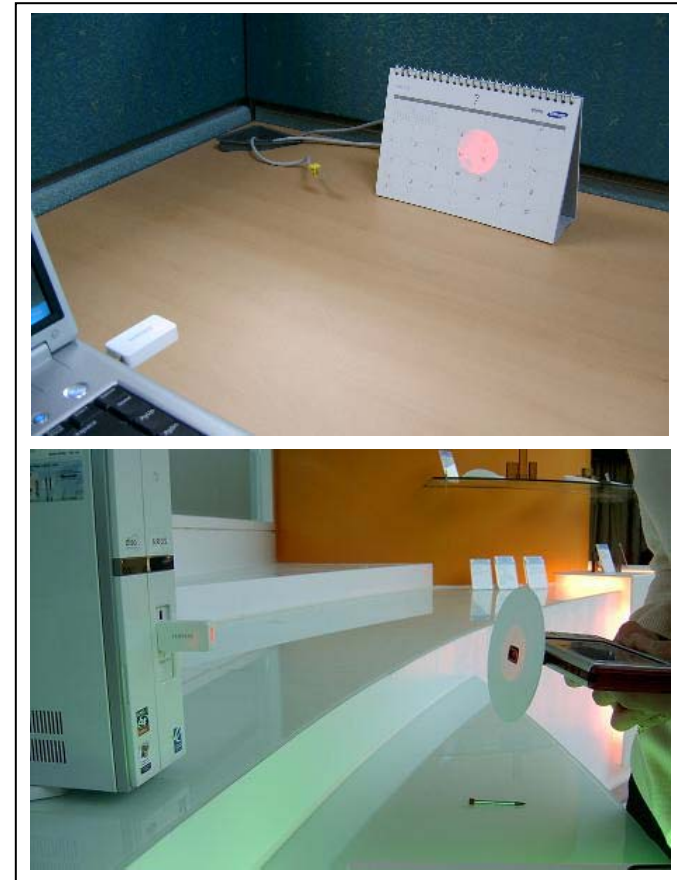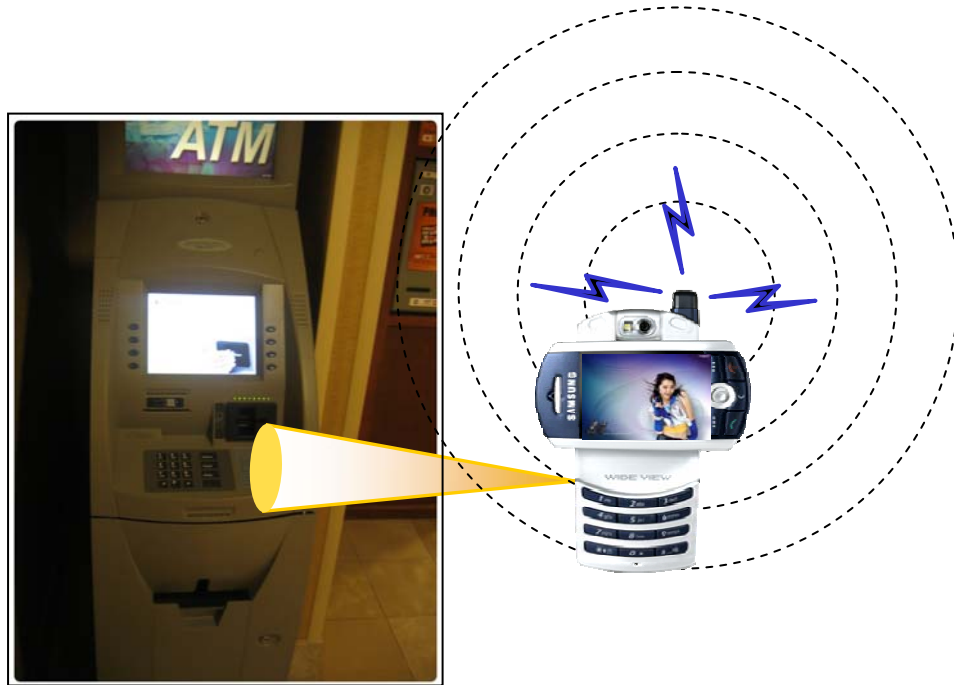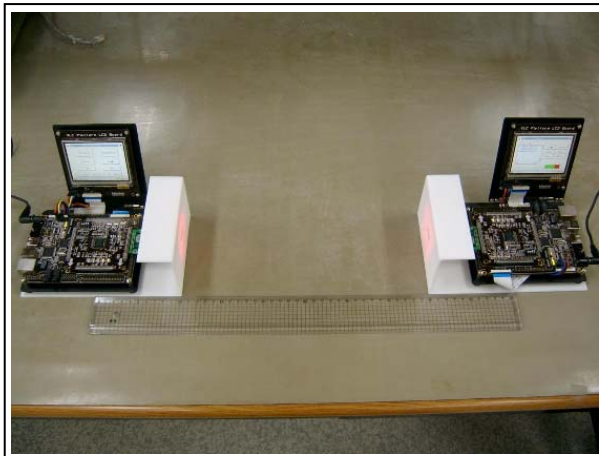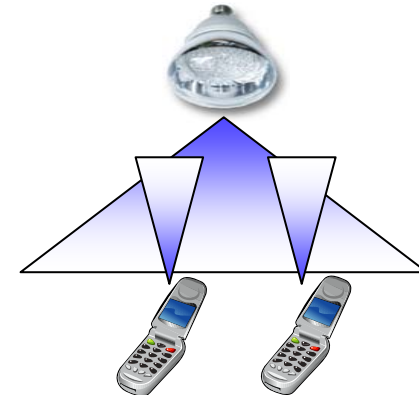
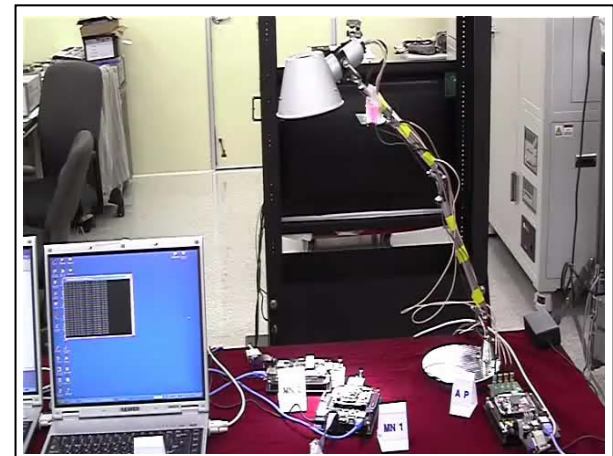# VLC Demonstration
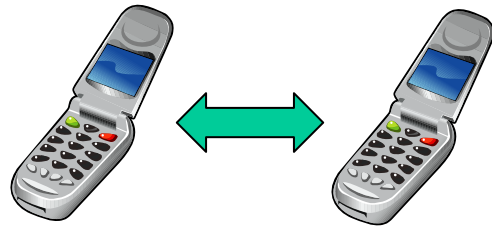
Mobile to Mobile
Mobile to Infra
Mobile to Infra

100 Mb/s, 1m
Bi-direction

20 Mb/s, 3m
Uni-direction
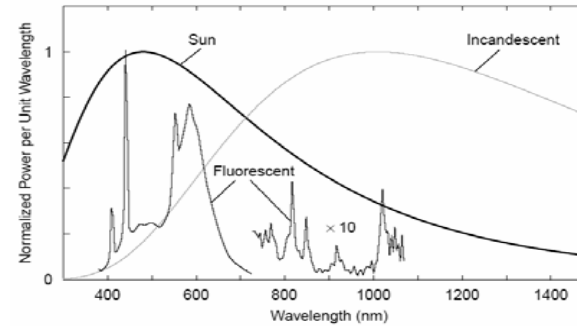
4 Mb/s, 3m
Bi-direction

VLC Research Issue
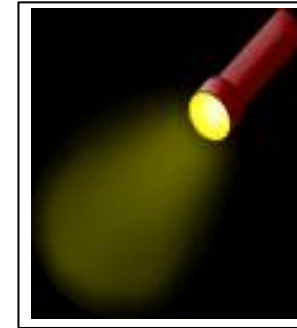
Visible TRx
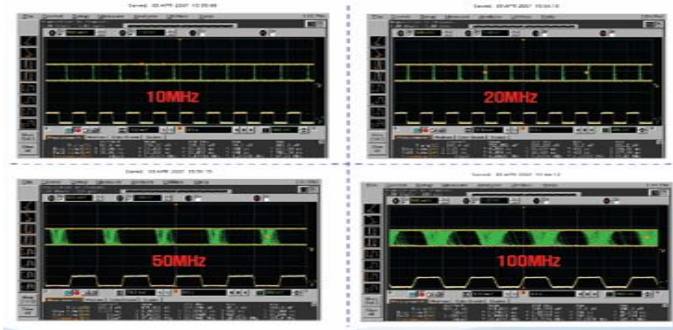
LED modulation bandwidth limit (KOPTI)

Visible band

Ambient light

Protocol for visibility

• **Collection Efficiency**

• **Field of View**

PD

Optical antenna
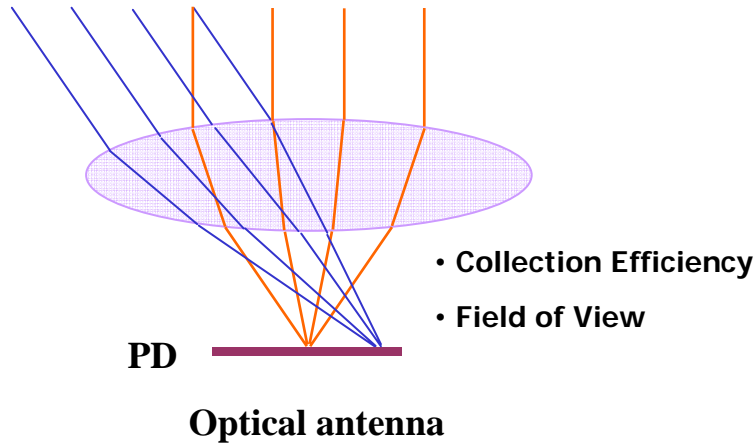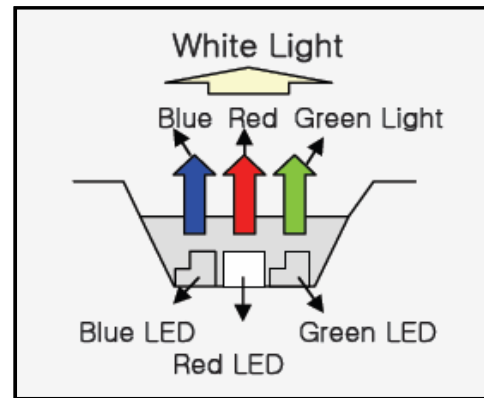
Summary

- **VLC motivation**
  - Prevailing LED infra
  - Visual appeal, security

- **VLC application**
  - Indoor: Navigation, High-speed connectivity
  - Outdoor: Intelligent Transportation system (ITS), Advertising
  - Demonstration

- **VLC research issue**
  - LED modulation bandwidth
  - High-gain optical antenna
  - Ambient light
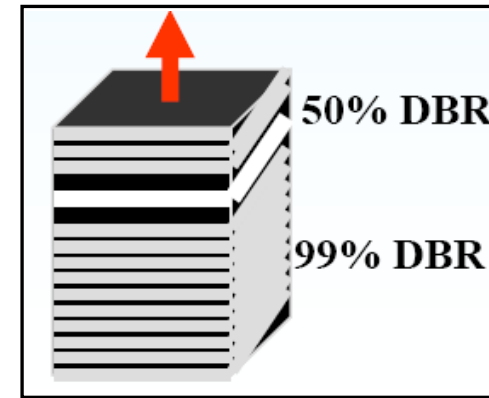 - Protocol to support visibility

Appendix : LED Modulation Bandwidth
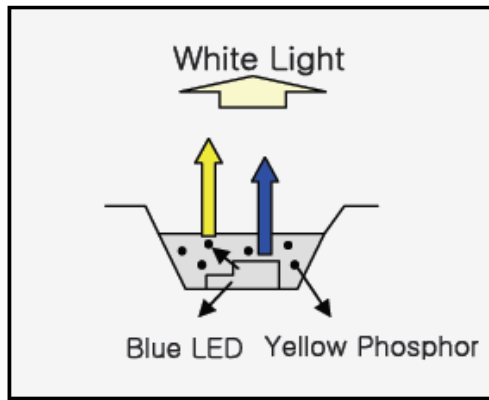
B + Phosphor LED

~40 Mbps

R+G+B LED

~100 Mbps

RCLED

~500 Mbps