Fraunhofer PORTUGAL

2011

An Emerging Visible Light Communication System for Driver Assistance

Navin Kumar

Institute of Telecommunication

University of Aveiro

© Fraunhofer Portugal 2010

kumar@ua.pt

An Emerging Visible Light Communication (VLC) System for Driver Assistance

- Introduction
- LEDs lighting and VLC
- VLC in ITS
- Technical and Implementation Issues
- Prototype VLC Information Broadcast System
- Experiments and Results
- Conclusions and Future Research

© Fraunhofer Portugal 2010

Fraunhofer PORTUGAL

VIsible Light Communication for Advanced Driver Assistance Systems (VIDAS)

Introduction and Background

- VLC is an emerging and novel Optical Wireless communication system which uses visible spectrum (approx. 390nm-750nm) emitted from light emitting diodes (LEDs).
- VLC is becoming an alternative choice for next-generation wireless access technology by offering:
  - Cheap and unregulated bandwidth, and
  - Ubiquitous infrastructures support.
- A wide range of applications, both indoor as well as outdoor:
  - simple large size file transfers
  - road safety traffic information transmission in Intelligent Transportation Systems (ITS) to assist drivers while driving on road (Fig.1).
- VLC Systems offer many distinctive features:
  - Lighting/signaling and Communication simultaneously
  - And novel applications: minimize road accidents and casualities.

© Fraunhofer Portugal 2010

Fraunhofer PORTUGAL

ITS Application Scenario

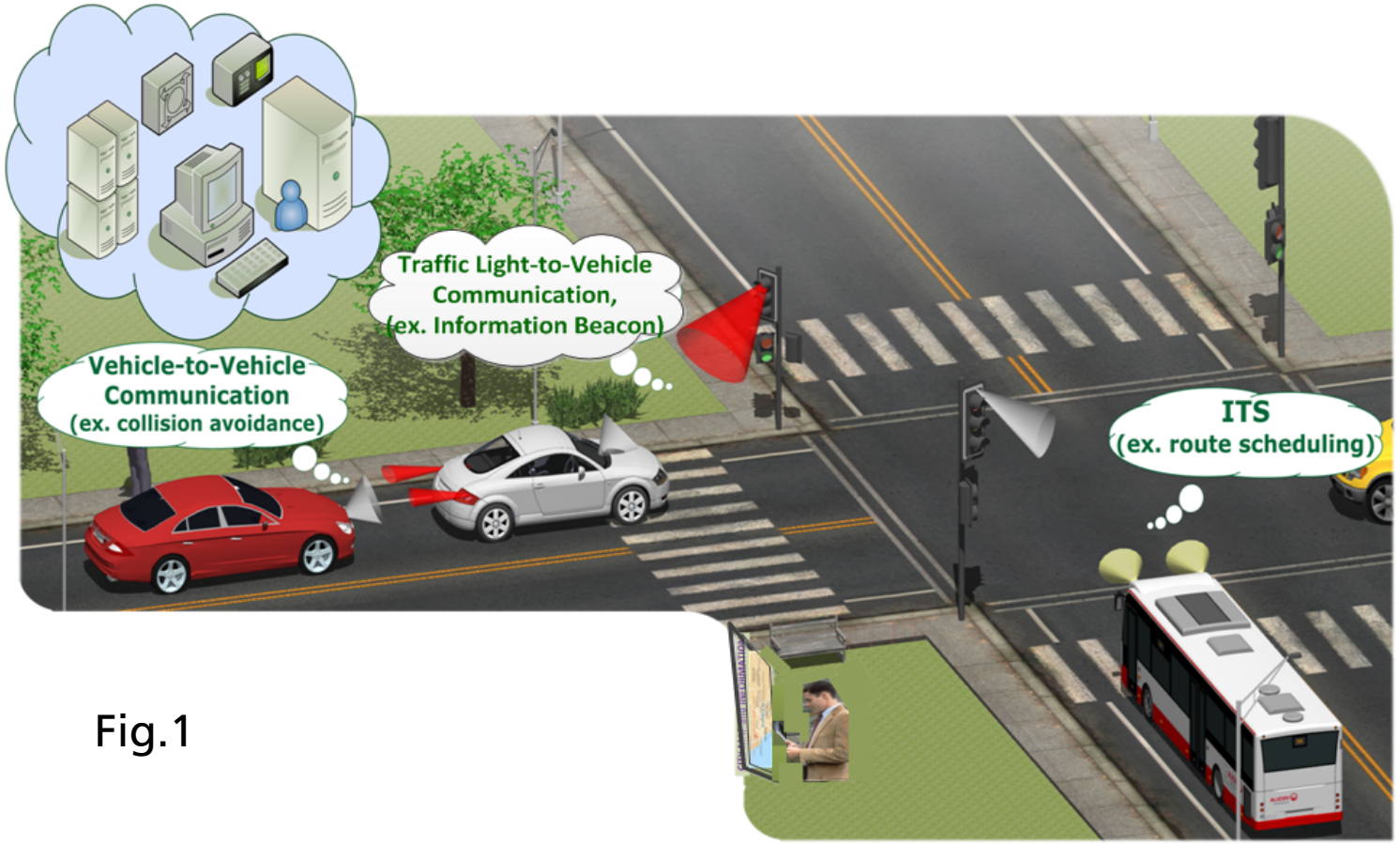


Fig.1

© Fraunhofer Portugal 2010

Fraunhofer PORTUGAL

LED and VLC

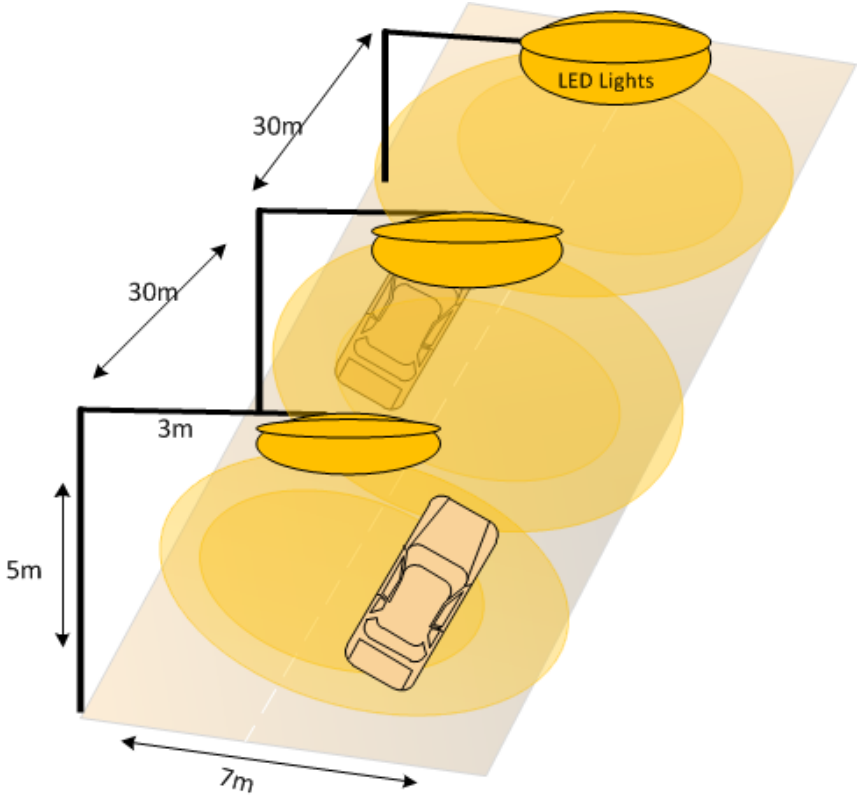
- LEDs, projected as next generation of lighting systems; enjoy
  - High efficiency (70-80% of energy saving), ▲ Better Visibility
  - Low maintenance cost ▲ Long life (>100,000 hrs) ▲ Illumination in desired direction
- VLC technology uses inherent switching characteristics of LEDs without affecting its primary use of lighting/signaling.
- Wide spread of existing infrastructures, such as
  - Traffic lights, automobile's head and brake lights: VLC transmitter , while
  - Low cost photo detector (already in place on automobile) : as VLC receiver.
- In future, street/road lights based on LED can offer:
  - Ubiquitous and seamless communication connectivity (ubiquitous road-to-vehicle communication (URVC)) (Fig.2) throughout travel.
- Therefore, a low cost VLC system can be implemented in ITS which is directly involved in *human and material safety*.

© Fraunhofer Portugal 2010

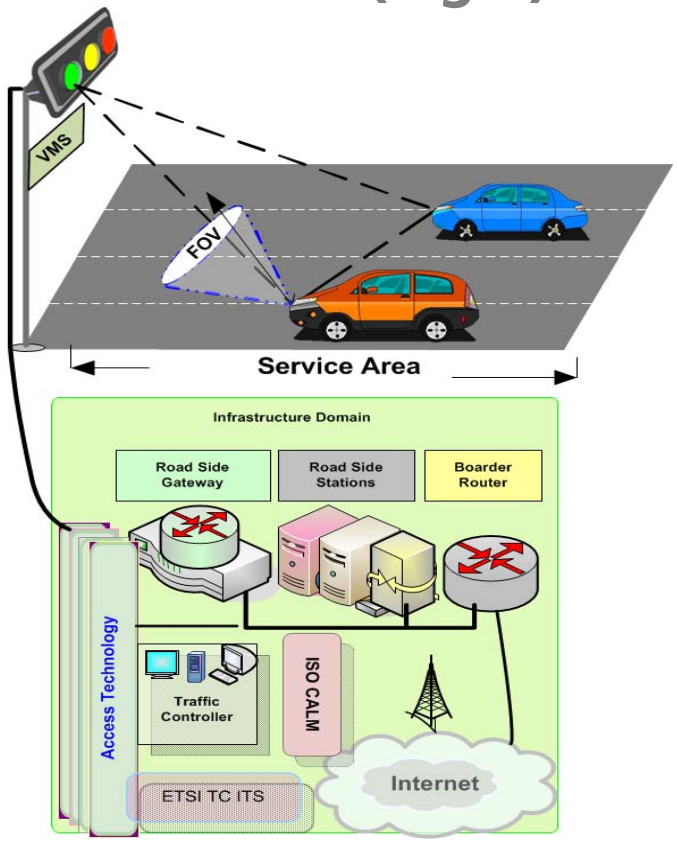
Fraunhofer PORTUGAL

VLC in ITS

Ubiquitous Road-to-Vehicle Communication (Fig.2)



VLC Integrated into ITS (Fig.3)



© Fraunhofer Portugal 2010

Fraunhofer PORTUGAL

VLC in ITS ....

Issues and Actions

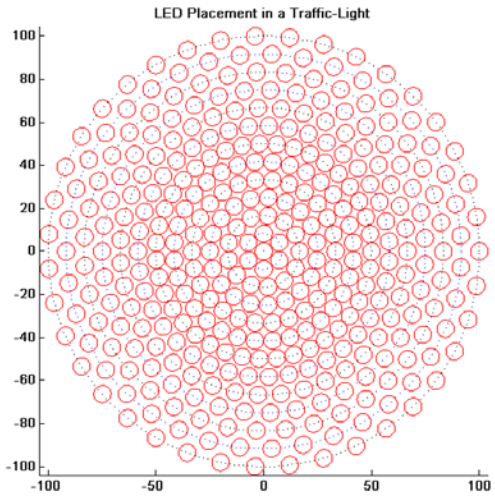
- Moreover, ITS is engineering science, involves many technologies.
- VLC can be an integral part of ITS (Fig.3)
  - Mostly because of existing infrastructures
  - VLC in ITS leads a Green growth (uses eco-friendly IT green technology)
  - Reduction in Radio system leads to reduced energy in turns reduced carbon emissions
  - Releases burden on Costly and Highly Congested Radio Frequency
- However, there are some technical issues and challenges in implementing VLC in ITS.
- 1) In ITS applications, VLC requires line-of-sight (LoS) link, limiting communication range.
- To increase the range, we can:
  - Optimize illumination,
  - Optimize placement of luminaries, such as traffic lights (Fig.4),
  - Use relaying techniques (vehicle-to-vehicle, using brake lights)

© Fraunhofer Portugal 2010

Issues and Actions

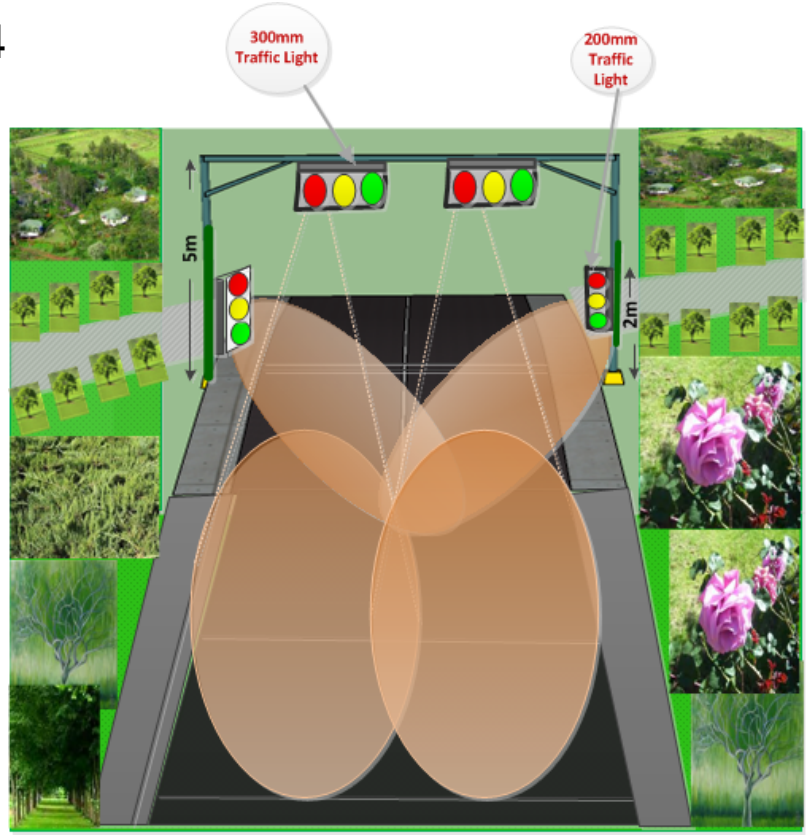
Optimized Placement of Luminaries (Traffic Lights)

Placement Strategy



Designed Traffic Light

Fig.4



Traffic Light Arrangement

© Fraunhofer Portugal 2010

Fraunhofer PORTUGAL

VLC in ITS

Issues and Actions ....

- 2) VLC system in ITS is largely affected by natural and artificial lights (noise and interference) such as Sun light, ambient lights, road/street lights etc.
- Effect of such noise and interference can be minimized using:
  - Optical filter
  - Infrared filter
  - Robust modulation techniques
- We have developed and implemented Direct Sequence Spread Spectrum (DSSS) Sequence Inverse Keying (SIK) modulation technique which is found to be very effective against such interference.
- However, use of DSSS limits the data trasmission rate. But in traffic broadcast system high data rate is not an important issue.

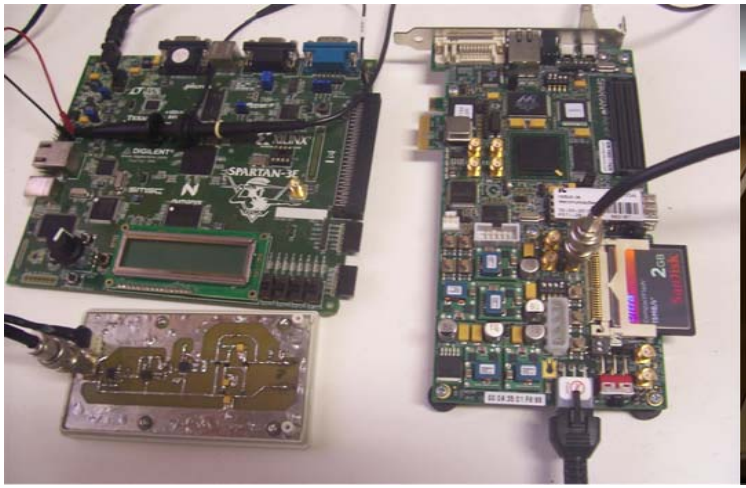
© Fraunhofer Portugal 2010

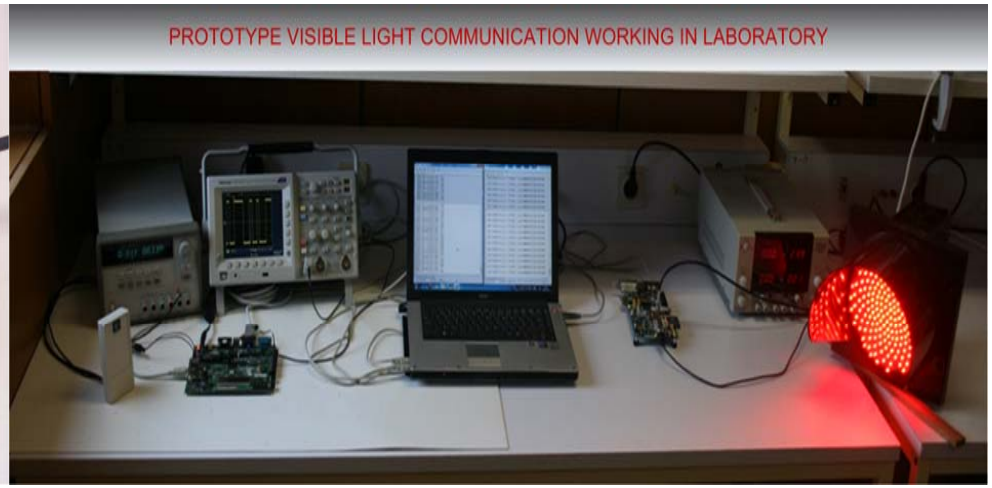
Prototype VLC Information Broadcast System

Prototype Hardware Assembly and Working in Laboratory Setting

- A low cost prototype VLC traffic broadcast system is hardware designed and implemented using optoelectronics and field programmable gate arrays (FPGA) (Fig.5).

OPTOELECTRONICS & FPGA





© Fraunhofer Portugal 2010

Fraunhofer PORTUGAL

Experiments and Results

Experiment Scenarios

Night on Road with Road Light

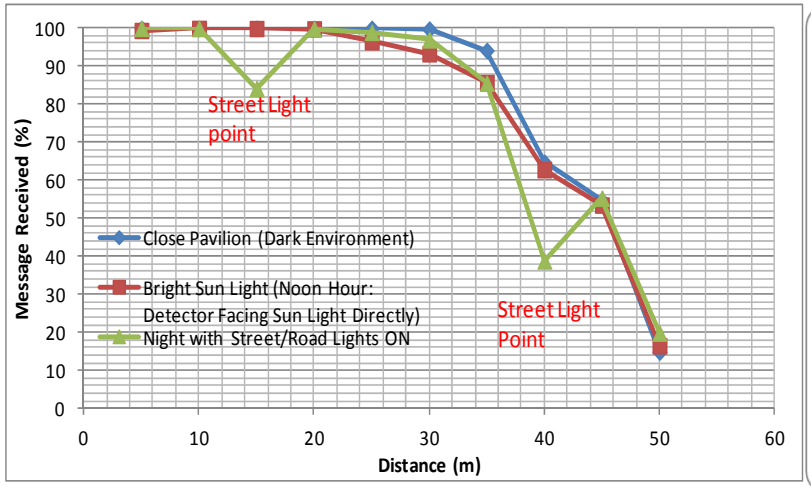
Day Time Under Bright Sun Light

© Fraunhofer Portugal 2010

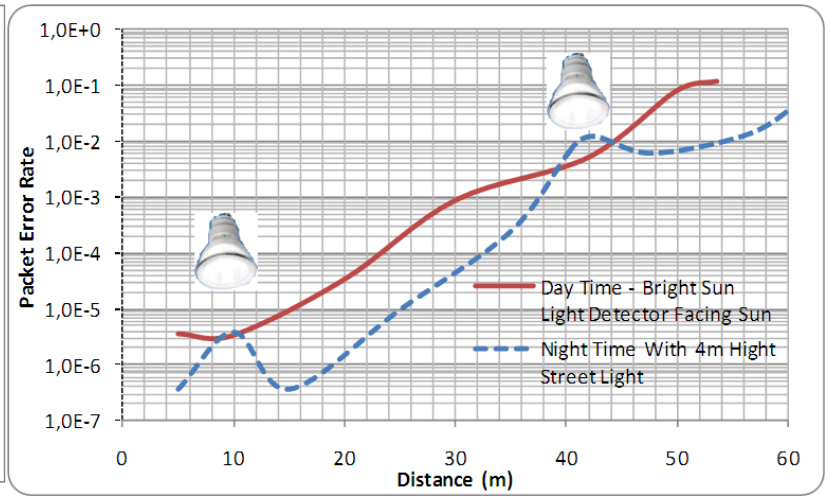
Fraunhofer PORTUGAL

Experimental Results

RECEIVED MESSAGES



PACKET ERROR RATE



© Fraunhofer Portugal 2010

Fraunhofer PORTUGAL

An EXAMPLE: VLC FOR TRAFFIC INFORMATION BROADCAST

Click on non-text part of Blue area for video clip

© Fraunhofer Portugal 2010

Fraunhofer PORTUGAL

Conclusion and Future Works

- Omni Present, Unlicensed and Unregulated Visible Spectrum based technology can very well supplement congested radio frequency based systems for novel applications in ITS.
- Supported by existing infrastructures, a low cost VLC can find wide range of applications, both outdoor and indoor offering ubiquitous and seamless connectivity.
- Our experimental results from prototype VLC guarantees data communication from infrastructure-to-vehicle, broadcasting many safety related information, hence suitable for road safety applications.
- The technology is in early stage and more research is needed to explore bi-directional link, high data rate transmission etc.

© Fraunhofer Portugal 2010

Thank You !!!

Questions ?

© Fraunhofer Portugal 2010

Fraunhofer PORTUGAL