Research Paper Presentation

Shashank Shanbhag

CS20BTECH11061

Title

Machine to Machine Based on Visible Light Communication for IoTs.

Authors

- Rodrique Chi Fon
- Alain R. Ndjiongue
- Khmaies Ouahada

  All of them are Professors in Dept. of Electrical and Electronic Engineering Science, University of Johannesburg, South Africa.

Pre-requisites

- Heterogeneous network
- Visible light communication (VLC)
- Machine-to-machine (M2M) VLC
- Modulation
- Internet of Things (IoTs)
- Signal Noise Ratio (SNR)
- On-Off Keying (OOK)
- Additive white Gaussian noise (AWGN)
- Bit Error Rate (BER)
- Line Of Sight(LoS)
- Handover

Heterogeneous network

Heterogeneous network means wireless network.

Visible light communication (VLC)

VLC is a data communication variant which uses visible light for data transmission, providing both lighting and high speed wireless access. It is a subset of optical wireless communication (**OWC**) technologies.

Machine-to-machine (M2M) VLC

M2M VLC is a communication architecture that makes it possible for heterogeneous devices to interact without human intervention using visible light modulated at certain frequency to enable communication.

Modulation

Modulation means the process of changing the amplitude or frequency of an electric signal by mixing it with another signal.

IoTs

IoTs describes the network of physical objects (things) that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices over internet.

Signal Noise Ratio (SNR)

SNR ratio means the ratio of power of signal to power of background noise.

OOK

OOK denotes the simplest form of converting digital data as variations in amplitude of a carrier wave to detect presence or absence of carrier wave. Ex: 1 for transmitting carrier wave and 0 for not transmitting.

AWGN

Additive white Gaussian noise (AWGN) is a tool used to mimic random processes in nature.

BER

BER is number of bit errors per unit time.

LoS

LoS is a type of propagation that can transmit and receive data only where transmit and receive stations are in view of each other without any obstacle between them.

Handover

Handover is a process in which cellular transmission (voice or data) is transferred from one base station (cell site) to another without losing connectivity to the cellular transmission.

Some Images to illustrate definitions

Figure 1: IoTs

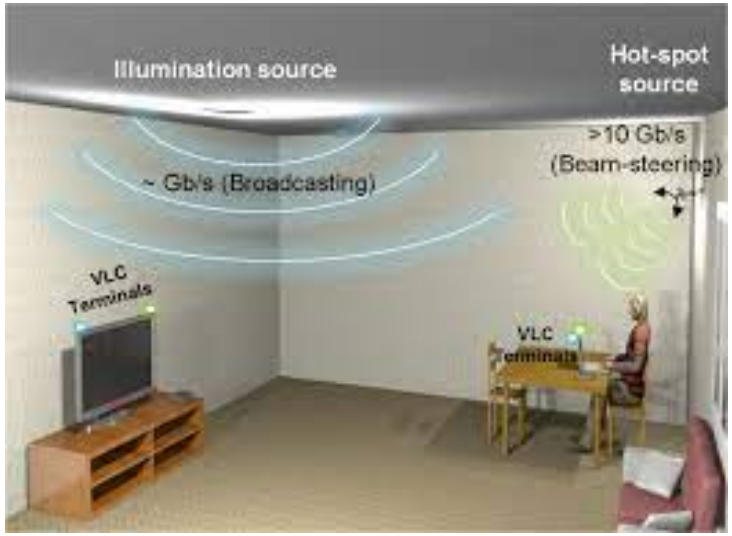

Figure 2: VLC

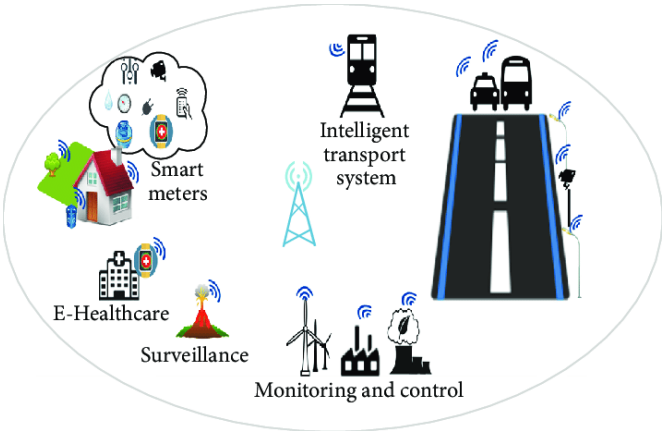

Figure 3: M2M

Why new technology?

The exponential increase in the number of devices that require internet services due to (M2M) and (IoTs). We now use **Radio frequency (RF)** wireless technologies like Wi-fi, Bluetooth with limitations of frequency spectrum, power usage and high rate of energy consumption.

Expectations

Better connectivity, High SNR, High data speed.

Solution

The paper proposes VLC. Here we use LED's to provide a light signal which is modulated at high speed to carry information, in addition to it lower power consumption. Also it has advantages like wide spectrum as well as readily available spectrum, less interference and harmless to humans. It can completely replace RF.

Applications

- Smart home
- Smart office
- Remote monitoring
- Vehicle-to-Vehicle communication(V2V)
- Digital signage
- Wireless sensor network

All the applications of IoTs are targeted mainly.

Figure 4: Smart Home

Figure 5: V2V

How does M2M VLC based system work?

- As VLC is a part of OWC, so it has all the properties of OWC. VLC is consisted of three main parts, transmitter, channel and receiver and often characterized by additive white Gaussian noise (AWGN).
- To facilitate M2M communications with VLC, machine-type-communication devices must be connected to VLC access points.
- VLC's short range transmission can be tackled by cascading with backbone networks such as laser, power line communication, fiber optics.
- The channel is the space from the transmitter antenna (LEDs) to the receiver antenna (PD)
- The channel could be characterized as single or multiple channels. Single channels are such that only one LED and one PD are utilized. Multiple channels are when there exist multi-colored LEDs

How does M2M VLC based system work?

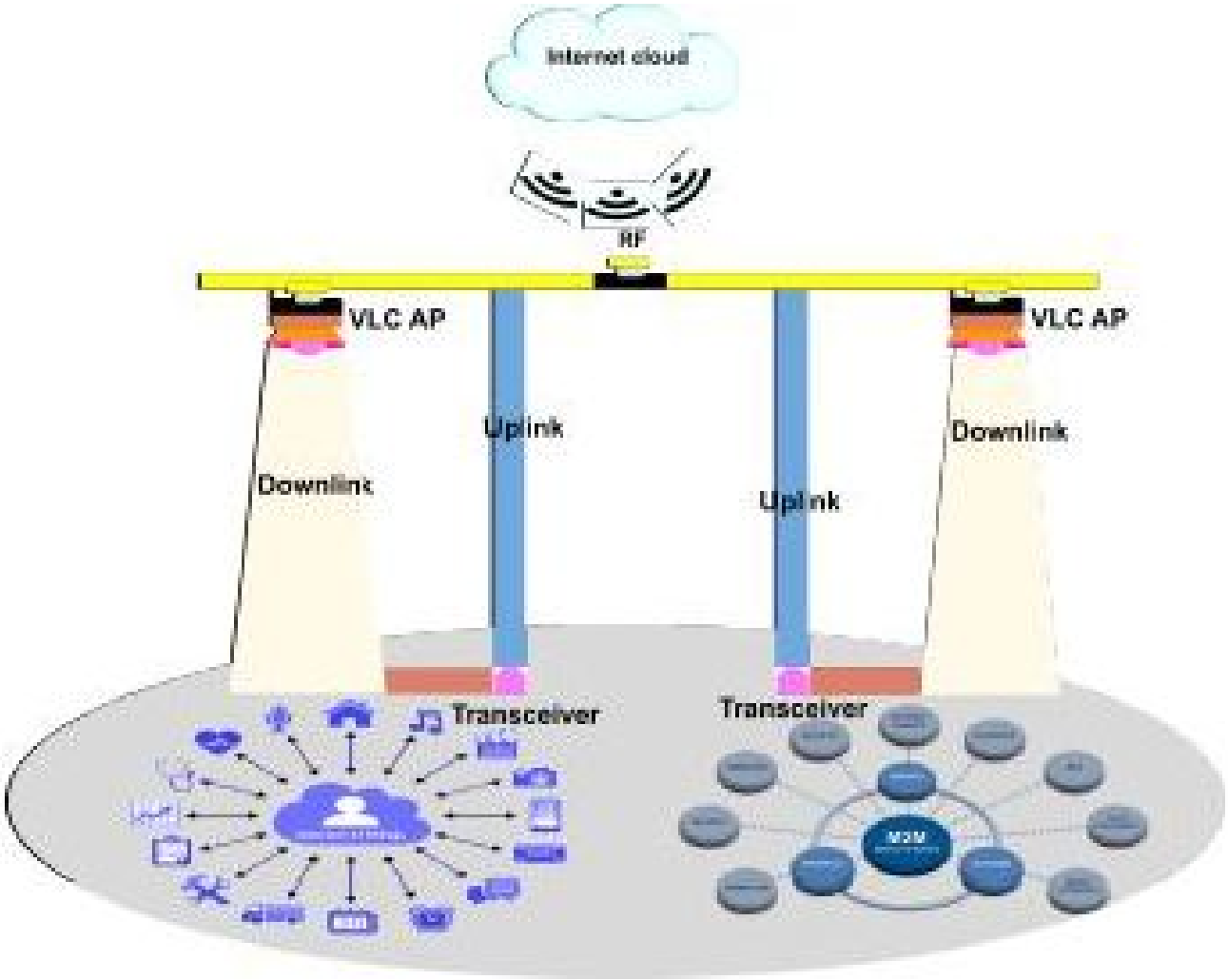

Figure 6: A multi-channel VLC access system based on an indoor scenario.

How does M2M VLC based system work?

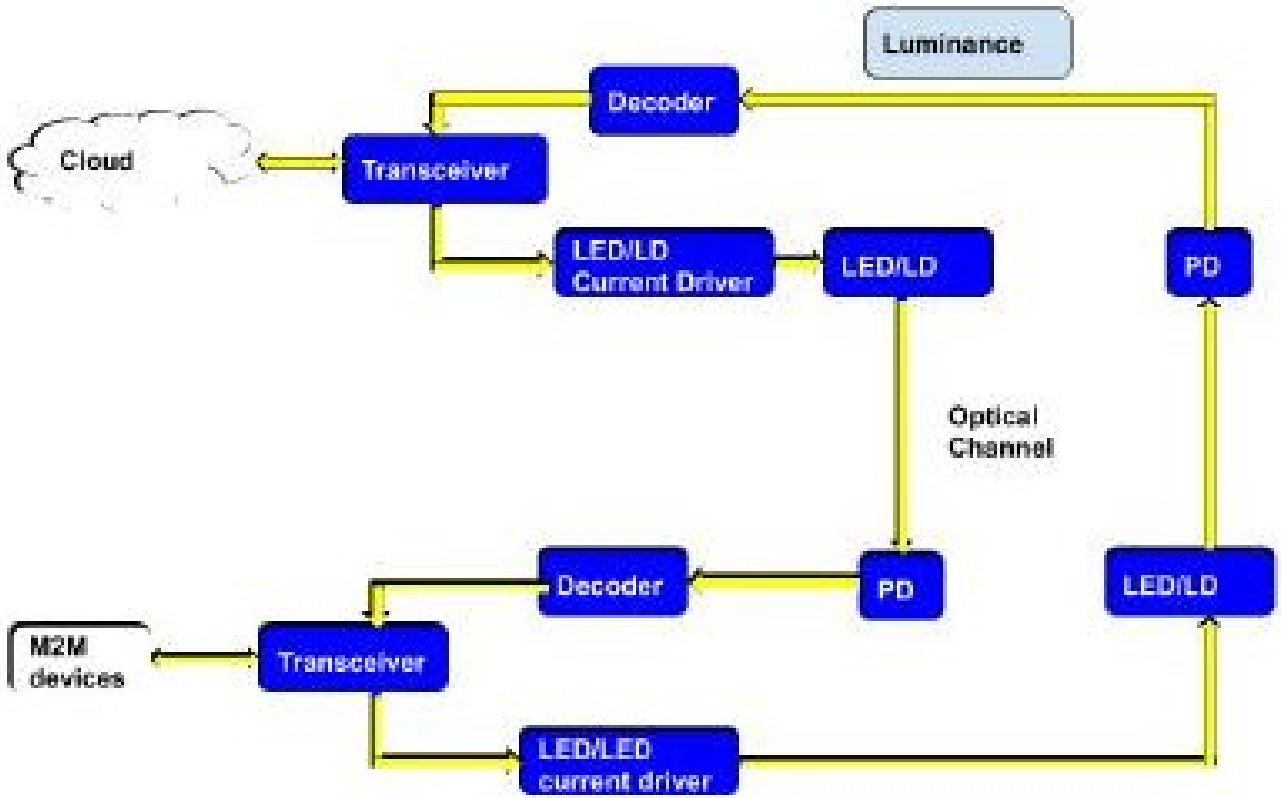

Figure 7: A block diagram for M2M VLC based channel model for indoor and outdoor scenario

VLC for Outdoor environment

- We propose our analysis based on an amplify forward (AF) strategy, where no processing of data is involved, in case of re-transmission.
- The light signals are detected and directly converted to a corresponding current and to the power of the LEDs or LDs.
- Considering that sunlight is principal source light, we model the system with a Gaussian normal distribution.

$$S_0 = H_0 S + N_0 \tag{1}$$

where S is the original message, S_0 is the message at the LD receiver and N_0, AWGN.

- For outdoor environment such as vehicle-to-vehicle communication, , only LoS is considered. This is because the power due to the NLoS is negligible when compared with the power from LoS part.

- The outdoor part is a single mode Gaussian beam stochastic-channel governed by

$$H_{LoS(o)} = \frac{2A_l e^{-\gamma L}}{\pi \theta^2 L^2} \tag{2}$$

where A_l is the effective laser receiver area, θ is the small angle beam divergence, L is the transmission range and γ is the intensity of the attenuation coefficient.

VLC for indoor channel

- In an indoor environment, such as office, smart homes, both line-of-sight (LoS) and non-line-of-sight (NLoS) are considered.
- The indoor channel assumes the additive white Gaussian response while taking into consideration the non-line-of-sight (NLoS)

$$S_i = H_i S + N_i \tag{3}$$

where S is the original message, S_i is the message at the LED receiver and N_i AWGN.

- The transfer function of the M2M VLC based indoor system is the summation of the LoS and NLoS links, which is a complicated mathematical expression.

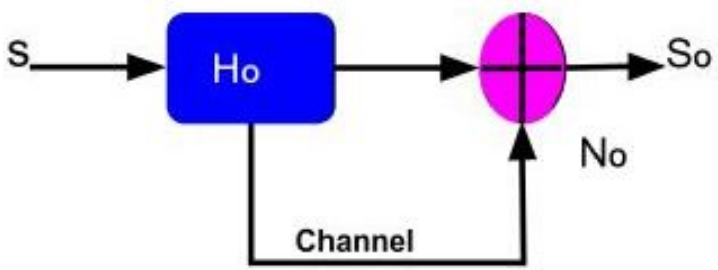

Figure 8: Simplified channel modeled of LD systems in an outdoor environment

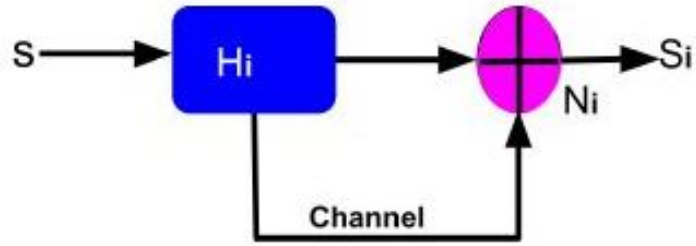

Figure 9: Simplified channel modeled of LED systems in an indoor environment

Simulation results

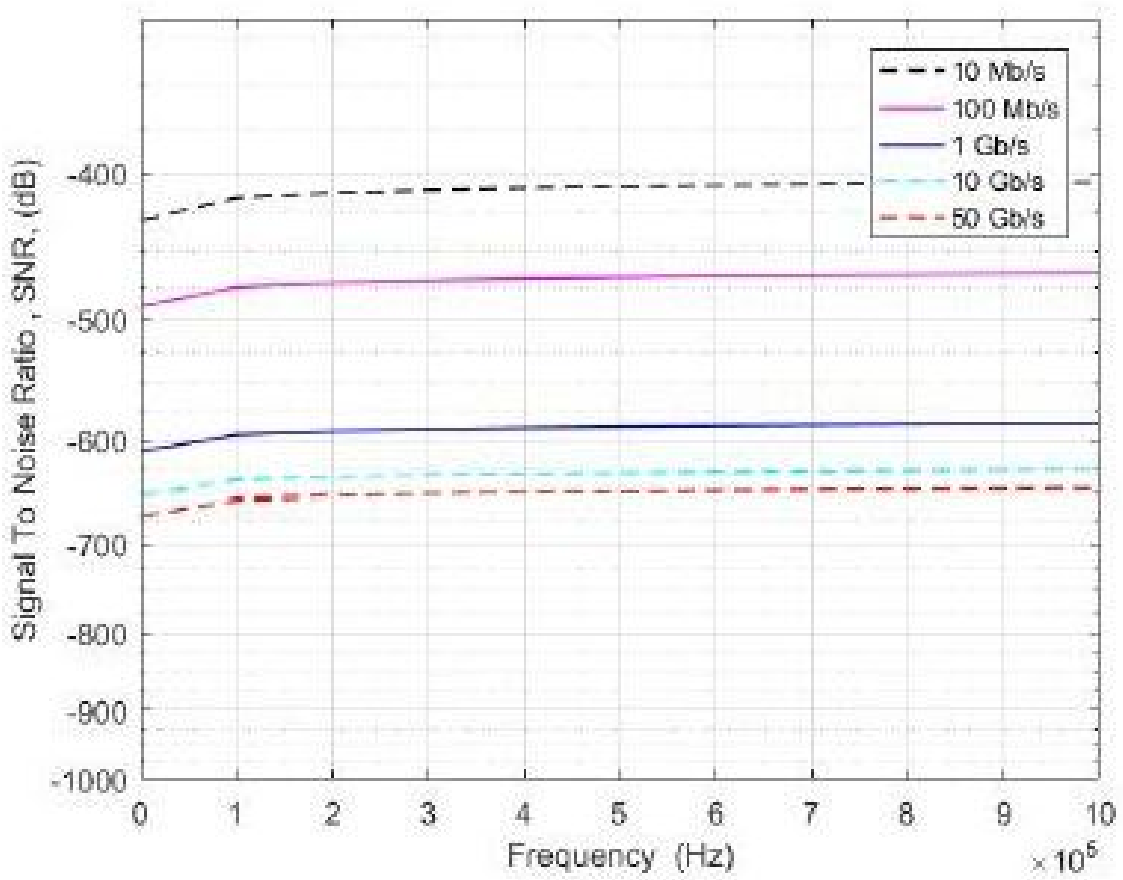

Figure 10: Average received SNR for multiple values of the bit rate B of the channel against frequency.

Simulation results

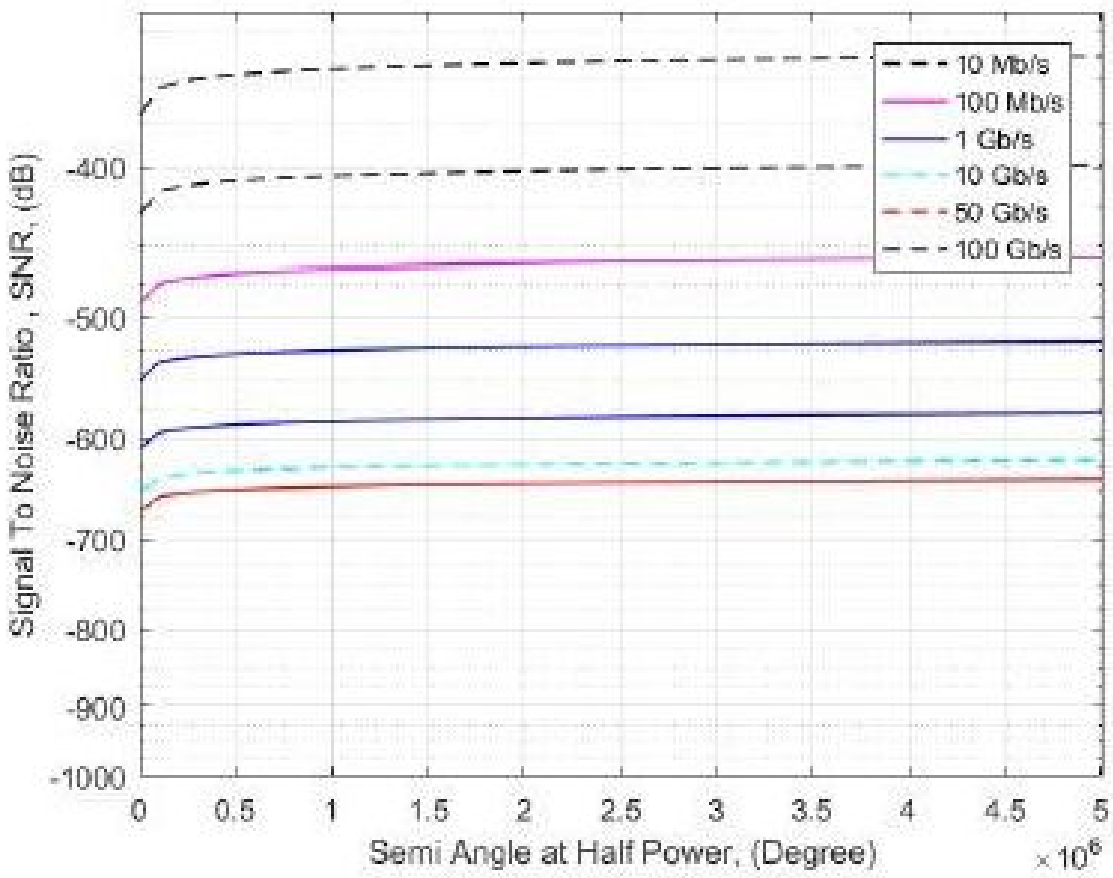

Figure 11: Average received SNR for multiple values of the bit rate B of the channel against semi angle at half power.

Simulation parameters

Parameters	Value
Reflection coefficient	0.8
Transmitted power per LED	10W
Semi-angle at half power	10^{o}, 70^{o}
Height of receiver level	0.5 m
FOV	40
Refractive index	1.5
Gain of optical filter	1
Responsivity of PD, (R)	0.54
Bandwidth factor (I_2)	0.562
Bit rate, B	30 Mb/s
Absolute Temperature, (T_k)	298 K
Fixed capacitor per unit area, (ζ)	$112pF/cm^2$
Detected physical area, (A_r)	1 cm^2
FET channel noise factor, (Γ)	1.5
FET transconductance, (g_m)	30 mS
Bandwidth factor, (I_3)	0.0868

Figure 12: Parameters used in simulation experiment

Conclusion

- The paper proposed a machine type communication (MTC) for M2M VLC based with an incorporation of energy harvesting system using a power transfer unit (PTU) with a centralized VLC access point (AP) with a probabilistic model, where an investigation is performed to show the signal to noise ratio (SNR) distribution with a semi angle at half power of a chosen link.
- M2M VLC based presents one of the most reliable secured and viable communication in IoTs with a proven tract of releasing high data rates and serves as a solution to already congested, overcrowded electromagnetic spectrum.