Free Space Optical (FSO) networks and Visible Light Communication (VLC)

EN 1054
Introduction to telecommunication
University of Moratuwa

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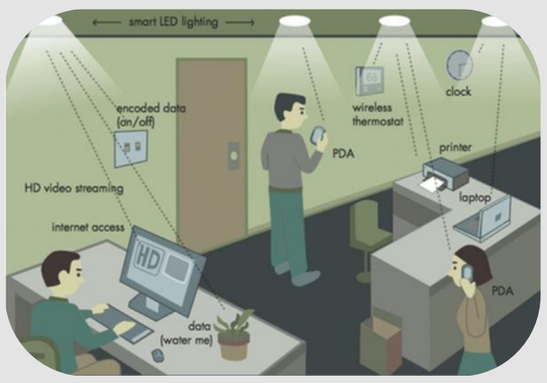
two advanced forms of optical wireless communication that use light to transmit data through the air without the need for physical cables. These technologies offer high-speed, secure communication solutions for both indoor and outdoor environments, each with unique strengths and applications.

WHAT ARE FSO & VLC?

Free Space Optical (FSO)

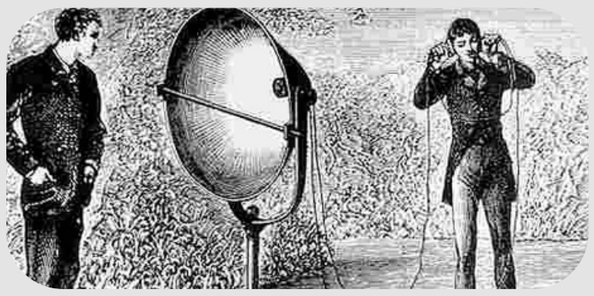
Communication is a wireless technology that uses light beams, typically lasers, to transmit data through the atmosphere, offering fiber-like speeds without physical cables.



Visible Light Communication (VLC) uses the visible light spectrum emitted by LEDs to wirelessly transmit data. It supports both illumination and high-speed data transmission in indoor environments.

Both technologies are part of the broader category of Optical Wireless Communication (OWC), revolutionizing how we handle high-bandwidth, secure, and interference-free communication.

HISTORY



- **Optical signaling dates back to ancient times using smoke, fire, and mirrors.**
- **FSO was first developed for military and space applications in the mid-20th century.**
- **VLC evolved more recently, leveraging the rise of LED technology in the 2000s.**
- **The Li-Fi concept (a type of VLC) was popularized by Prof. Harald Haas in 2011.**

ARCHITECTURE

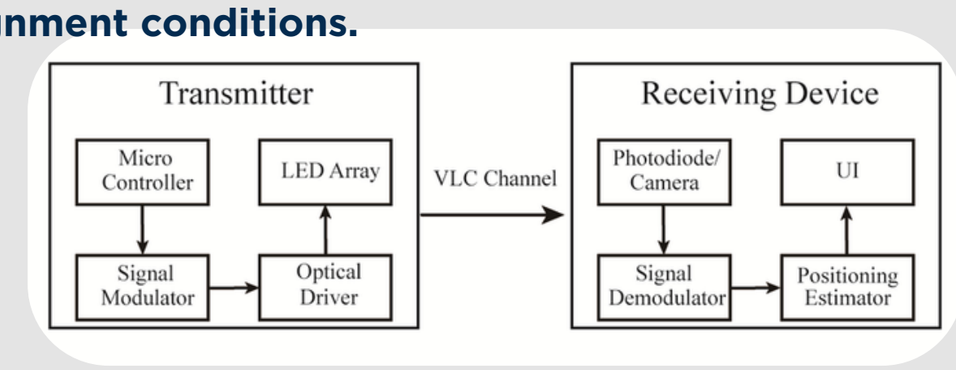
FSO System:

- **Transmitter: Laser diode + modulator**
- **Free-space channel: Air or vacuum**
- **Receiver: Photodetector + demodulator**

VLC System:

- **Transmitter: LED light source**
- **Channel: Indoor visible light path**
- **Receiver: Photodiode or camera sensor**

Both systems require line-of-sight (LoS) or minimal reflection paths and are sensitive to environmental and alignment conditions.

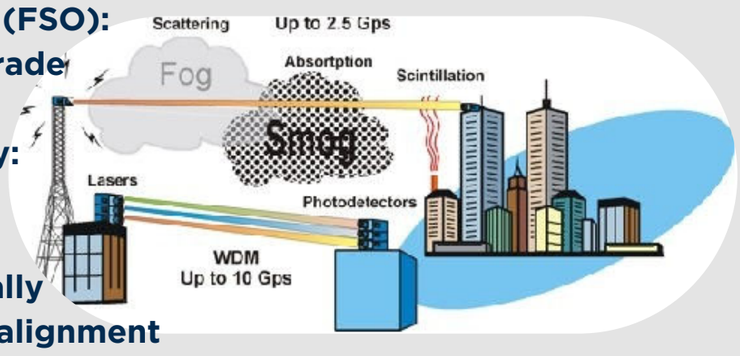


COMMUNICATION TECHNOLOGIES

Feature	FSO	VLC
Spectrum	Infrared/laser	Visible light (400–700 nm)
Max Data Rate	Up to 100 Gbps	Up to 10 Gbps
Transmission Medium	Free-space (air, vacuum)	LED light in indoor space
Range	Several km	Short (a few meters)
Interference Resistance	High (no RF interference)	High (no EMI)
Applications	Satellites, backhaul, IoT	Indoor IoT, hospitals, aircraft

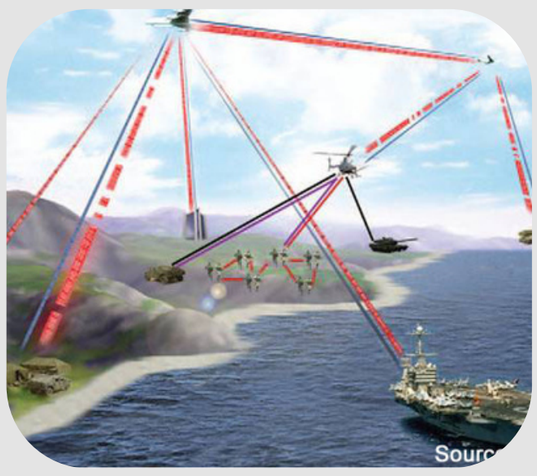
CONCERNS

1.Environmental Sensitivity (FSO): Rain, fog, or dust can degrade signal strength.
2.Line-of-Sight Dependency: Obstacles block the communication path.
3.Alignment Issues: Especially critical in FSO, where misalignment leads to signal loss.



4.Ambient Light Noise (VLC): Sunlight or other light sources can interfere.
5.Limited Range (VLC): Suitable for short distances only.
6.Standardization: VLC is still evolving in terms of protocols and integration

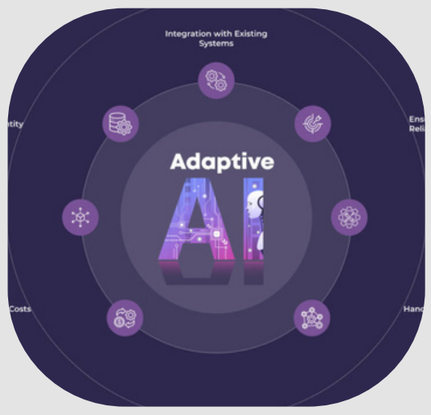
APPLICATIONS



1.Satellite and Ground Station Links
2.Inter-building Connectivity
3.Underwater Communications (VLC)
4.Aircraft Cabin Internet
5.Hospitals (EMI-sensitive environments)
6.Smart Lighting Systems
7. Secure Military Communication
8. Internet of Things (IoT) and Smart Homes

FUTURE

- **Hybrid Systems: Integrating VLC and FSO with RF for seamless switching.**
- **Li-Fi Networks: Expanding indoor high-speed data communication using lighting.**
- **Nanoscale Components: Development of compact transmitters/receivers for IoT.**
- **Quantum FSO Links: For ultra-secure space and satellite communications.**
- **AI & Adaptive Systems: For environmental tuning and signal optimization.**
- **Smart Infrastructure Integration: Street lights, traffic systems, homes.**



scan this for references: