

# Free-Space Optical Communications

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# “Illumination and Communication”

## Three key messages

### 1. Solid State Lighting is coming

- It brings an opportunity to embed *networking*

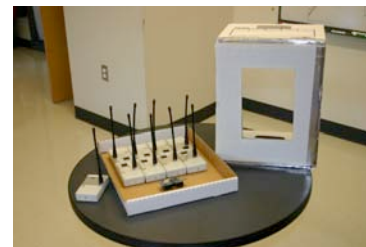
### 2. Pervasive Computing is upon us

- Mobile wireless devices, embedded networked sensors, RFID, WiFi hotspots
- *Never far from the Internet* (a) indoors and (b) outdoors

### 3. LED-based communication and networking has important advantages:

- Bandwidth, bandwidth density
- Privacy--security
- Ubiquity if piggybacked on lighting
- Unregulated spectrum

⇒ Incredible opportunity to affect new medium for ubiquitous network access



# Free-Space Optical Networking: Where it Matters



From Airbus ([www.airbus.com](http://www.airbus.com))

## ■ Deliver HD video to individual seats

- Airbus holds > 500 people; HD requires 13 Mb/s; short range personal lighting/communication for channel isolation; copper is heavy. **High bandwidth density (>10 Mb/m<sup>3</sup>)**

## ■ Localized communication between vehicles

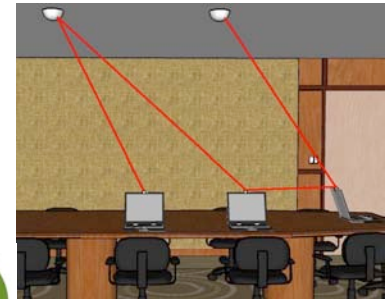
- Emerging safety-oriented technology: active braking, traffic monitoring; warning message propagation.
- Directional transmission, **PRF < 1%, < 100ms latency**

## ■ Indoor localization

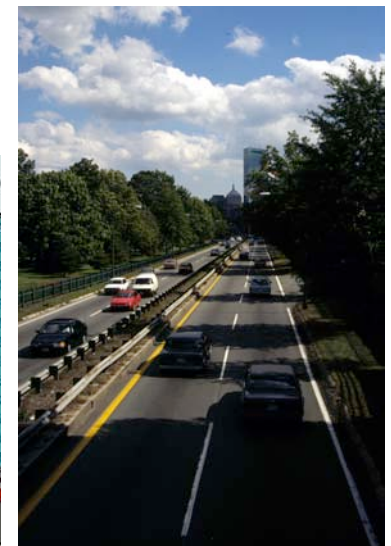
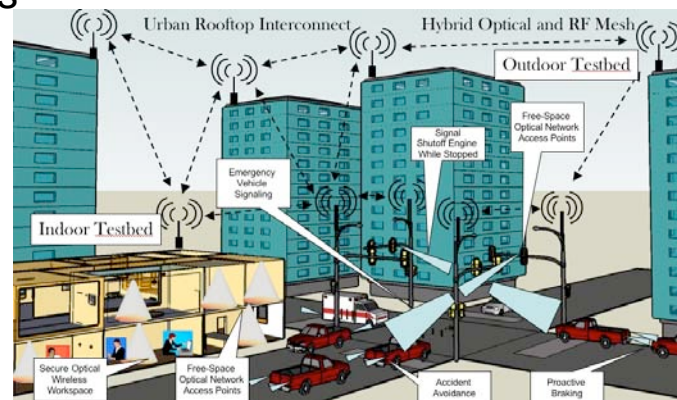
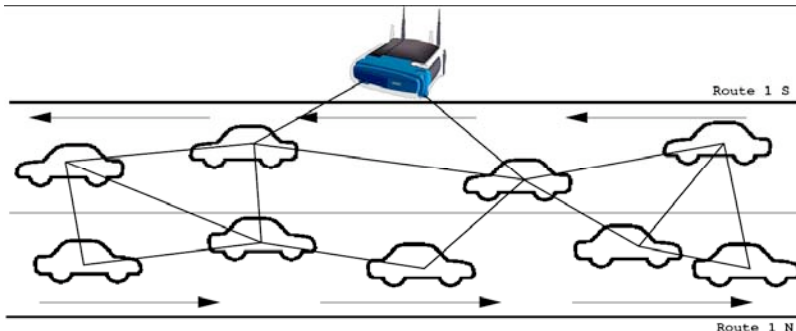
- Finding roaming patients and doctors in a hospital; RF techniques can be problematic; lights can be uniquely modulated with ID; tagging bats; security in downlink channel. **Data trickle.**

## ■ Providing opportunistic mobile access

- Hotspots wherever there is illumination. **Ubiquity.**
- Moving vehicles. Internet access
- Mesh networks



Courtesy of Thomas Kunz

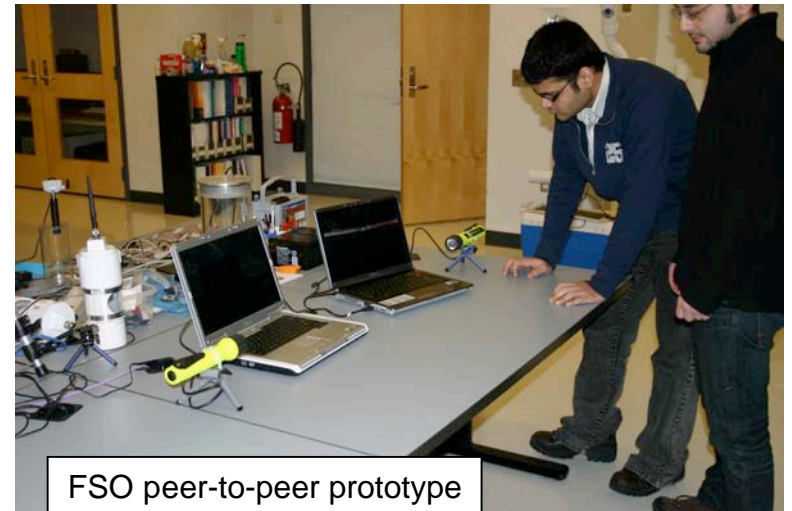


## RF (802.11) vs. Free-Space Visible Spectrum (LED)

Attribute	RF @ 2.4 GHz		LED FSO		Advantage
Security/privacy	Promiscuous, known limitations, penetrates walls		Opacity, LOS, locality		FSO
Trans	Attribute	RF @ 2.4 GHz	LED FSO	Advantage	
Availa	Security/privacy	Promiscuous, penetrates walls	Opacity, LOS, locality	FSO	O
Cost	Available BW capacity	Limited by contention, degrades from peak	LOS permits spatial reuse	FSO	O
Point	Cost of additional spectrum	Very high when available	None (yet)	FSO	O
Safet	Interference	Self, multipath, ISM sources	Visible natural and man made light	Varies	ies
Interf	Aesthetics	Additional item in room	Built into lighting	FSO	ies
Data	Installation cost	Moderate - separate item	Low - piggybacked	FSO	O
Data	Multipath	Destructive interference	Noise at receiver	FSO	O
Insta	Picocell deployment	Difficult to control trans. range	Directional, controllable intensity	FSO	ies
Sym	Estimated comp. cost	< \$20	< \$2 (based on IrDA)	FSO	O
Multip	Performance under contention	Decreases with transmission footprint	Limited by no. sources, not a function of footprint	FSO	O
Point	Path redundancy	Achieved with multiple access points	Achieved with multiple LEDs	FSO	O
Pico					F
Anten					F
Est. c					F
Perf.					F
Anten					F
Volun					F
Layer					F
Path redundancy	Achieved with multiple access points		Achieved with multiple LEDs		FSO

# Research Focus--Benefits

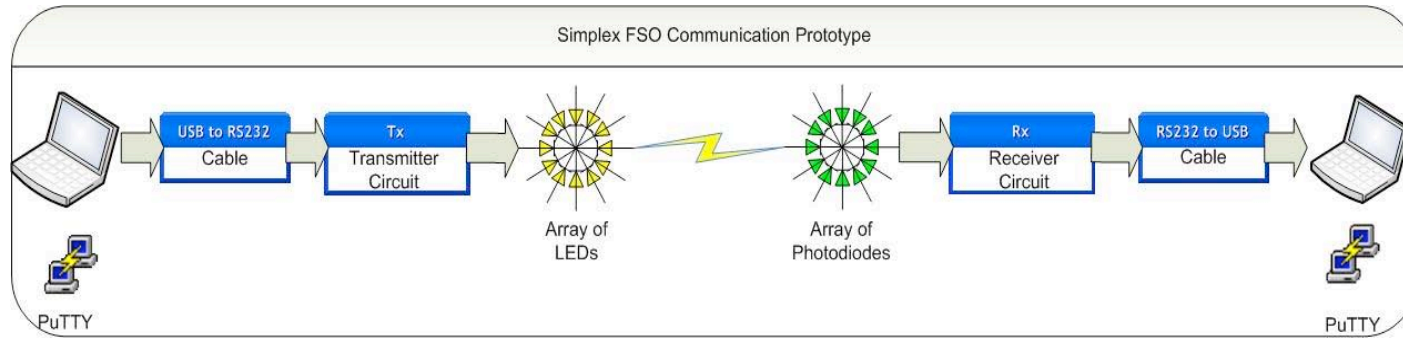
1. **An opportunity to embed networking**
  - Leverage power line modems, WiFi, lower energy use
  - Networking where there is illumination
2. **Ubiquitous communication is an enabler**
  - Mobile wireless devices, embedded networked sensors, RFID, WiFi hotspots, transportation
  - Never far from the Internet (a) indoors and (b) outdoors
  - Better data and control from/to the physical world
3. **LED-based communication and networking has important advantages:**
  - Bandwidth, bandwidth density
  - Privacy--security, bypassing RF
  - Ubiquity if piggybacked on lighting
  - Unregulated spectrum



FSO peer-to-peer prototype



# Demonstration of FSO Communications using COTS Components



(PHO 445)

