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Departamento de Señales y
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# Optical Communications

Telecommunication Engineering
School of Engineering
University of Rome La Sapienza
Rome, Italy
2004-2005

**Lecture #12, June 15 2006**

# Wireless Optical Communications and Standards

# OUTLINE

- Infrared Wireless application scenarios
- Wireless channel
- Standards: IrDA, IEEE 1073.3.3

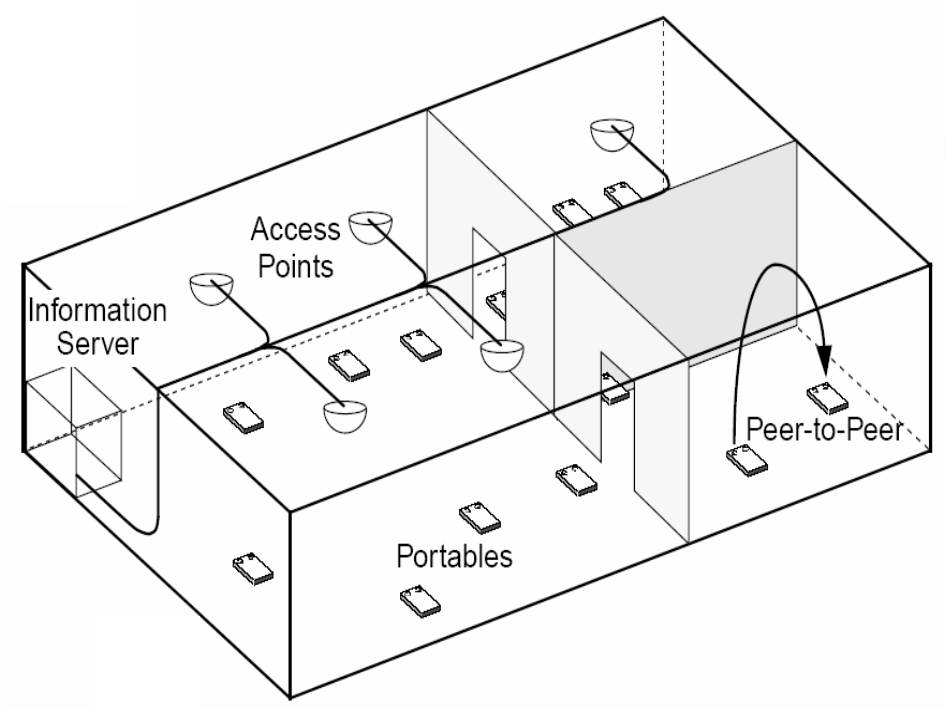
# WHAT DO WIRELESS INFRARED COMMUNICATIONS OFFER?

- They neither produce, nor are affected by EM interferences, so they can be used in EM restricted scenarios and in others (in-house applications, sensor networking) in which interferences are currently present (and will even more in the future…..)
- Right now, they do not require legal procedures to be installed, and thus one has all the bandwidth one can manage (as, for example, for last-mile access or building interconnection)
- They can be intercepted (especially in Line-Of-Sight communications) but interception is easily detected by the intended receiver, even without coding
- Cheap commercial devices are commonly available, operating under well established standards that offer tens of Mb/s for indoor networking, hundreds of Mb/s for outdoor access

# IR vs. RF

| Properties | IR | RF |
|---|---|---|
| • legal requirements for channel allocation | No | Yes |
| · Multi-path Fading | No | Yes |
| · Multi-path dispersion | Yes | Yes |
| · Transmission through walls and obstacles | No | Yes |
| · Dominant noise source | illumination / Other users | Other users |
| · Propagation losses | Very High | High |

# INDOOR APPLICATION SCENARIOS




Home Networking and sensor interconnection


Cable replacement


System interconnection

# INDOOR APPLICATION CONSIDERATIONS

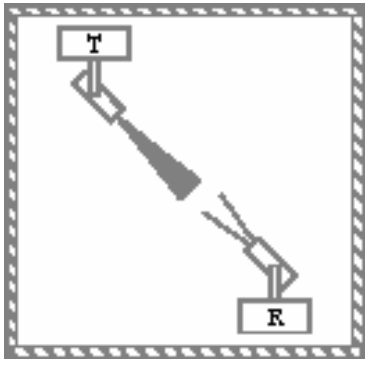
- Low-power, low/medium baud-rate systems - power consumption and cost are main concerns
- Two strategies:
  - Point-to-point communications for cable replacement
  - Diffuse systems for full coverage and mobility (e.g. sensor networking)
- Strictly limited by safety regulations (using IRED instead of LASER)
- Standards offer fully interconnection with other networks
- Ranges from 1 to 5 meters
- Bandwidth limited by multi-path dispersion (diffuse systems) and by technological limitations on emitters and receivers (point-to-point links)
- Noise from artificial light sources, electrical components, and other users

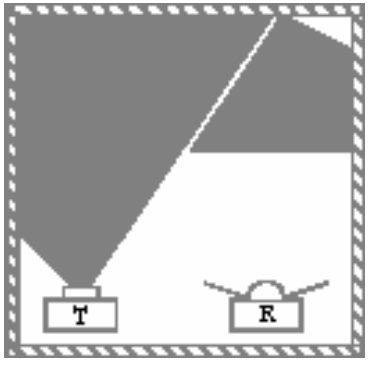
# More on INDOOR CHANNELS: IR LINKS BY REFLECTION

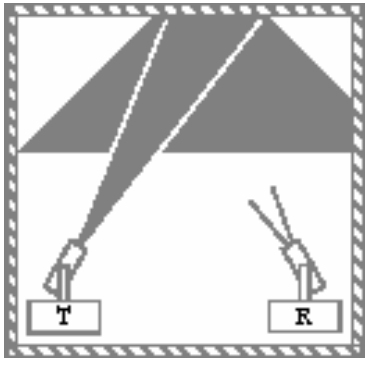
LOS

diffusion

quasi-diffusion

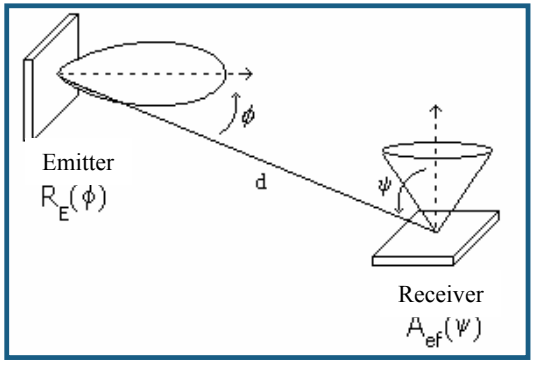


# More on INDOOR CHANNELS: RECEIVED POWER ESTIMATION

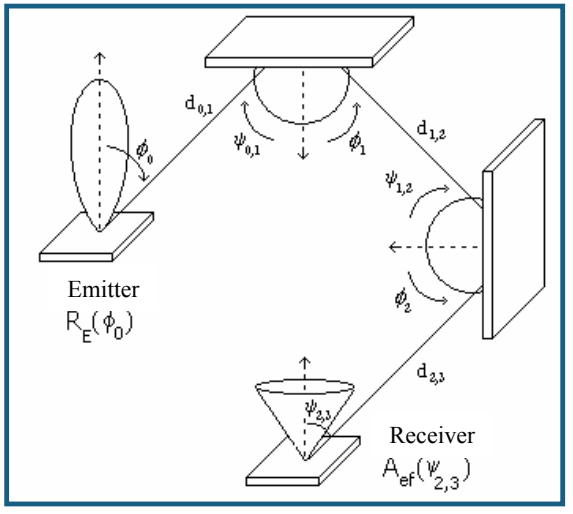
## LOS-LINKS




$$H(0) = \frac{P}{P_E} = \frac{R_E(\phi)\,A_{ef}(\psi)}{d^2}$$

$$h(t;E,R) = \frac{P_E\,R_E(\phi)\,A_{ef}(\psi)}{d^2}\,\delta\left(t - \frac{d}{c}\right)$$

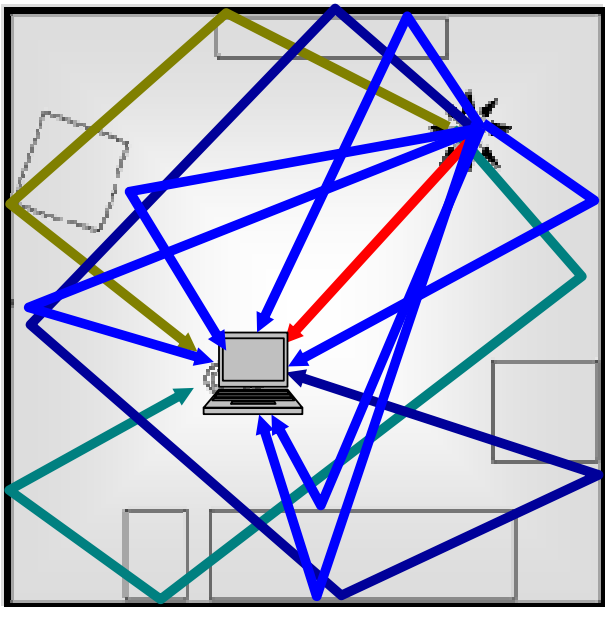
## DIFFUSION AND Q-DIFFUSION



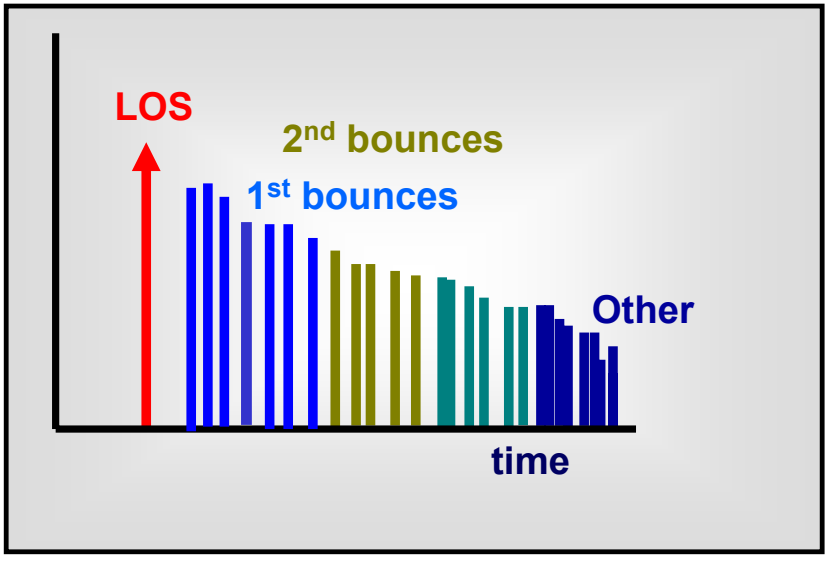

**Analytical solutions are not practical!!!**

# DIFFUSE CHANNEL IMPULSE RESPONSE

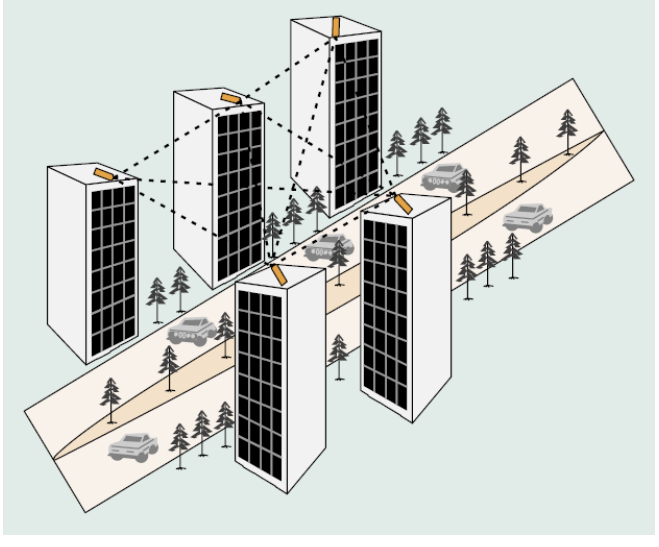
## ray representation



## impulse response h(t)



# OUTDOOR: FREE SPACE OPTICAL LINKS



A MAN UOWC

Includes all outdoor optical communication systems

Urban optical wireless communication (UOWC) is rapidly gaining popularity as an effective mean for transferring data at high rates over short distances.

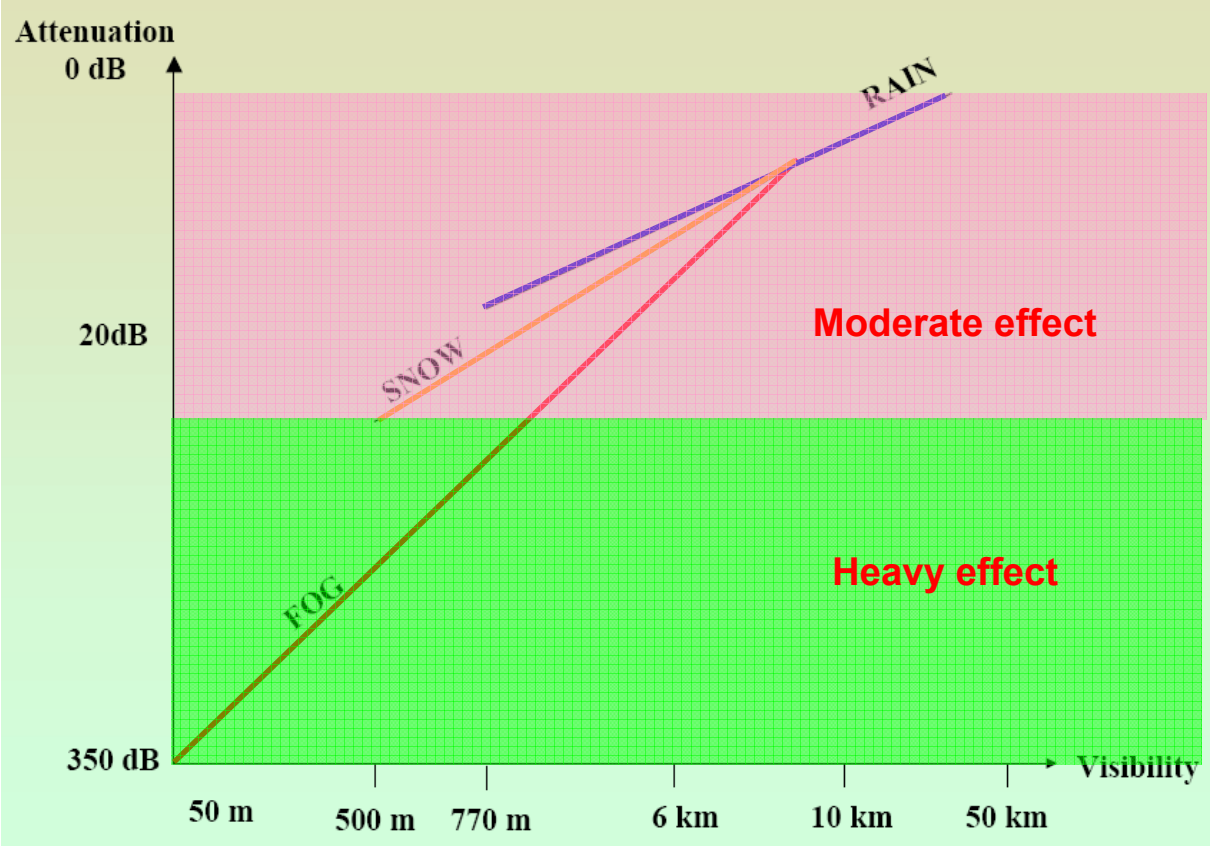
The UOWC system includes an optical transmitter and a receiver that may be separated by several hundreds of meters.

UOWC advantages:

- Rapid deployment
- Lightweight
- High-capacity communication without licensing fees.

- Main drawback is dependence with weather atmospherical conditions

# More on OUTDOOR CHANNELS



# More on OUTDOOR CHANNELS

6.5db/km 150db/km 225db/km


## Examples of fog attenuation (Denver, CO, USA)

Source: White papers from AirFiber: "*Physics FSO*" www.airfiber.com

# STANDARDS: COMPARISON OF IrDA vs. 802.11 and BLUETOOTH

- **IrDA**
  - **Low power, low cost, very secure, no interference**
  - **Line of sight, 1 meter (IrDA IR)**
  - **Suitable for continuous network access by portable devices such as Portable Digital Assistant or cellular phones**
  - **Available rates: 115 kb/s to 16 Mb/s**

- **802.11a/b/g**
  - **Long distance, real time connection, high power consumption, unsecure unless well protected, interference**
  - **Not suitable for continuous network access**
  - **Available rates: 11 to 54 Mb/s**

- **Bluetooth** (someone defined it as "… a solution looking for a problem")
  - **Medium distance, medium power consumption.**
  - **Less secure than IR, interference, add-on card (high cost), interoperability issues.**
  - **Technology is getting mature as applications are growing**
  - **Available rates: 1Mb/s (other rates on the way)**

# What is IrDA?

**Infrared Data Association** (IrDA) is a non-profit trade association providing standards to ensure the quality and interoperability of infrared (IR) hardware. The association currently has a membership of over 160 companies from around the world, representing computer and telecommunications hardware, software, components and adapters.

IrDA typically uses direct infrared i.e. point-to-point, line-of-sight, one-to-one communications.

Contact:
Home http://www.irda.org
Linux-IrDA support: http://cesdis1.gsfc.nasa.gov/linux/misc/irda.html
http://www.cs.uit.no/linux-irda/

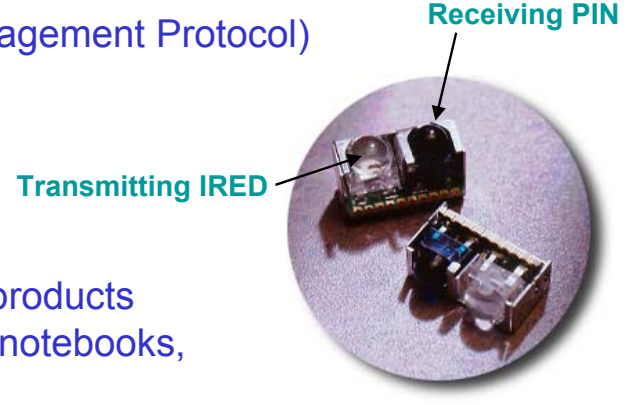
Infrared Data Association®

# IrDA Standard

IrDA defines standards for both hardware and protocols.

The standards include:

- IrDA Data that foresees the presence of the following three mandatory layers:
  - IrPHY (SIR, FIR, VFIR)
  - IrLAP (Link Access Protocol)
  - IrLMP (Link Management Protocol)
- IrDA Control
- IrDA AIR (evolution of IrDA Data)

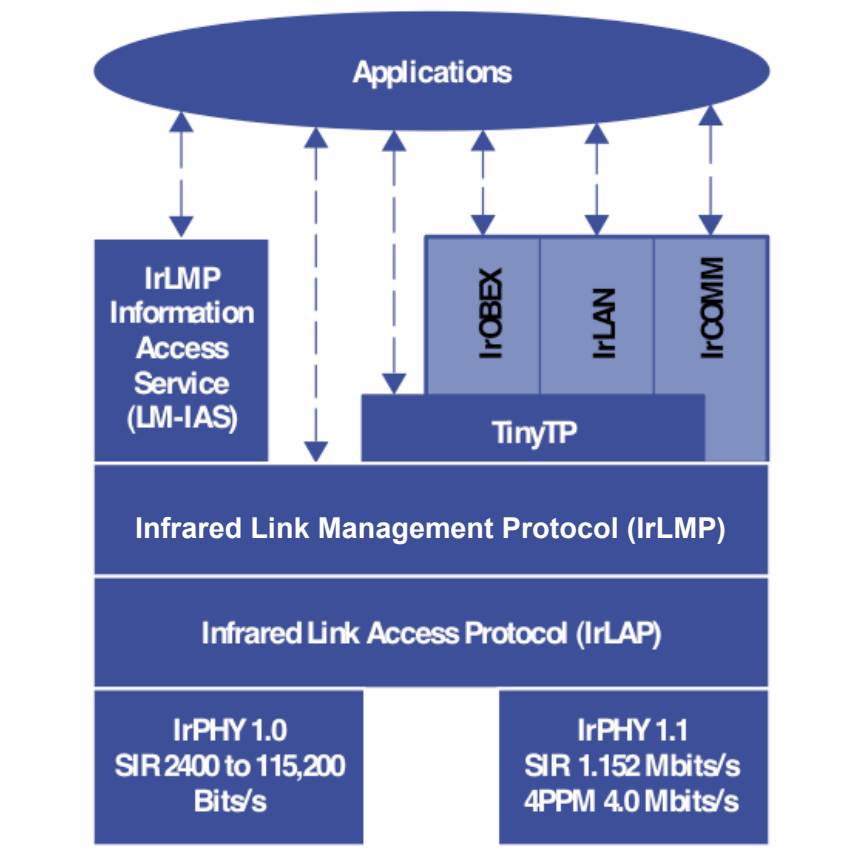



IR ports compliant with above standards can be found in products such as PDAs, Palm devices, printers, desktop adapters, notebooks, and digital cameras.

IrDA devices communicate using infrared LEDs. Wavelength used is 875 nm (with a tolerance around 30 nm).

Receivers use PIN photodiodes

# The IrDA Data Protocol Stack



# IrDA SlowIR SIR (v1.0)

IrDA devices conforming to standards IrDA 1.0 and 1.1 work over distances up to 1.0m with BER $10^{-9}$ (on a maximum level of surrounding illuminance of 10 klux, equivalent to daylight).

Values are defined for a 15 degree deflection (off-alignment) of the receiver and the transmitter; output power for individual optical components is measured at up to 30 degrees.

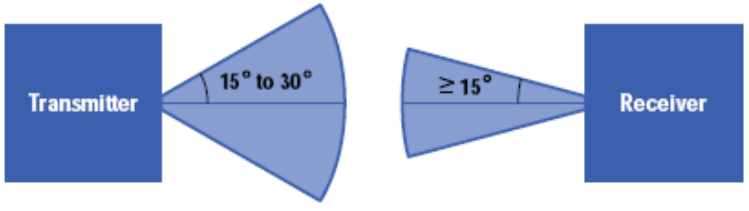
Transmitter uses a pulse with duration

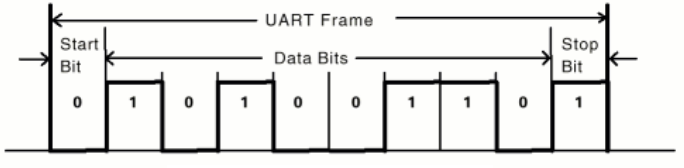
$T_p = 3/16\ T_{bit}$ (Zero Return)

For the maximum bit rate of 115.2 kbps this corresponds to $T_p = 1.63\ \mu s$

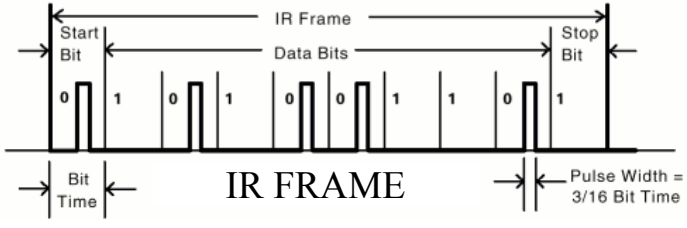
ZR is required since a high-pass filtering is adopted to reduce the effect of daylight

*Viewing angle specified in IrDA specification 1.0.*




UART FRAME




IR FRAME

# IrDA MIR and FIR (v1.1)

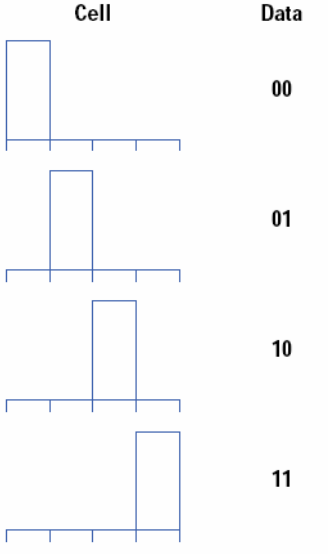
IrDA v1.1 has same specification of v1.0 regarding distance (up to 1.0m) and BER ($10^{-9}$ in daylight).

IrDA v. 1.1 defines two additional transmission modes:

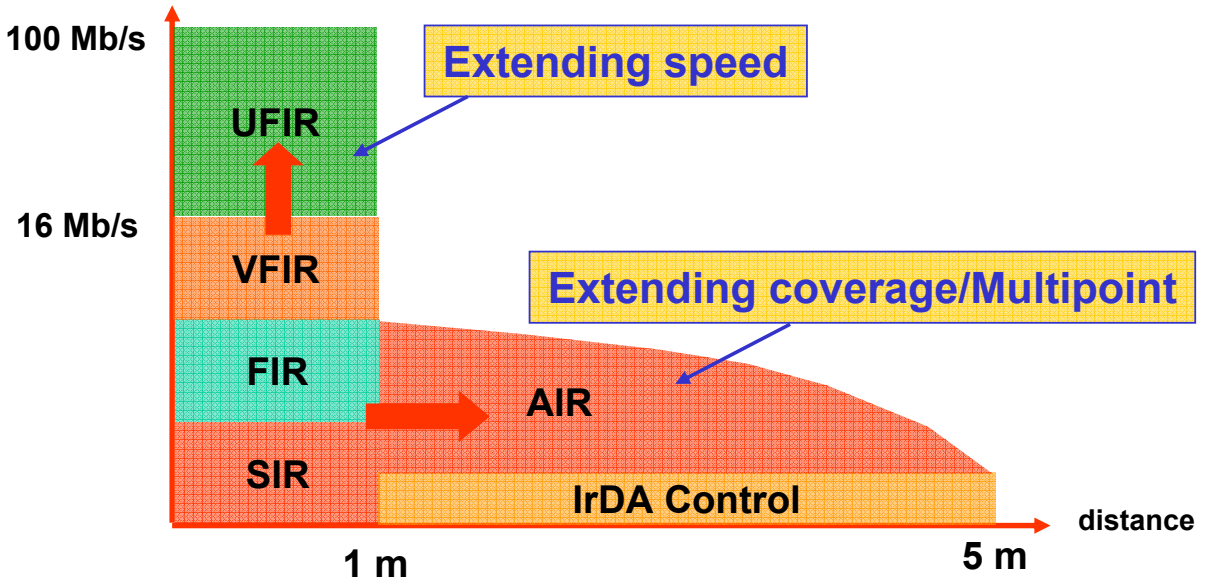
1) Medium Speed IR, with speeds 0.576 and 1.152 Mbps

2) FIR, with speed 4 Mbps, adopting 4PPM instead of OOK

*4PPM message encoding.*



# IRDA STANDARD EVOLUTION



# WIRELESS INFRARED FOR MEDICAL APPLICATIONS

- Standardization for medical applications is still far from complete

- Information technology (IT) standards within the commercial application domain (e.g., IEEE 802.x standards) are **inadequate** to fully address the needs of the clinical IT domain, particularly at the patient bedside

- RF systems have **security** and **operation** problems that not affect IR systems (e.g. with legacy equipment using ISM bands or privacy of medical data)

# THE IEEE 1073.3.3 STANDARD

- IrDA-based standard
- Interconnection of computers and/or medical devices
- Suitable for new device designs, but targeted to ***legacy*** devices:

  - Already in use in clinical facilities
  - can be added-on devices that are already under production

The operation of adding on the standard must be flexible and simple in order to avoid prohibitive costs

# IEEE 1073.3.3 STATUS

Infrared Wireless transport draft standard (P1073.3.3) was **approved** on its first ballot in **2003**.

The infrared wireless transport standard **extends** the capabilities of its **cable-connected** counterpart, IEEE 1073.3.2-2000, to include an infrared wireless physical layer. This interface is based on IrDA-based ports.

It also defines a **LAN access** point whereby devices can interact with other systems across a TCP/IP-based LAN, in a point-to-multipoint fashion

# IEEE 1073.3.3 PURPOSE

**The 1073.3.3 standard is based on IrDA and defines:**

- A **point-to-point**, narrow angle (±15° half-angle cone) infrared physical layer that operates over a 0-1 meter distance at signaling rates of 9600 bits/sec to 4Mbits/sec.

- A transport-level **device discovery and communication** negotiation process

- **Information Access Layer** (IAS) entries are defined for identifying a device and its services across an IrDA connection.

- Mechanisms for using **Simple Network Time Protocol** (SNTP) to synchronize clocks across the link

- The primary goal of the IEEE 1073 is to define a Medical Information Bus, using all available communication technologies