Non-Directed Indoor Optical Wireless Network with a Grid of Direct Fiber Coupled Ceiling Transceivers for Wireless EPON Connectivity

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Outline

- Research motivation
- Proposed system
  - EPON standard
  - Theoretical model
  - Synchronization
- Results and discussion
- Conclusion and future work
Research Motivation

Expanding market of portable devices and applications

**Goal:** high-speed, secure and power efficient indoor communication system for mobile users

Indoor optical wireless networks:
- **High speed**
- **Line of sight (LOS)**
- **Low power consumption**
- **Electromagnetic interference immunity**

OLT - optical line terminal
ONU - optical network unit
CM - ceiling module

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Proposed System - EPON

New standards or compatibility with current fiber standards – EPON (802.3ah)
- Provides seamless connectivity for IP-based communications
- Scalable bit rates for the users
- Widely used and cost effective

\[ \text{OLT} \quad \text{Splitter} \quad \text{ONU} \quad \text{ONU} \quad \text{ONU} \]
\[ \text{OLT} \quad \text{Splitter} \quad \text{CM} \quad \text{CM} \quad \text{ONU} \quad \text{ONU} \quad \text{ONU} \]

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Proposed system – Theoretical Model

\[ L_{\text{tot}} = L_{\text{split}} L_{\text{coupling}} L_{\text{beam}} L_m \]

\[ P_{Ar} = P_t L_{\text{tot}} G_{OA} \]

- \( G_{OA} \) – Optical gain
- \( \omega \) - Beam waist
- \( r_2 \) - Rx aperture diameter
- \( L_{\text{tot}} \) – Total loss
- \( L_m \) – Loss margin
- \( P_{Ar} \) – Received optical power

\( \omega = 1 \text{m}, \ r_2 = 20 \text{mm}: \)

\( L_{\text{beam}} = 45 \text{dB} \)

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Proposed system – Theoretical Model

\[ SNR_d = \frac{(P_{Ar} \rho_{RX})^2}{\langle i_{ase}^2 \rangle + \langle i_{bn}^2 \rangle + \langle i_{th}^2 \rangle} = \frac{(P_{t,d} L_{tot} G_{OA} \rho_{RX})^2}{4I_s G_{OA} I_{ASE} L_{tot} \frac{B}{\Delta v_f} + 2e\rho_{RX} P_{bn,d} B + \frac{4kTB}{R_{in}}} \]

\[ SNR_u = \frac{(P_{t,u} L_{tot} G_{OA} \rho_{RX})^2}{4I_s G_{OA} I_{ASE} L_{tot} \frac{B}{\Delta v_f} + 2e\rho_{RX} P_{bn,u} BG_{OA} + \frac{4kTB}{R_{in}}} \]

**Eye safety**

The transmit power in the wireless part is under 10dBm;

(Class 1 laser product: IEC 60825-1)
Proposed system - Synchronization

- Synchronization in the fiber part can be achieved by path equalizing.
- In wireless part the mobile device is mobile with random location – only the biggest delay can be estimated.

\[ h = 2m, \quad r = 1m, \quad \Delta t = 0.64\text{ns} \]
Results – Downlink

- 0dBm transmit power
- Big indoor coverage
- Reliable high speed link (100Mbps)

100Mbps link with receiver aperture diameter $r_2=50\text{mm}$

100Mbps link with beam spot diameter $D=2\text{m}$

PD responsitivity: 0.8A/W
PD load resistor: 50Ω
Results - Uplink

- LD with transmit power $P_{t,d} = 0$ dBm
- Reliable high speed uplink (100Mbps)
- Lower speed will further increase the system performance
Conclusion

- Proposed system - Sustainability:
  - Compatible with EPON standard;
  - High-speed communication for mobile users;
  - Low power consumption compared to RF;
  - High security;
  - Free RF spectrum (interference immunity)
    - lower human exposure to electromagnetic waves;
    - free resources for other applications;
  - Eye safety regulations considered;
Future work

- Proposed system:
  - Better theoretical model;
  - Enhanced performance:
    - Transimpedance amplifier implementation;
    - Gigabit links;
  - Prototype;

- Standardization:
  - Update of EPON standard for wireless networks;
  - Propose for change in the uplink wavelength;
Thank you for your attention!

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