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

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Outline

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

Expanding market of portable devices and applications  High capacity mobile access network

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

Indoor optical wireless networks:
- Diffusive
- Line of sight (LOS)
Proposed System - EPON

New standards or compatibility with current fiber standards – EPON (802.3ah)

- Provides seamless connectivity for IP-based communications
- Widely used and cost effective
- Scalable bit rates for the users

OLT - optical line terminal
PON - passive optical network
ONU - optical network unit
CM - ceiling module
Proposed system – Theoretical Model

OLT – optical line terminal
OA – optical amplifier
PD – photodiode
LD – laser diode

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

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

\[ \omega = 1\text{m}, r_2 = 20\text{mm}: \]
\[ L_{beam} = 45\text{dB} \]

\[ \omega \] - beam waist
\[ r_2 \] - Rx aperture diameter
Proposed system – Theoretical Model

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

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

\[
\rho_{RX} \quad \text{PD responsitivity}
\]

\[
I_s \quad \text{signal current in the PD}
\]

\[
I_{ASE} \quad \text{ASE current in the PD}
\]

\[
B \quad \text{bandwidth}
\]

\[
\Delta v_f \quad \text{band pass filter bandwidth}
\]

\[
e \quad \text{elementary charge}
\]

\[
P_{bn} \quad \text{ambient noise power}
\]

\[
R_{in} \quad \text{feedback resistance}
\]

\[
k \quad \text{Boltzmann’s constant}
\]

\[
T \quad \text{absolute temperature}
\]

Eye safety

The transmit power in the wireless part is under 10dBm;
Higher transmit power is possible (diverged beam);
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.

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

- 0dBm transmit power
- Reliable high speed link
- Big indoor coverage

PD responsivity: 0.8A/W
PD load resistor: 50Ω

100Mbps link with receiver aperture diameter $r_2=50\text{mm}$
100Mbps link with beam spot diameter $D=2\text{m}$

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Results - Uplink

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

\[
\text{BER} = 10^{-\left(G_{\text{EDFA}} / 10\right)}
\]

- \( r^2 = 120 \text{mm} \)
- \( D = 3 \text{m} \)
- \( r^2 = 120 \text{mm} \)
- \( D = 2 \text{m} \)
- \( r^2 = 100 \text{mm} \)
- \( D = 2 \text{m} \)
Conclusion

Proposed system advantages:
- 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;

Future work:
- Consideration of GEPON;
- Better theoretical model and enhanced performance;
Thank you for your attention!

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