ABSTRACT

The Batununggal area in Bandung is experiencing increasing demand for high-speed internet services. However, the development of access networks is hindered by space limitations and local regulations, specifically Bandung Mayor Regulation No. 589 of 2013, which prohibits aerial cables and mandates that optical networks be installed underground. This makes G-PON technology inefficient in terms of technical performance, cost, and aesthetics. To address this issue, a hybrid access network solution was designed by combining Free-Space Optics (FSO) as the feeder link and Next-Generation Passive Optical Network (NG-PON) as the distribution link. By eliminating the need for excavation, NG-PON offers higher cost efficiency due to its broader coverage, enabling it to serve more homepasses within a single distribution area. The system is supported by real-time monitoring based on the Internet of Things (IoT) through a web-based platform that detects environmental conditions and sends notifications when disturbances occur.

The methodology included surveying and mapping the network path using AutoCAD and digital mapping tools, simulating optical performance using optical simulation software, and testing the network's technical parameters. The IoT system was developed with five types of sensors (rainfall, temperature, humidity, vibration, and dust), integrated into the Skylink website. Testing was conducted under various environmental scenarios to evaluate the reliability of the network and the responsiveness of the sensors to environmental disturbances.

Simulation and testing results show that the hybrid system performs very well under various conditions. Link Power Budget (LPB) values ranged from -25.196 dBm (nearest user, light rain) to -25.704 dBm (farthest user, clear weather), well above the minimum threshold of -28 dBm. Bit Error Rate (BER) ranged from 6.89×10^{-9} to 2.95×10^{-7}, exceed standards 10^{-6} threshold. Signal-to-Noise Ratio (SNR) remained stable around 60 dB, and Q-Factor ranged from 4.99 to 5.58, approaching the ideal value of 6. The rain sensor detected attenuation up to ±20 dB/km, temperature and humidity sensors recorded values between 25–45°C and 71.4–72.6%, and the vibration and dust sensors showed high sensitivity to movement and airborne particles affecting transmission. All data were visualized through the Skylink website, which successfully delivered automatic and accurate notifications during suboptimal environmental conditions. Economically, the hybrid network implementation reduced the cost per homepass by approximately 25% compared to conventional G-PON systems, due to the elimination of physical feeder links and the broader coverage of NG-PON distribution.

***Keywords**: FSO, IoT, hybrid network, NG-PON, Skylink*