OPTI-6G

OPTICAL 6G CELL FREE NETWORKS

OPTICAL 6G COMMUNICATION AND LOCATION SENSING NETWORK

The OPTI-6G project aims to develop low-cost, cell-free near-IR networks with multi-connectivity, enhancing link quality and resilience. This eliminates the need for subdividing in-building networks into cellular areas or accessing licensed spectrum, as it operates in optical unlicensed bands with AI-driven interference management. Using VCSEL arrays ensures resilience against natural visible light interference, providing a robust solution.

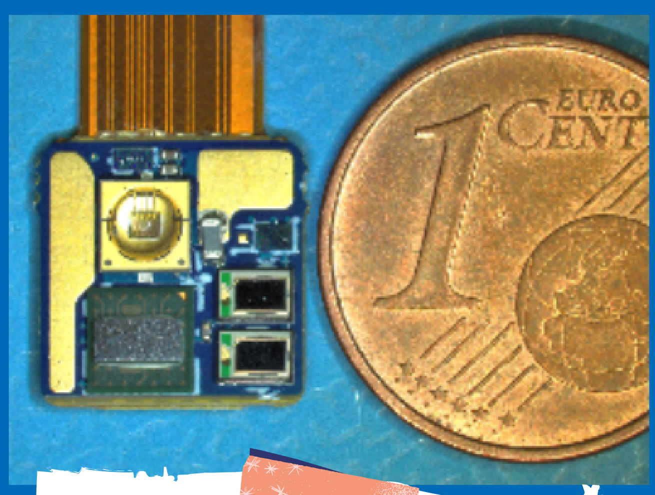

Figure 1: Current optical antenna used in cell-based LiFi systems

OVERVIEW

The OPTI-6G project advances broadband optical wireless communication (OWC) using VCSEL arrays in the 850-1050 nm near-IR range, ensuring interference-free indoor coverage. It delivers 1 Gbps over 5 m at 25° and 3 Gbps at 15°, paving the way for beam-steered OWC with wider access angles.

Building on 6G BRAINS research, the project also enhances OWC localisation, integrating Angle of Arrival (AoA) and Time Difference of Arrival (TDoA) to surpass the 1–3 cm accuracy limit of RSS-based methods. This is crucial for AGVs, XR headsets, drones, IoT, and robotics, with comparisons to 3.5 GHz localisation to assess performance.

RSS-BASED POSITIONING AND TRILATERATION IN OWC SYSTEMS

Positioning Requirements:

- *At least 3 optical sources are needed for accurate 2D positioning.*
- *The transmitted optical power must be known.*
- *The receiver's orientation significantly affects accuracy.*

Trilateration: *Uses estimated distances to determine the UE's position*

Core Idea: *RSS-based positioning estimates absolute distances from multiple access points to a user equipment using a known path loss model..*

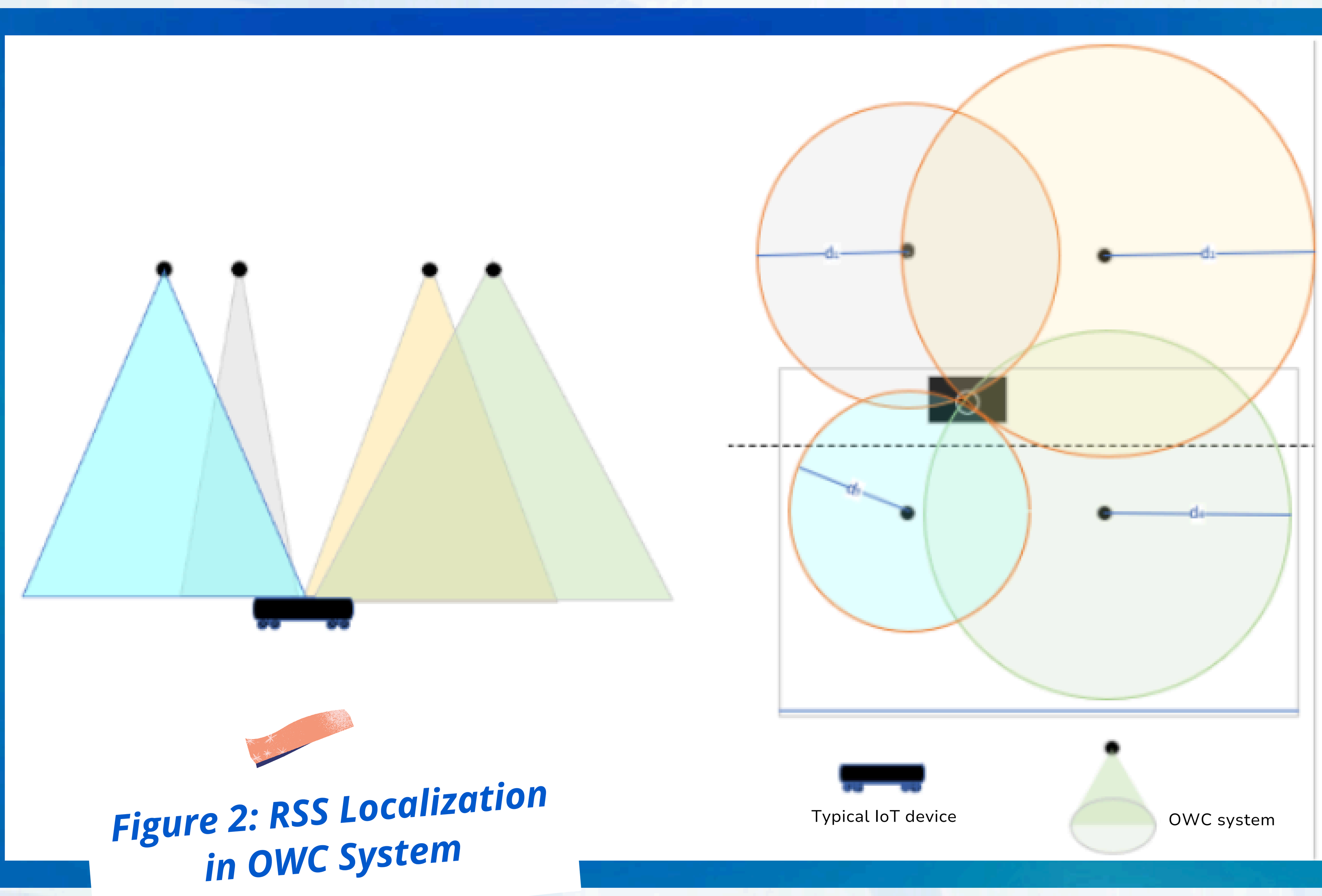

Figure 2: RSS Localization in OWC System

Mathematical Model:

- *APs are assumed to point to the floor, while the UE points to the ceiling.*
- *The received optical power from each AP is calculated using a LOS path-loss model.*
- *Multiple equations with two unknowns (x, y) are derived from RSS measurements.*

SYSTEM ARCHITECTURE AND DTOA PROCESSING

System Structure:

- *Single-site system with a 3-branch distributed antenna.*
- *Wireless-to-optical converters placed at the front of the RF chain in each branch.*

Signal Processing:

- *Front-end processors decode and digitize the UE uplink (UL) signal at each branch.*
- *Fast Fourier Transform converts signals to the frequency domain.*
- *Phase differences of OFDMA subcarriers (related to propagation delay) are analyzed.*

Differential Time of Arrival (DToA) Calculation:

- *Phase differences between signal replicas are used to determine DToA.*
- *Common reference sampling time across all antenna elements simplifies measurement.*
- *No complex calibration needed, ensuring high accuracy.*

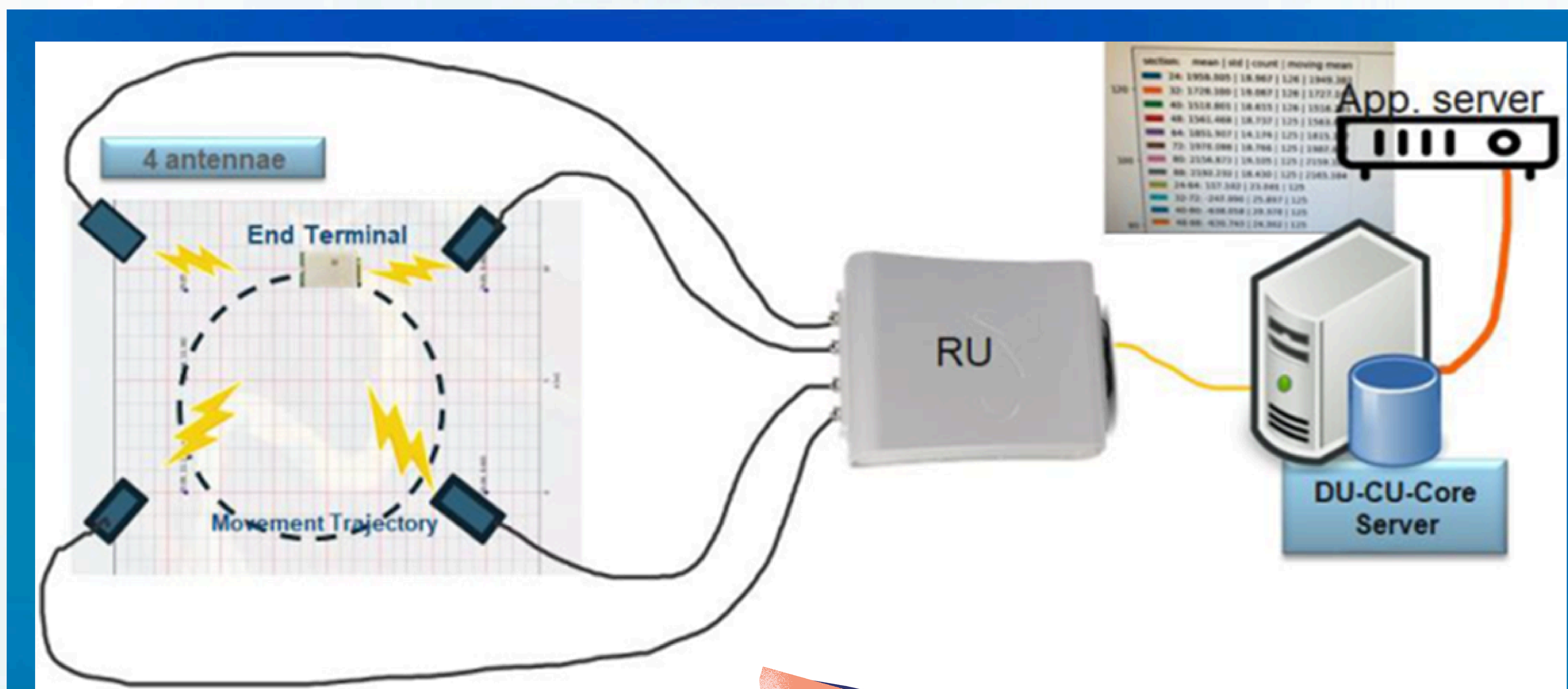

Figure 3: Accurate DToA processing

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