PROJECT ABSTRACT

LoRa Coverage Planner with Link-Budget Analysis

A web-based LoRa network planning tool: place gateways on a site map, predict RSSI per node with a log-distance path-loss model at 868 MHz, consult an SF7–SF12 link-budget table built from Semtech SX1276 datasheet sensitivities, and get a deployment report with duty-cycle and ADR guidance — built-to-order with source code, report, PPT and viva kit.

01. Title

LoRa Coverage Planner with Link-Budget Analysis

02. Introduction / Background

LoRa is the natural choice for long-range, low-power sensor networks on campuses, farms and industrial sites — but planning a deployment is usually guesswork. Gateways get mounted wherever a pole is handy, dead zones are discovered only after hardware is installed, and spreadsheet link budgets are abandoned once antennas go up. LoRaPlan makes coverage planning interactive and explainable: the student places gateways on a site map, picks the environment, spreading factor and TX power, and the tool predicts received signal strength at every end node. A link-budget table shows, for every spreading factor, receiver sensitivity, bit rate, maximum coupling loss and rural/urban range estimates — all computed from genuine Semtech SX1276 datasheet figures at 125 kHz bandwidth. A deployment report then answers the real question: how many gateways does this site actually need, and where should they go.

03. Problem Statement

Campus-scale LoRa projects are deployed by guesswork because professional RF planning software is expensive and assumes a radio-engineering background. Students cannot answer basic viva questions — why SF12 reaches farthest, what a link budget is, why the 1% duty-cycle rule matters — without a tool that computes these quantities honestly and shows the working. This project fills that gap with an explainable planner whose numbers are model estimates, clearly labelled as such, with a validation procedure for the real site.

04. Objectives

- Build an interactive coverage map: place gateways, see predicted RSSI rings and per-node signal colour-coding (strong / marginal / weak).
- Implement a link-budget table for SF7–SF12 from SX1276 datasheet sensitivities, TX power, antenna gains and an 8 dB fade margin.
- Provide environment presets (rural n=2.0, suburban n=2.4, urban campus n=2.9) driving the log-distance path-loss model at 868 MHz.
- Check the worst-node duty cycle against the EU 1% band rule.
- Generate a deployment report: gateway rollout list, coverage percentage, backhaul notes, cost-vs-gateway diminishing-returns analysis.

- Document an ADR strategy and a GPS walk-test validation procedure for the student's own site.

05. Proposed Methodology

The site is modelled as a 1.2 × 0.8 km urban campus with 48 end nodes (meters, valves, weather pods). Path loss follows PL(d) = 80.5 + 10·n·log10(d/10 m) at 868 MHz. Each node is assigned to the gateway giving the best predicted RSSI (TX power + antenna gains – path loss) and coloured against the SX1276 sensitivity for the selected spreading factor: strong (≥ –90 dBm), marginal (–110 to –90 dBm), weak (below –110 dBm). The link-budget engine derives maximum coupling loss per spreading factor and converts it to rural and urban range estimates (SF12/14 dBm: approximately 21.13 km rural, 1.96 km urban — model estimates, not measured claims). The duty-cycle checker converts payload size, spreading factor and reporting interval into airtime and flags nodes over the 1% band rule. All figures are design estimates; the included walk-test procedure validates the plan against measured RSSI on the real site.

06. System Architecture / Working

Single-file HTML/CSS/JS web app with three views: (1) Coverage Map — environment/SF/TX-power controls, gateway placement, live RSSI rings and node colour-coding with an RSSI legend; (2) Link Budget — per-spreading-factor table of sensitivity, bit rate, coupling loss and rural/urban range with the model assumptions printed; (3) Deployment Report — gateways planned, end nodes, nodes covered at –110 dBm, worst-node duty cycle, gateway rollout list and planner notes (ADR strategy, antenna height trade-offs, fiber vs LTE-M backhaul, walk-test validation, cost note). The working flow is: set environment and radio parameters → place gateways → read the coverage map → consult the link-budget table → generate the deployment report for the final report.

07. Hardware / Software Requirements

- Any modern browser (Chrome, Edge, Firefox) — the app is a single HTML file and runs fully offline
- No hardware required; it is a planning and teaching tool
- Site dimensions and node coordinates for the student's own site (templates included)
- GPS-tagged LoRa node for the optional walk-test validation

08. Expected Outcomes

A working planner in which placing three gateways on the demo urban campus covers 48/48 nodes at SF12 with the worst-node duty cycle at 0.9% (within the 1% band rule) — figures computed live by the app from the documented model. The student can defend every number in the viva: the path-loss equation, the datasheet sensitivities, the fade margin, and why the model must be validated by survey.

09. Applications

- Planning campus, farm and industrial LoRa deployments
- Wireless-communication coursework on link budgets and spreading factors
- Demonstrating ADR strategy and duty-cycle compliance

- Producing the deployment plan chapter of a project report

10. Future Scope

- Importing real site maps and building footprints
- Capacity/airtime study for dense networks
- 433 MHz and 915 MHz band parameter sets
- Export of the deployment report to PDF