TERRAIN-AWARE INFRASTRUCTURE PLANNING: AUTOMATED PLACEMENT OF RELIABLE GATEWAYS FOR LARGE-SCALE IOT NETWORKS

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Abstract. *Deploying large-scale Internet of Things (IoT) infrastructures in complex geographical environments presents significant challenges for maintaining reliable wireless connectivity. Terrain features such as elevation changes, obstacles, and line-of-sight limitations strongly affect signal propagation and coverage quality. This study investigates the optimal placement of LoRa gateways to ensure robust communication for distributed sensor networks operating in three-dimensional terrain.*

The problem is formulated as a Minimum k-Dominating Set [1] over a terrain-aware geometric graph, where edges represent feasible communication links derived from Digital Elevation Models (DEM) [2] and line-of-sight constraints. Our approach is to identify the smallest set of gateway locations providing k-redundant coverage. The resulting optimization problem is NP-hard, making exact solutions computationally challenging for large-scale instances.

To address this complexity, the study compares exact optimization methods based on Integer Linear Programming with metaheuristic optimization approaches. The proposed methodology constructs a DEM-based connectivity graph and evaluates algorithm performance across different terrain scenarios, measuring execution time, scalability, and optimality gap relative to exact solutions. The results demonstrate the potential of terrain-aware optimization models for automated infrastructure planning in real-world IoT deployments.

Key words: IoT, Infrastructure Planning, Terrain-Aware Optimization, Minimum K-Dominating Set, Wireless Sensor Networks, Gateway Placement, Digital Elevation Models, LoRa

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