Journées LPWAN 2026

NC-LoRaSim: A No-Code LoRaWAN Simulation Framework for NS-3

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OUTLINE

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    b) Limitations of existing LoRaWAN simulators
    c) Motivation
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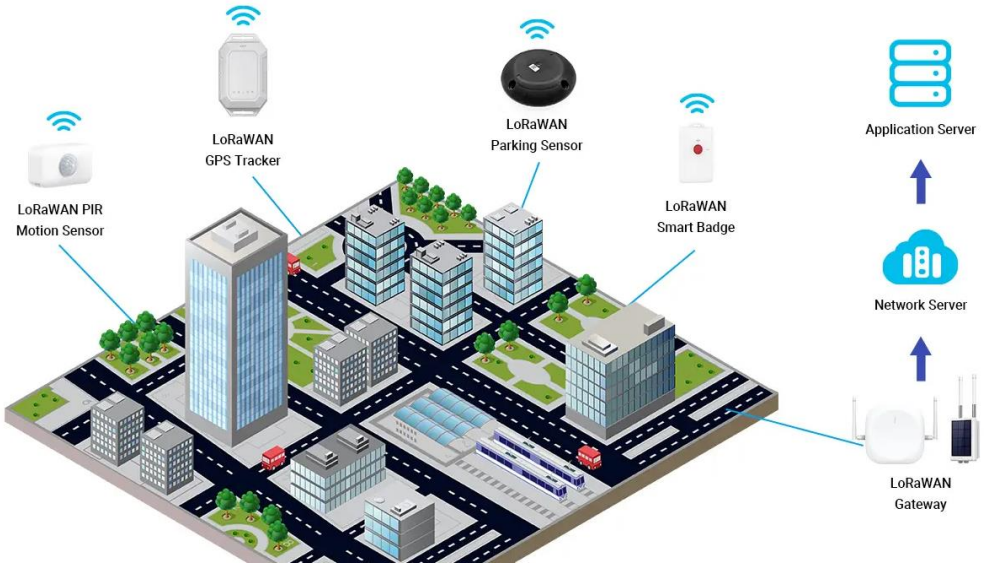
    a) Architecture and design
    b) Operation modes:
        i. Manual
        ii. Automatic
        iii. Advanced

3) Conclusion

Introduction

- ✓ The Internet of Things (**IoT**) is a reality today:
  - ✓ Smart cities
  - ✓ Smart farming
  - ✓ Smart metering
  - ✓ Environmental and Infrastructure Monitoring
  - ✓ Etc.



- ✓ A keystone solution: **LoRa/LoRaWAN** technology: enable long-range, low-power sensing and low cost.

Introduction

- ✓ Designing LoRa networks needs many parameter sweeps (SF, TP, GWs, placement, traffic load, propagation conditions, etc.) and extensive simulation.
- ✓ Existing tools trade off accessibility and fidelity:

Simulator	Strength	Limitation	Energy	Batch	GUI	Geo
LoRaSim	lightweight Python	simplified PHY/MAC	~	x	x	x
FloRa	OMNeT++ ecosystem	configuration complexity	✓	x	✓	x
LoRaWANSim	MATLAB modeling	proprietary environment	✓	x	x	x
ns-3 LoRaWAN	high fidelity	code-based workflow	~	x	x	x

- ✓ The issue is not only simulation accuracy, is how to make **systematic**, **reproducible**, **large-scale** LoRaWAN simulation **feasible** for more users.

Problem Statement & Objectives

- Gaps to fill:
  - **Accessibility**: simulators require **programming** skills and lack **a user-friendly**, graphical interface to configure or visualize LoRaWAN scenarios.
  - **Automation**: the batch execution and parameter sweeping must be **scripted manually**, with no integrated tools to automate or manage large experiment sets.
  - **Statistical Rigor**: Simulators do not natively support **repeated runs**, **confidence interval computation**, or built-in **statistical validation** of results.
  - **Visualization**: Current tools offer only **static plots** or raw log outputs, without interactive or **map-based visualization** of network behavior.
  - **Geographic Realism**: Simulations rely on **abstract coordinates** and idealized **propagation**, with no integration of real-world maps or **obstacles**.
- Problem:
  - How to fill these gaps?

Problem Statement & Objectives

- **NC-LoraSim**:
  - Web platform (client-server-data architecture) ➔ No-code, web UI for scenario design.
  - Three modes: Manual, Automatic (batch), Advanced (light C++ IDE).
  - OSM integration, multiple propagation models ➔ Realistic environments.
  - Predefined protocols (LLNRM, GeoNet, ADR) + exportable .cc
  - Automated statistics with 95% CI of a built-in metrics.
  - Persistent results storage.
- M-A. H. Amor and I. Bennis, 23rd International Symposium on Network Computing and Applications (**NCA**), Lisbon, Portugal, 2025, pp. 39-42, https://doi.org/10.1109/NCA67271.2025.00019

Targeted Public and Use Cases

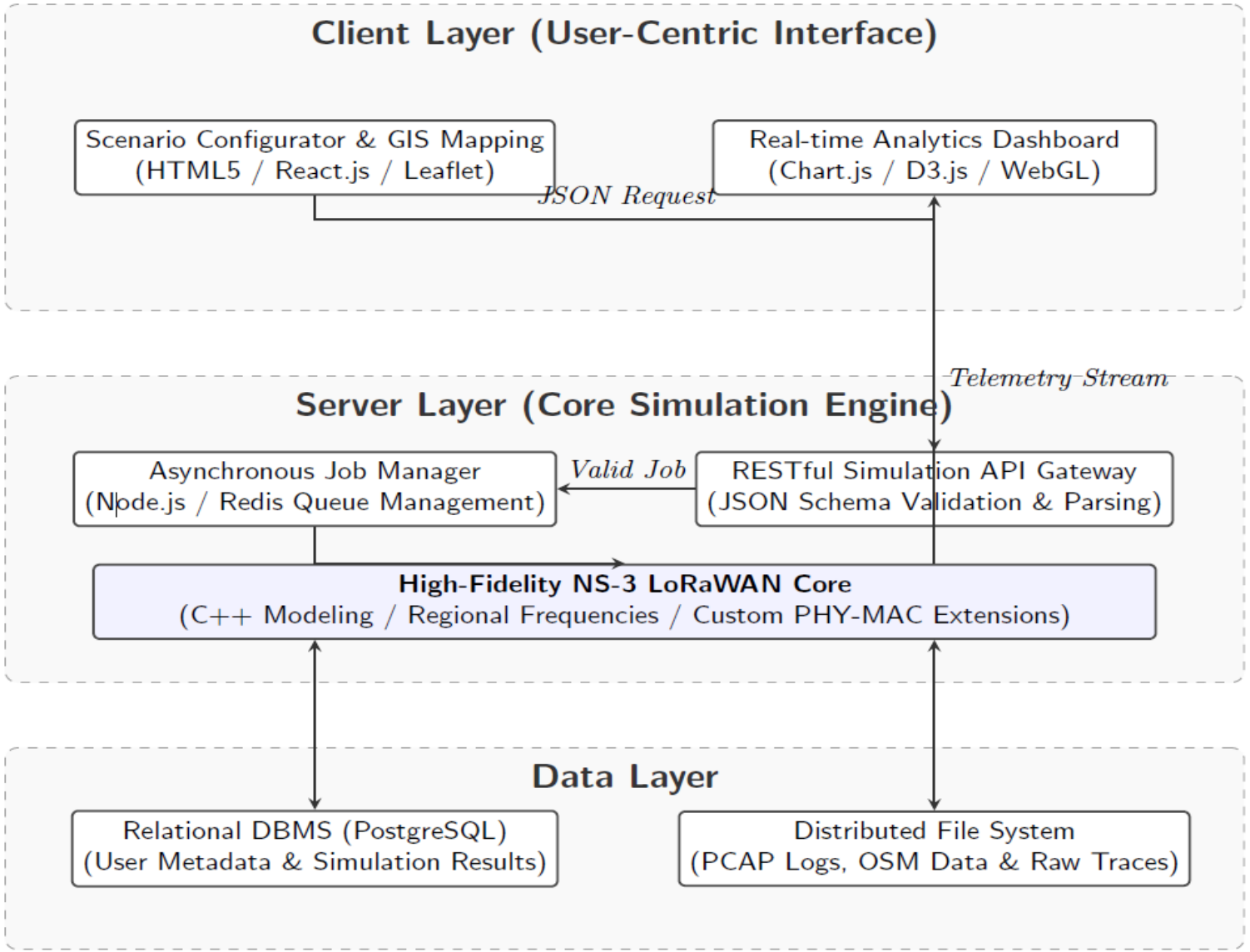
Research	Industry	Education
• Rapid prototyping of new LoRaWAN protocols. • Large-scale parameter sweeps. • Reproducible experiments with confidence intervals. • OSM-based realistic environments.	• Virtual testbed before real deployment. • Coverage and capacity planning. • QoS prediction (PDR, latency, energy). • Gateway placement and network optimization.	• Hands-on learning without NS-3 programming. • Understanding SF, ToA, and propagation effects. • Interactive visualization and experimentation. • Progressive learning (Manual → Automatic → Advanced).

✓ **NC-LoRaSim** democratizes high-fidelity LoRaWAN simulation for researchers, engineers, and students while preserving scientific rigor and reproducibility.

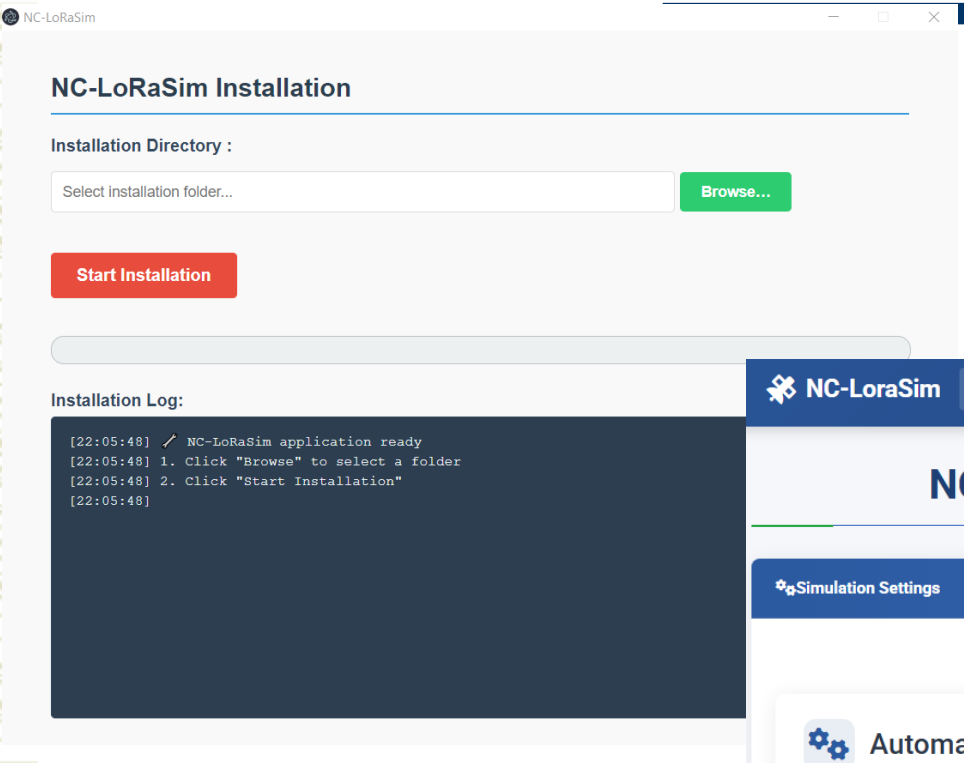
System Architecture

- **Client Layer**:
  - Provides an intuitive web interface using HTML, CSS, and JavaScript with frameworks (Bootstrap, Leaflet, Chart.js, and Three.js).
  - Users can configure simulation parameters and select real map areas from OSM without programming.
- **Server Layer**:
  - Built on Node.js, it manages simulation execution, **translates** user inputs into **NS-3 commands**, and parses results.
  - Custom NS-3 extensions in C++ and Python to add gateway placement, energy tracking, and realistic geographic modeling.
- **Data Layer**:
  - Uses an SQL database to store configurations, results, and map data, ensuring **persistence**, **reproducibility**, and **reliable** experiment management.

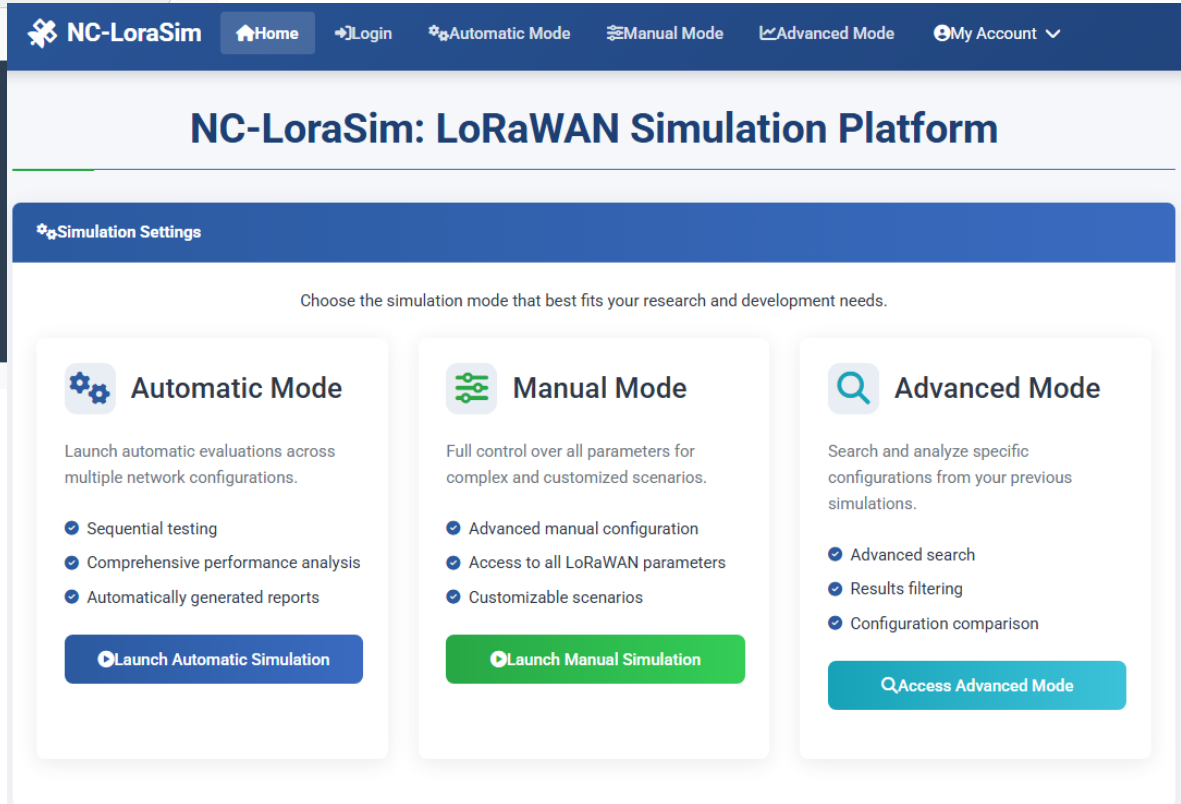
System Architecture



System Setup

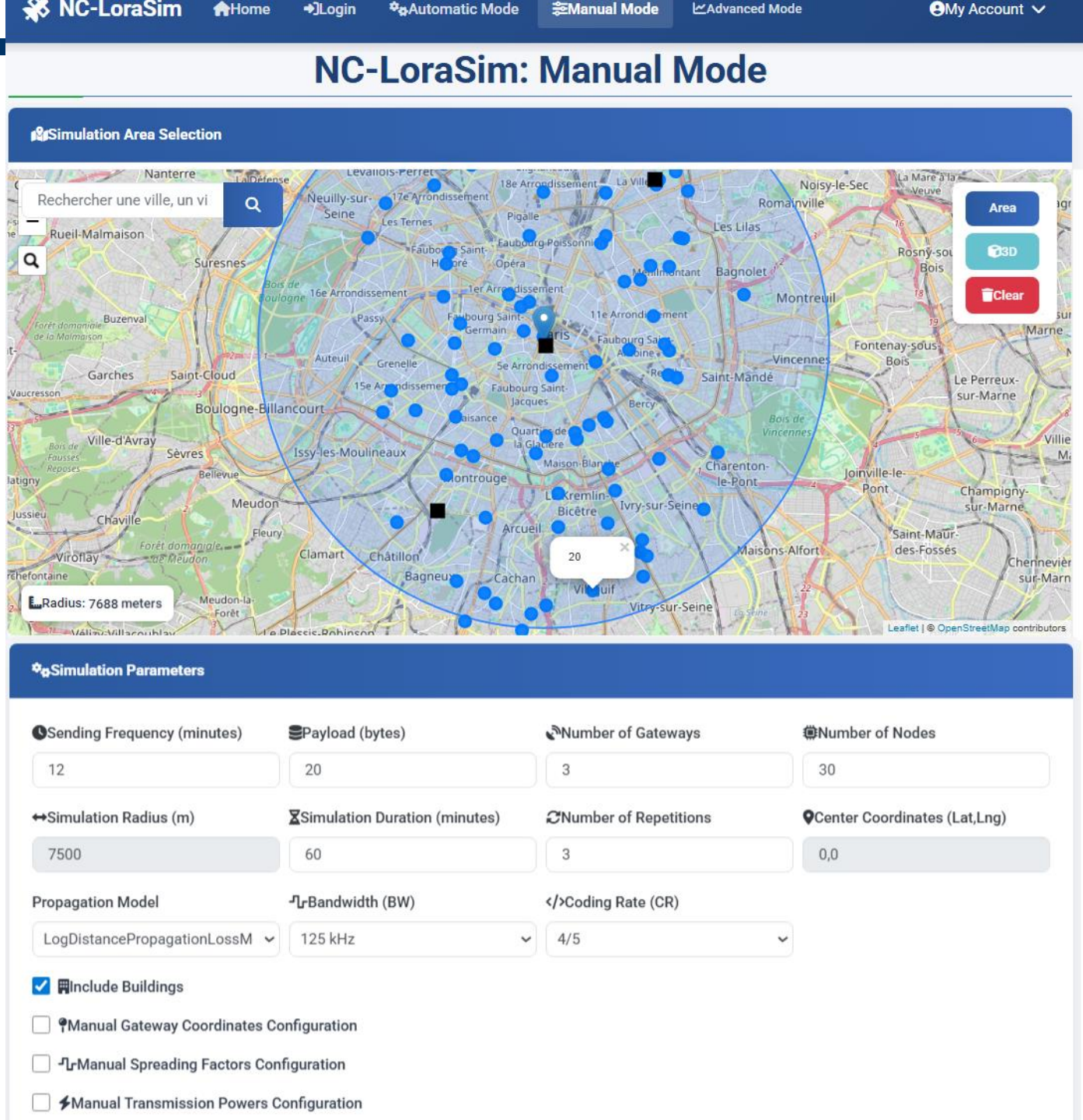


- ✓ includes an automated deployment framework, designed to reduce the configuration overhead



- ✓ main interface exposes three workflows

- ✓ Point-and-click scenario configuration (nodes, gateways, coords).
- ✓ Radio parameters: BW (125/250/500 kHz), CR (4/5…4/8), SF, TP.
- ✓ Propagation models: free-space, log-distance, shadowing, Nakagami, hybrid.
- ✓ Different output levels: global results / in-depth analysis.



Manual Mode – Global Results

- ✓ Total number of transmitted and successfully received packets, the overall PDR, and the 95% CI.
- ✓ **Gateway-level** metrics report the number of packets collected by GW.
- ✓ **Node-level** metrics detail: PDR, energy consumption, spatial coordinates, SF, data rate, and ToA.

Simulation Summary

3000	2121	70.7%	65.6% – 75.8%
Total Packets Sent	Total Packets Received	Packet Delivery Ratio (PDR)	95% Confidence Interval

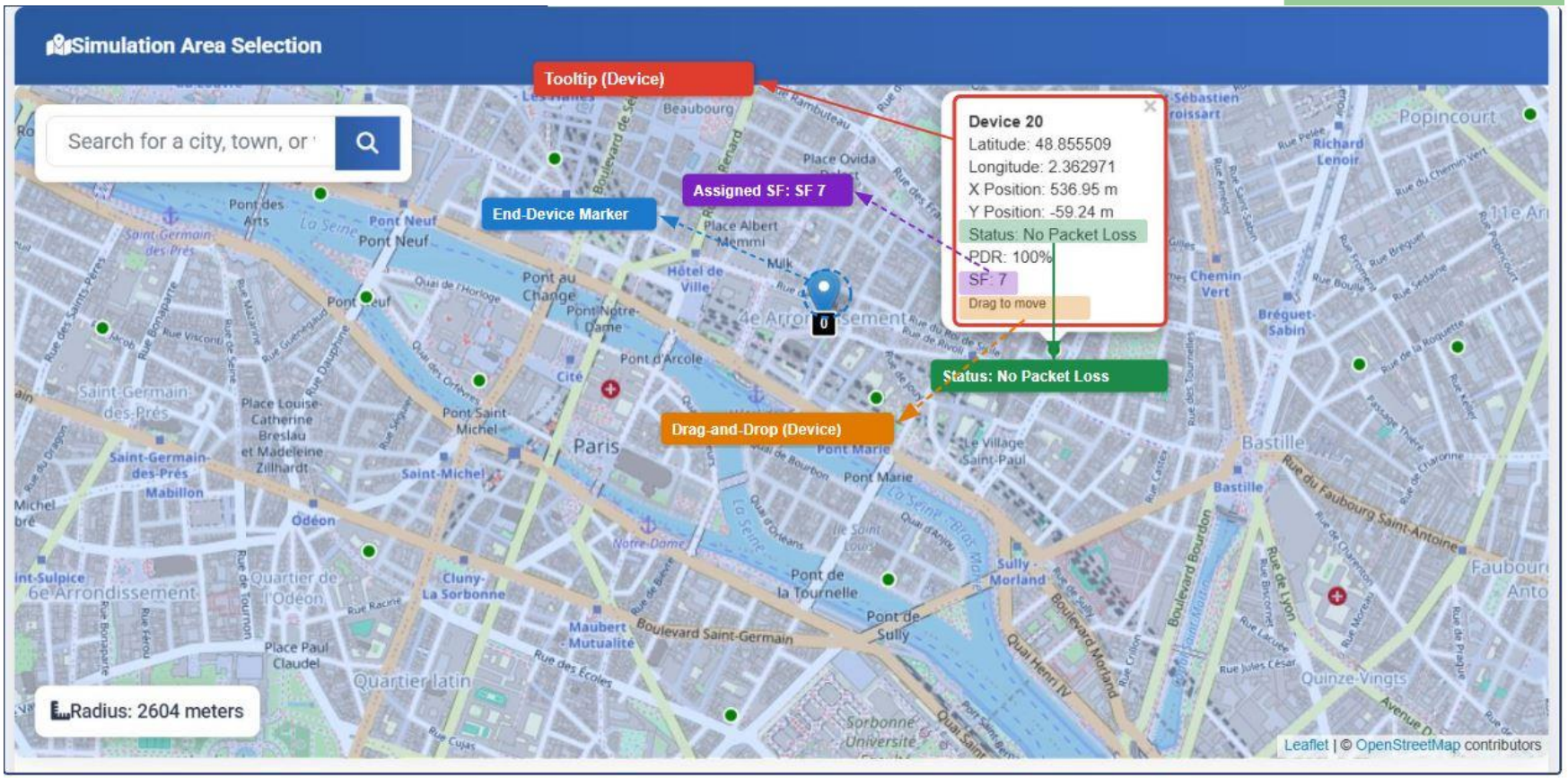
Packets Received per Gateway

Gateway ID	Packets Received	95% Confidence Interval (Packets)
GW0	900	851 – 949
GW1	750	704 – 796
GW2	650	606 – 694
GW3	500	460 – 540
GW4	400	363 – 437

Node Details

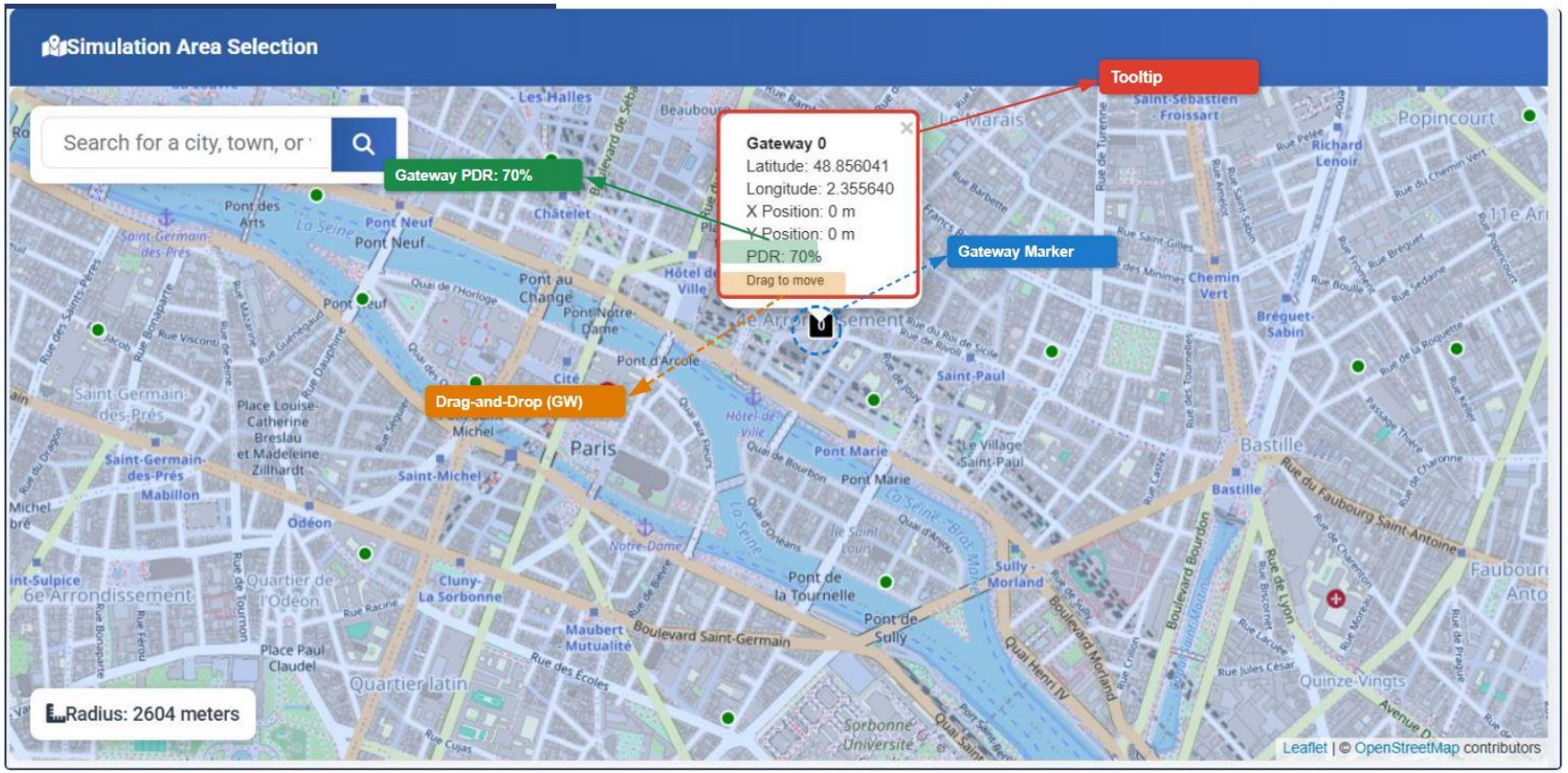
ID	X (m)	Y (m)	SF	Sent	Received	PDR (%)	ToA (ms)	Rate (kbps)	Energy (J)
1	500	7500	7	120	115	95.8%	56	2.86	0.60
2	1520	2000	9	130	120	92.3%	125	1.28	1.16
3	2322	1202	12	100	85	85%	1450	0.11	6.20
4	300	180	10	150	120	80%	450	1.8	0.40

Manual Mode – Interactive Exploration of Local Network Behavior



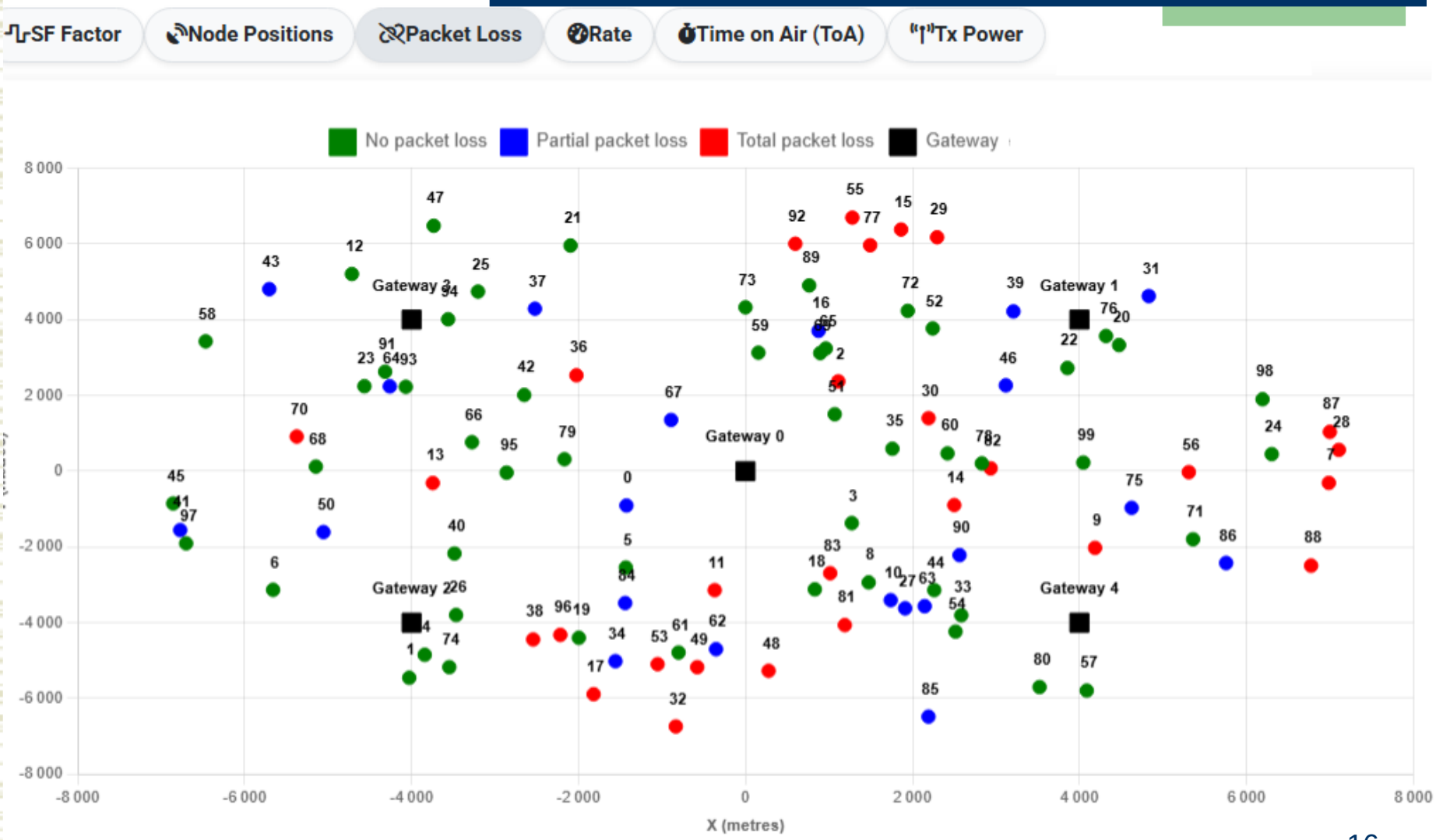
- ✓ Node and GW-level infos. (Position, SF assignment, loss status, PDR)
- ✓ identification of: coverage holes, overloaded GW, anomalous nodes.

Manual Mode – Interactive Exploration of Local Network Behavior



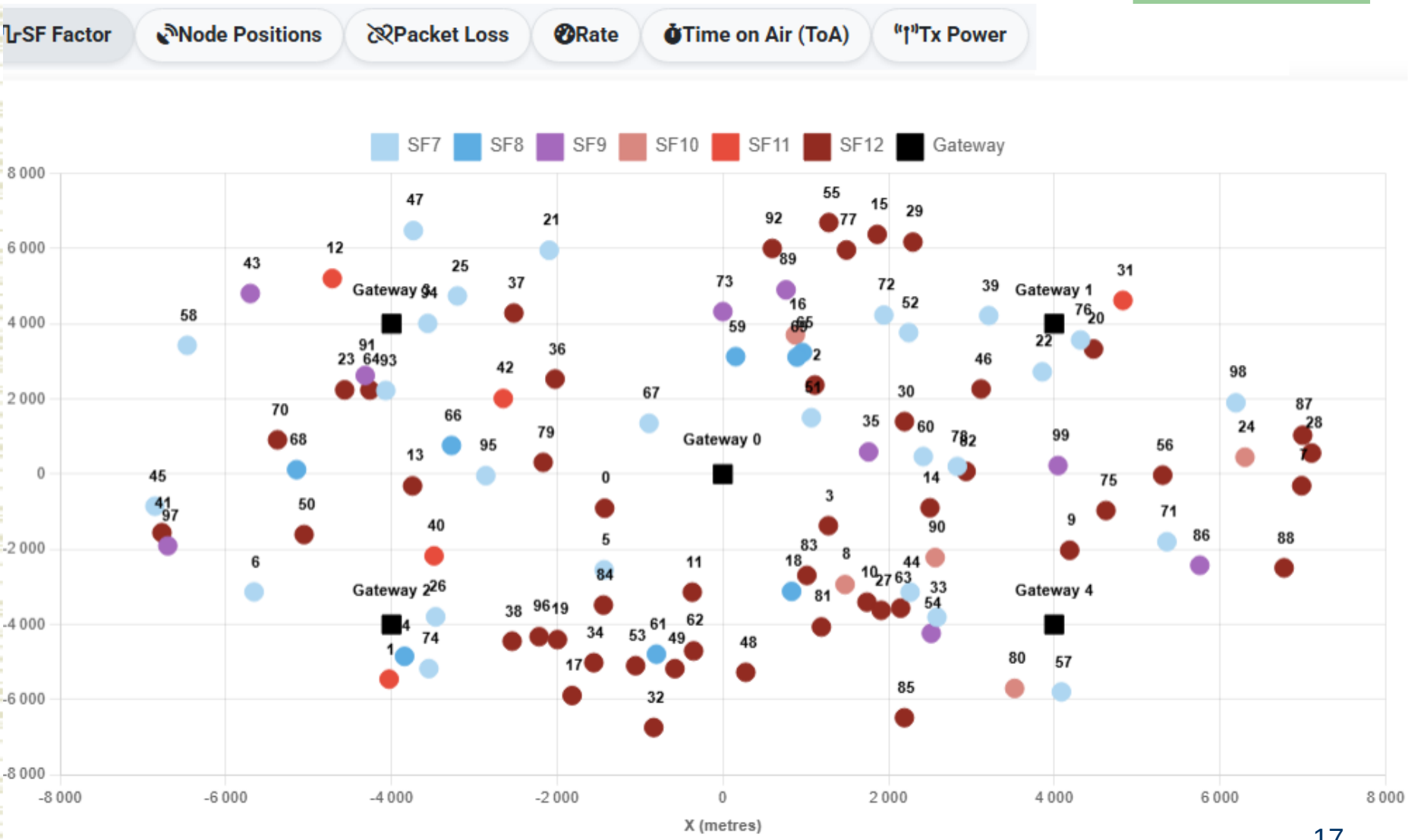
- ✓ Interactive Deployment Analysis: Drag-and-drop of nodes and GW.
- ✓ Rapid evaluation of coverage gaps and GW diversity.

Manual Mode – in-depth Analysis



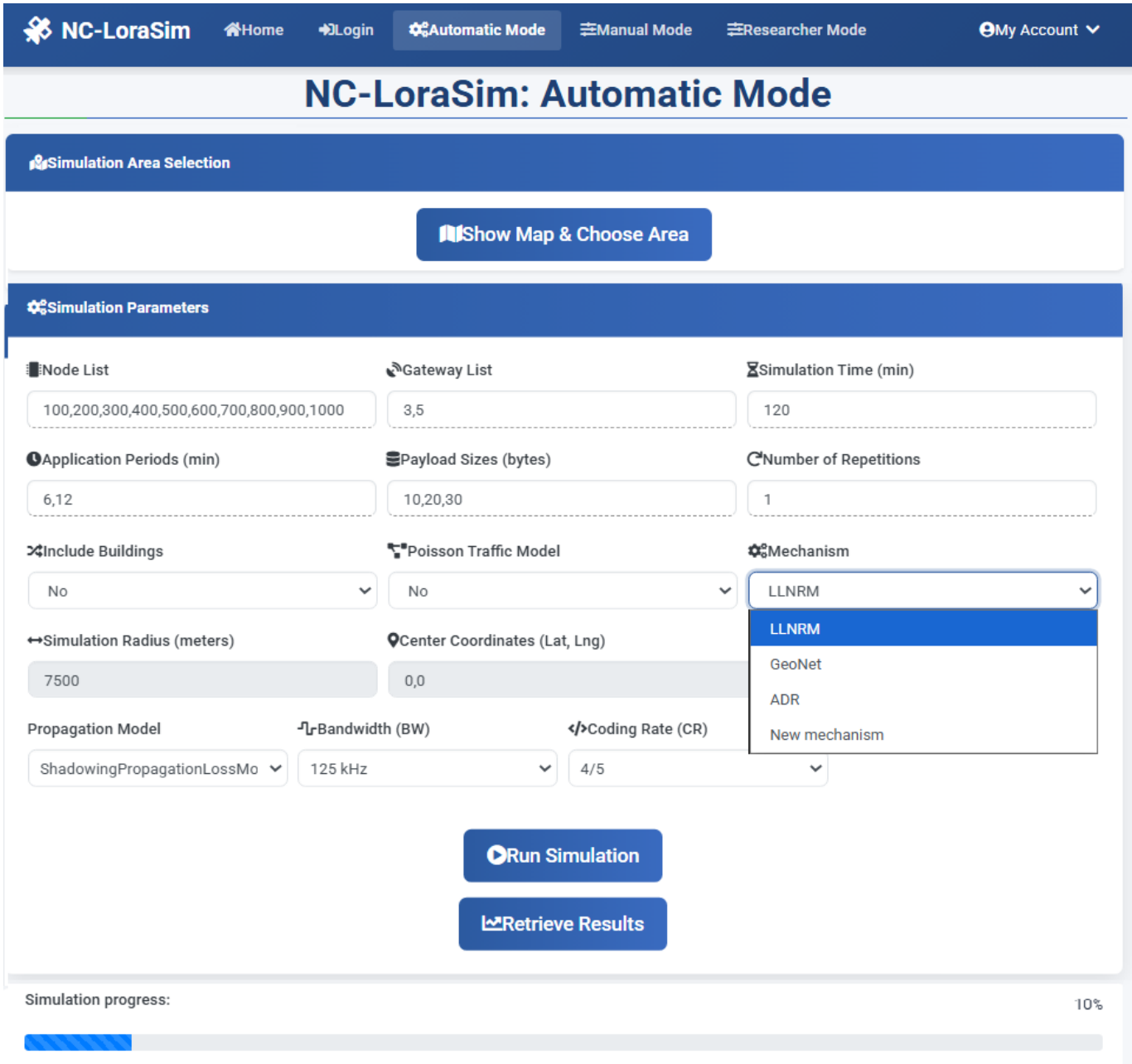
Coverage map with packet loss

Manual Mode – in-depth Analysis



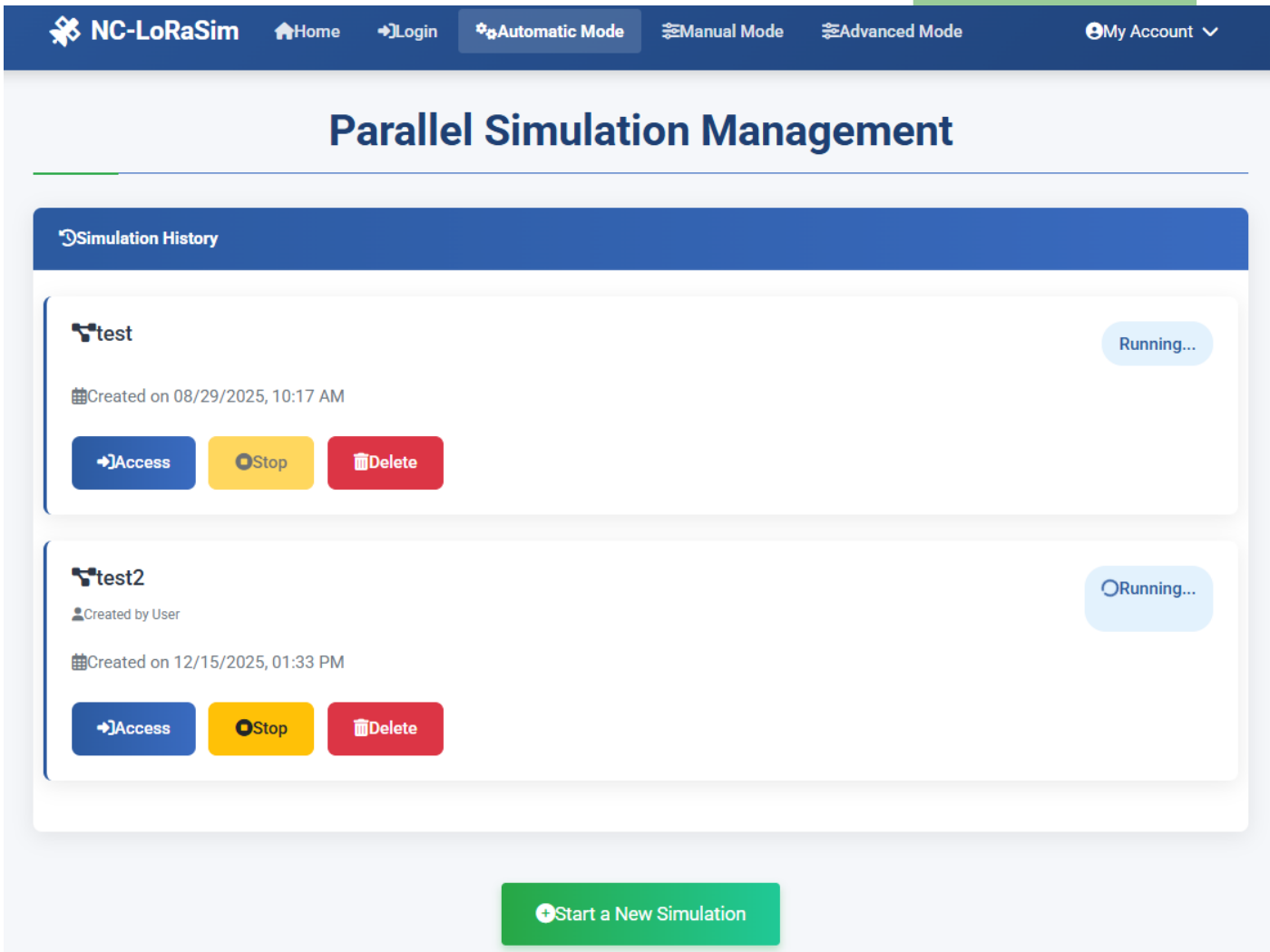
Coverage map with SF distribution

- ✓ Simplify and accelerate testing of multiple network parameters.
- ✓ Built-in protocols: LLNRM, GeoNet, ADR; upload custom protocol (.cc).
- ✓ key performance indicators: PDR, energy consumption, and latency.

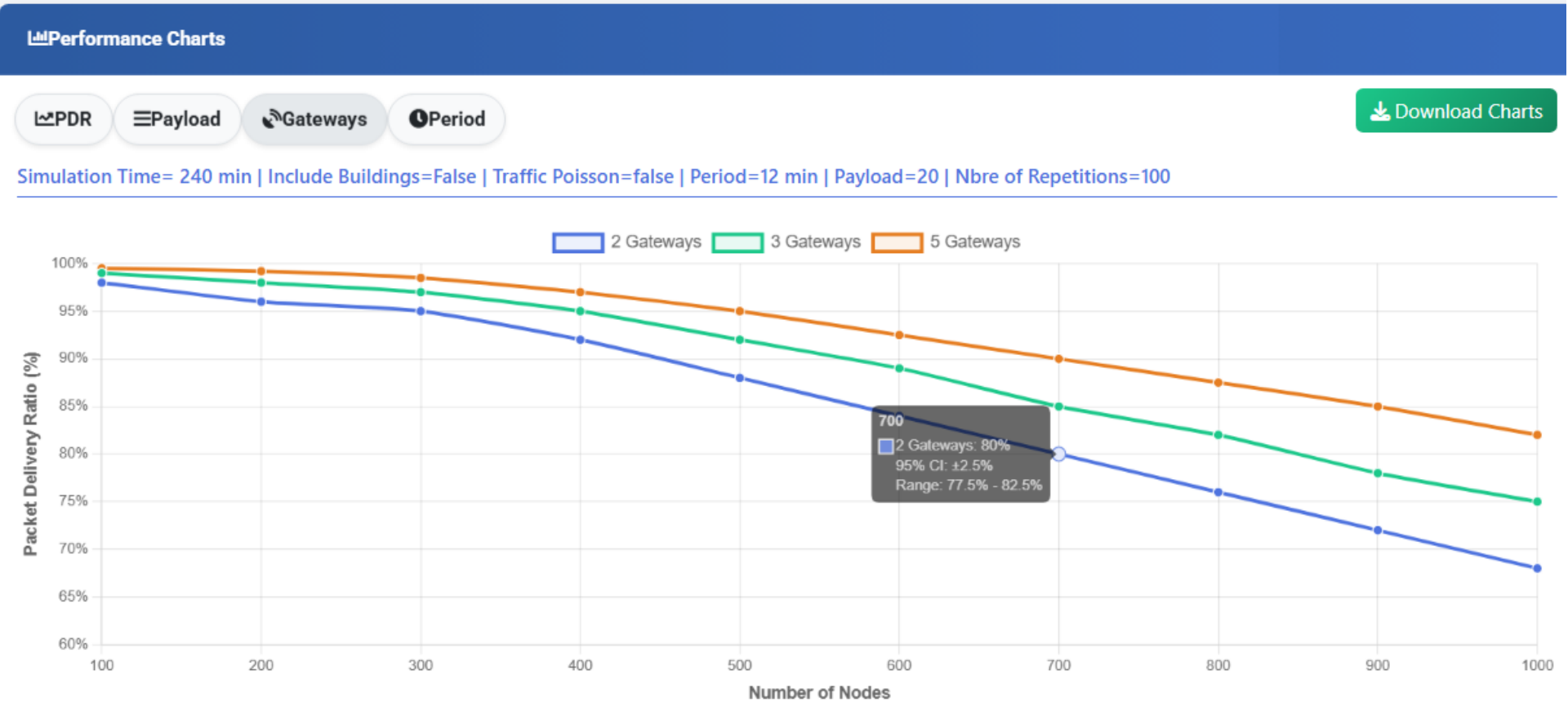


Automatic Mode

- ✓ Centralized interface for managing simulation campaigns
- ✓ Define, save, reuse, and modify simulation scenarios
- ✓ Handles scenario generation, execution scheduling, progress monitoring, error logging, and result storage



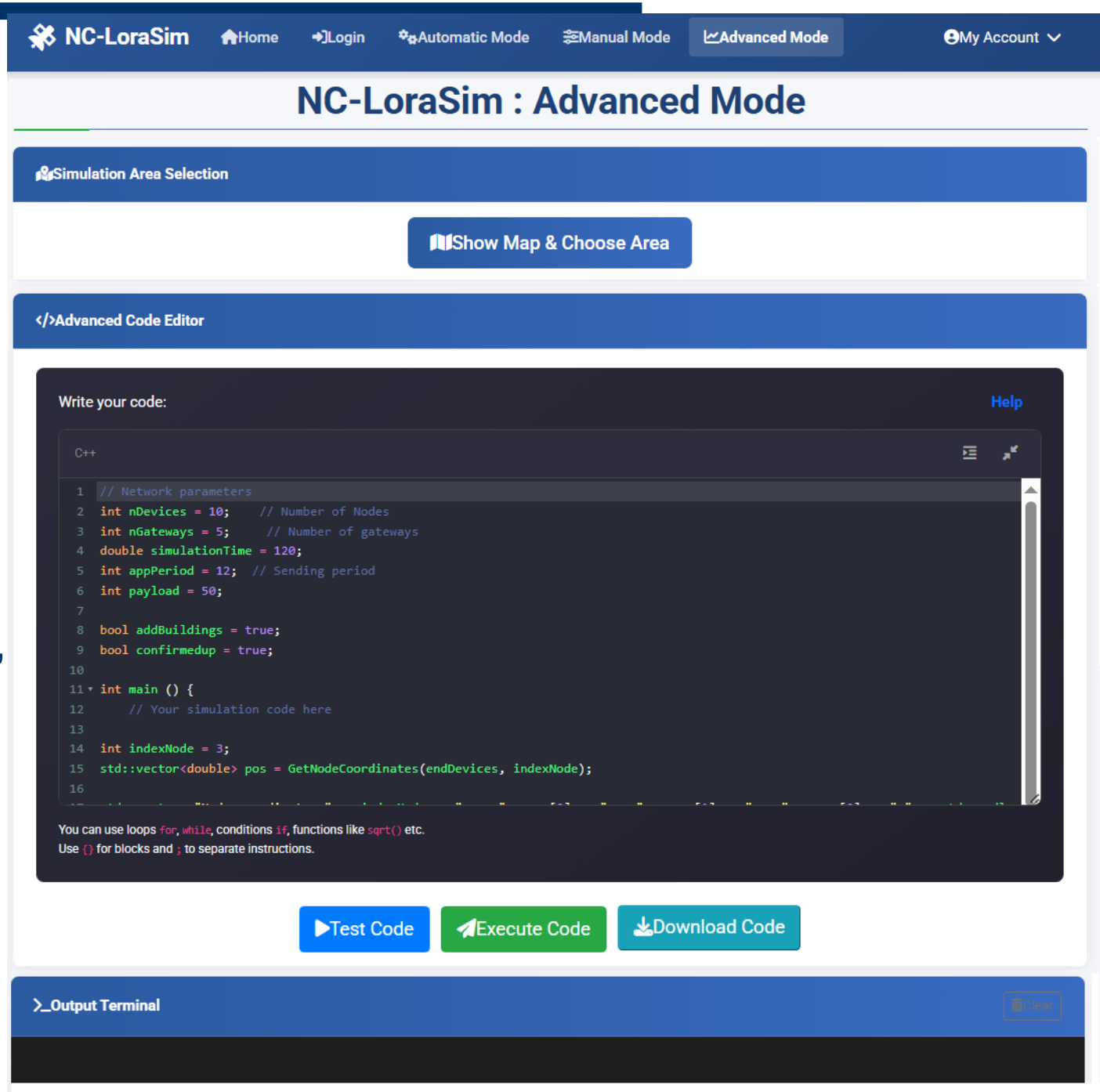
Automatic Mode - Outputs



Interactive performance graphs with confidence intervals

➔ highlight the impact of key factors on network performance

- ✓ Integrates a lightweight C++ IDE with interactive terminal.
- ✓ Pre-defined functions: **changeSF**(), **changePT**(), **statisticsPDR**(), etc. ➔ enable researchers to focus on the logic of their experiments



Conclusion

- **NC-LoRaSim** offers lowers entry barrier to realistic LoRaWAN research.
- Combines NS-3 accuracy, no-code GUI, batch statistics and prototyping IDE.
- Available:

- Future Research Directions:
  - ✓ Include mobility scenarios.
  - ✓ Extend analysis with additional metrics.
  - ✓ Validate through a real-world testbed comparisons and large-scale stress tests.