

NCA 2025

The 23rd IEEE International Symposium on
Network Computing and Applications

November 5-7th, 2025
Instituto Superior Técnico, Lisbon, Portugal

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

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OUTLINE

1) Introduction and Context

- a) IoT & LoRaWAN
- b) Limitations of existing LoRaWAN simulators
- c) Motivation

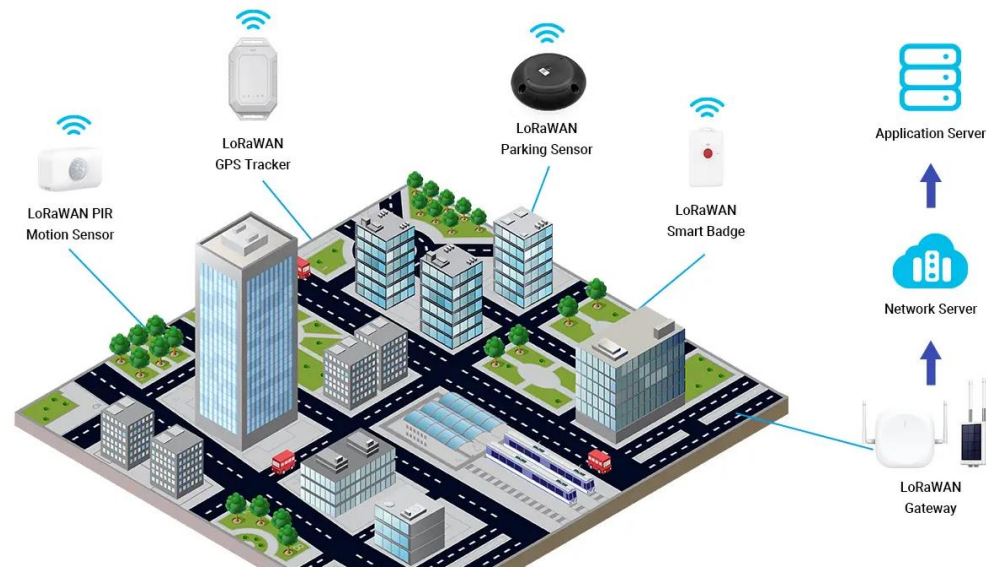
2) Proposed solution : NC-LoRaSim

- 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

Introduction

- ✓ Designing LoRa networks needs many parameter sweeps (SF, TP, gateways, placement...) and extensive simulation
- ✓ Existing tools trade off accessibility and fidelity:
 - **LoRaSim, LoRa-MAB**: lightweight/Python, limited stack (PHY/MAC)
 - **FLoRa, LoRaWANSim**: richer, but tool & license limitations
 - **NS-3** LoRa modules: accurate but code-only
- ✓ 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 statement & objectives

✓ Problem:

- ✓ How to fill these gaps?
- ✓ Researchers/teachers lack **accessible, reproducible** LoRaWAN simulation tools with NS-3 **fidelity**

✓ 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



System arc

Client Layer:

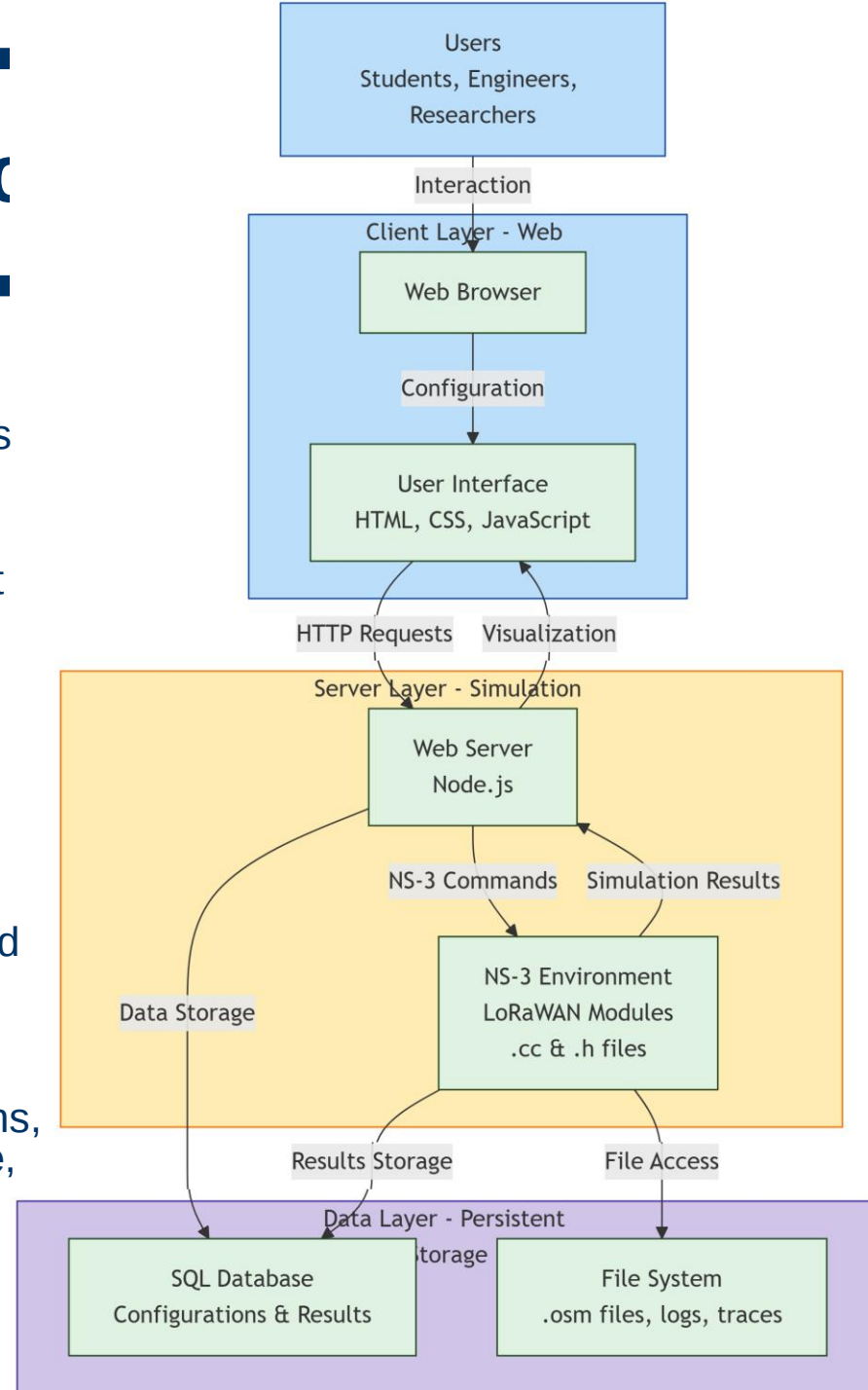
- ✓ Provides an intuitive web interface using HTML, CSS, and JavaScript with frameworks (Bootstrap, Leaflet, Chart.js, and Three.js).
- ✓ Users can configure simulation parameters and select real map areas from OSM without programming.

Server Layer:

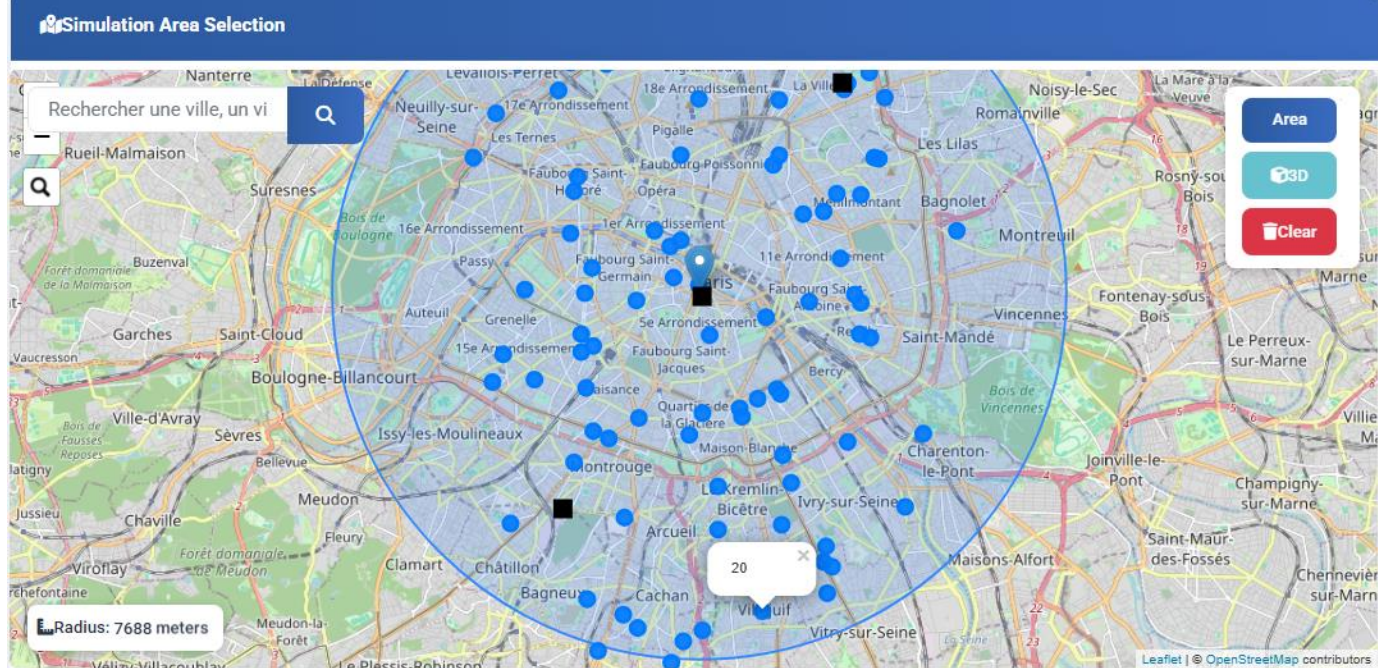
- ✓ Built on Node.js, it manages simulation execution, **translates** user inputs into **NS-3 commands**, and parses results.
- ✓ Custom NS-3 extensions in C++ and Python add gateway placement, energy tracking, and realistic geographic modeling.

Data Layer:

- ✓ Uses an SQL database to store configurations, results, and map data, ensuring **persistence**, **reproducibility**, and **reliable** experiment management.



NC-LoraSim: Manual Mode



Simulation Parameters

Sending Frequency (minutes)	Payload (bytes)	Number of Gateways	Number of Nodes
12	20	3	30
Simulation Radius (m)	Simulation Duration (minutes)	Number of Repetitions	Center Coordinates (Lat,Lng)
7500	60	3	0,0
Propagation Model	Bandwidth (BW)	Coding Rate (CR)	
LogDistancePropagationLossM	125 kHz	4/5	
☒ Include Buildings			
☐ Manual Gateway Coordinates Configuration			
☐ Manual Spreading Factors Configuration			
☐ Manual Transmission Powers Configuration			

✓ 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

Total Packets Sent

2121

Total Packets Received

70.7%

Packet Delivery Ratio (PDR)

65.6% – 75.8%

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 – in-depth analysis

⌵SF Factor

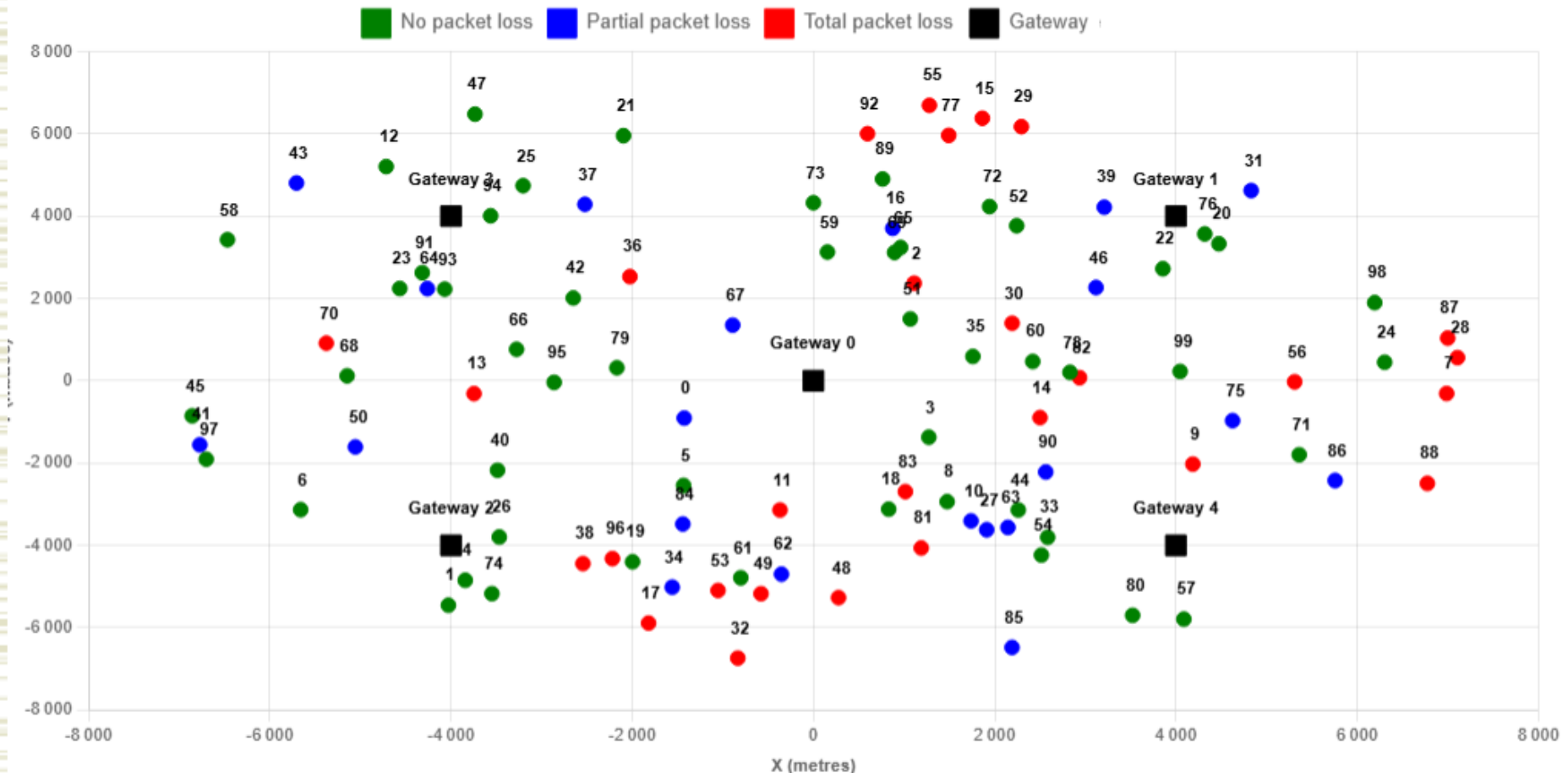
📍Node Positions

📶Packet Loss

📶Rate

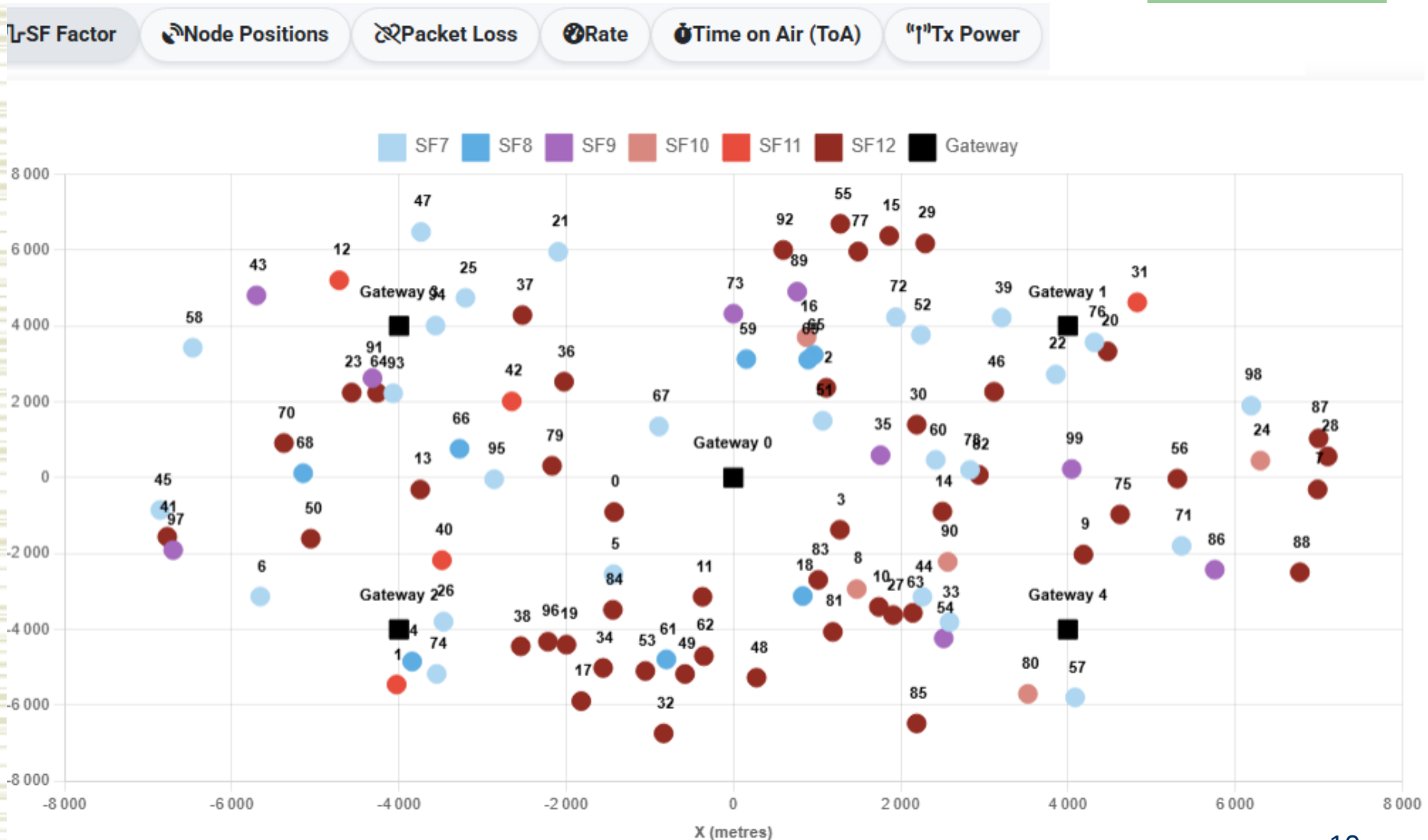
🕒Time on Air (ToA)

📶Tx Power



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


NC-LoraSim
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[Automatic Mode](#)
[Manual Mode](#)
[Researcher Mode](#)
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NC-LoraSim: Automatic Mode


Simulation Area Selection

[Show Map & Choose Area](#)


Simulation Parameters


Node List


Gateway List


Simulation Time (min)


Application Periods (min)


Payload Sizes (bytes)


Number of Repetitions


Include Buildings


Poisson Traffic Model


Mechanism

LLNRM
LLNRM
GeoNet
ADR
New mechanism


Simulation Radius (meters)


Center Coordinates (Lat, Lng)

Propagation Model


Bandwidth (BW)


Coding Rate (CR)

[Run Simulation](#)

[Retrieve Results](#)

Simulation progress:

10%

Automatic mode - Outputs

Performance Charts

PDR

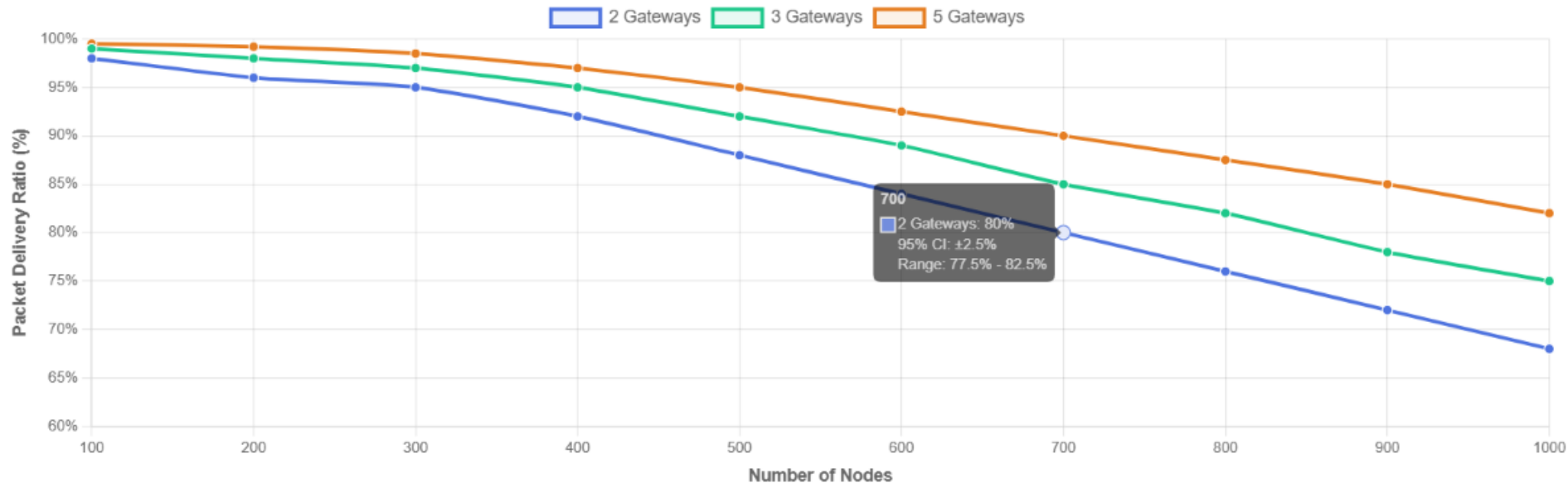
Payload

Gateways

Period

Download Charts

Simulation Time= 240 min | Include Buildings=False | Traffic Poisson=false | Period=12 min | Payload=20 | Nbre of Repetitions=100



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

NC-LoraSim

Home Login Automatic Mode Manual Mode Advanced Mode My Account

NC-LoraSim : Advanced Mode

Simulation Area Selection

Show Map & Choose Area

</>Advanced Code Editor

Write your code: [Help](#)

```
C++
1 // Network parameters
2 int nDevices = 10; // Number of Nodes
3 int nGateways = 5; // Number of gateways
4 double simulationTime = 120;
5 int appPeriod = 12; // Sending period
6 int payload = 50;
7
8 bool addBuildings = true;
9 bool confirmedup = true;
10
11 int main () {
12     // Your simulation code here
13
14     int indexNode = 3;
15     std::vector<double> pos = GetNodeCoordinates(nDevices, indexNode);
16 }
```

You can use loops `for`, `while`, conditions `if`, functions like `sqrt()` etc.
Use `{ }` for blocks and `;` to separate instructions.

Test Code Execute Code Download Code

>_Output Terminal [Clear](#)

Conclusion

- **NC-LoRaSim** offers lowers entry barrier to realistic LoRaWAN research
- Combines NS-3 accuracy, no-code GUI, batch statistics and prototyping IDE
- Repo: <https://github.com/HADJAMOR/NC-LoraSim>
- Future Research Directions:
 - ✓ Include mobility scenarios.
 - ✓ All-in-one solution: integrating all required dependencies over different platforms
 - ✓ Extend analysis with additional metrics.
 - ✓ Validate through a real-world testbed comparisons and large-scale stress tests