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Transmit Less, Deliver More

Frugal On-Device Intelligence for Energy- and Spectrum-Sustainable Direct-to-Satellite IoT

Inria | INSA Institut National des Sciences Appliquées Lyon

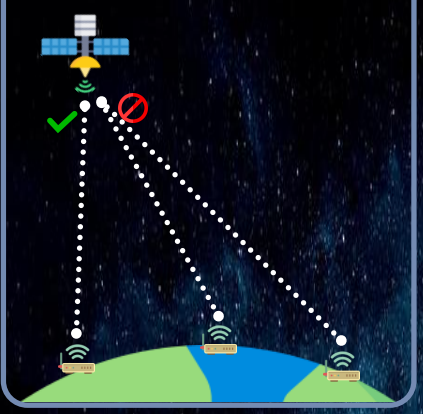
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The Problem

- **Resource-constrained nodes transmit blindly: fewer than 1 frame in 5 arrives.**
- **78% of losses are collisions: dead batteries and spectrum congestion.**



Innovation: From Blind to Intelligent Devices

The Innovation: a lightweight on-device ML predictor that skips transmissions predicted to fail, **reducing unnecessary energy consumption.**



64 KB model shipped as a firmware update: no downlink, no satellite change.

What are the benefits?

- Energy: radio energy per delivered packet halved, extending battery life.
- Spectrum: about 40% of airtime returned to the shared band.

Is it just congestion relief?

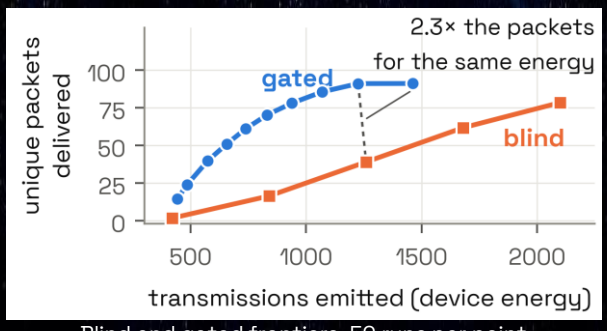
- No: at the same number of transmissions, gated devices deliver 2.3× more unique packets than blind ones (91 vs 38.9).

Results in Numbers

+16%	−42%	2.3×	2×
packets delivered	transmissions emitted	data for the same energy	packets per battery

Sustainability Impact and Improvement

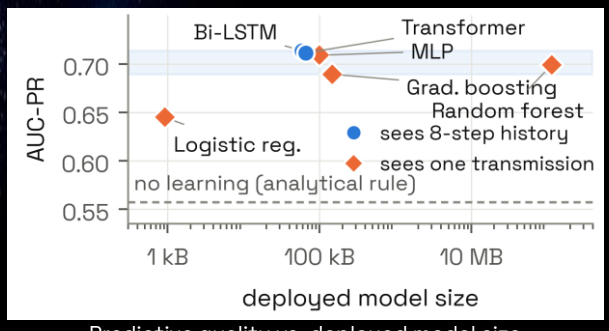
- **Reduction** of energy consumption and channel occupancy.
- **+16.1%** unique packets delivered
- **−41.6%** transmissions emitted



Blind and gated frontiers, 50 runs per point

The Overhead of On-Device Intelligence

- **Accuracy plateaus early**, but deployment costs span five orders of magnitude.
- In NTN, the **energy and memory** dictate viability, not marginal accuracy.



Predictive quality vs. deployed model size

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FLoRaSat simulator
open source