

Master's Thesis Proposal

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Title : Machine Learning-Based Traffic Prediction and Scheduling for IoT Uplink in Satellite Networks Considering Visibility Windows.

Targeted field of study: Datascience et intelligence artificielle

Context :

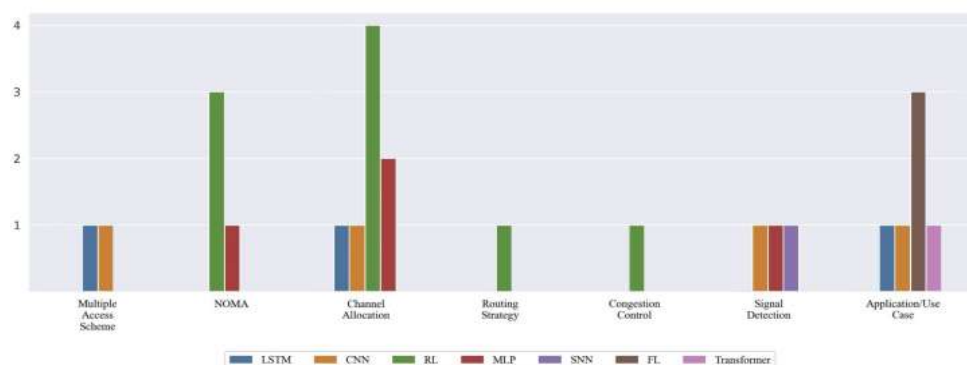
The increasing deployment of IoT devices in remote and underserved regions highlights the need for satellite-based communication systems to complement terrestrial networks. However, IoT traffic is inherently **bursty, heterogeneous, and unpredictable**, making it difficult to efficiently allocate satellite uplink resources. This challenge is amplified in **non-geostationary satellite constellations**, where the available transmission window is strictly limited to the **satellite visibility period**.

Traditional resource allocation and scheduling strategies are often **reactive**, relying on instantaneous demand rather than predictive analytics, which can lead to **resource underutilization, congestion, or high packet error rates (PER)**. To address this, it becomes crucial to **anticipate IoT traffic patterns** and align them with satellite visibility constraints, thereby enabling **proactive and intelligent scheduling**.

This problem motivates the use of **machine learning techniques** for predicting IoT uplink demand and dynamically selecting the optimal transmission slots to maximize efficiency and maintain Quality of Service (QoS).



ML Techniques used in SIoT domain



Objectives

1. Traffic Prediction

- Develop machine learning models (e.g., recurrent neural networks, LSTM, or temporal convolutional networks) to forecast the volume and timing of IoT uplink traffic.

2. Visibility-Aware Scheduling

- Incorporate satellite orbital parameters and visibility windows into the scheduling framework.
- Ensure that transmissions are aligned with periods of satellite coverage.

3. Resource Allocation Optimization

- Design a predictive resource allocation algorithm that determines the optimal number of Physical Resource Blocks (PRBs) or equivalent uplink resources required.
- Minimize packet error rate (PER) and maximize throughput.

4. Performance Evaluation

- Compare the proposed ML-based scheduling approach against baseline methods (e.g., random allocation, fixed scheduling).
- Assess performance in terms of **resource utilization, delay, PER, and energy consumption**.

Methodology

1. Data Collection / Simulation

- Generate IoT traffic models (periodic sensors, bursty event-driven traffic, mixed workloads).
- Simulate satellite visibility periods using orbital parameters (LEO constellation).

2. Machine Learning Model Development

- Train models (RNN, LSTM, GRU, or Transformer-based predictors) on IoT traffic traces.
- Predict traffic demand over short-term intervals.

3. Scheduling and Resource Allocation Algorithm

- Develop a visibility-aware scheduler that integrates ML traffic forecasts with satellite pass schedules.
- Implement preemption strategies for critical IoT traffic.

4. Evaluation and Benchmarking

- Evaluate the framework using simulation platforms (e.g., ns-3, OMNeT++, or custom Python-based simulator).
- Benchmark against static scheduling and non-predictive methods.

Bibliography

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2. **Release 18** – Enhancements for satellite IoT: Non-Terrestrial Networks (NTN) Overview
3. 3GPP Release-18 Physical Layer Enhancements for IoT-NTN
4. On the role of machine learning in satellite internet of things: A survey of techniques, challenges, and future directions.
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