Trajectory-Aware Rate Adaptation for Flying Networks

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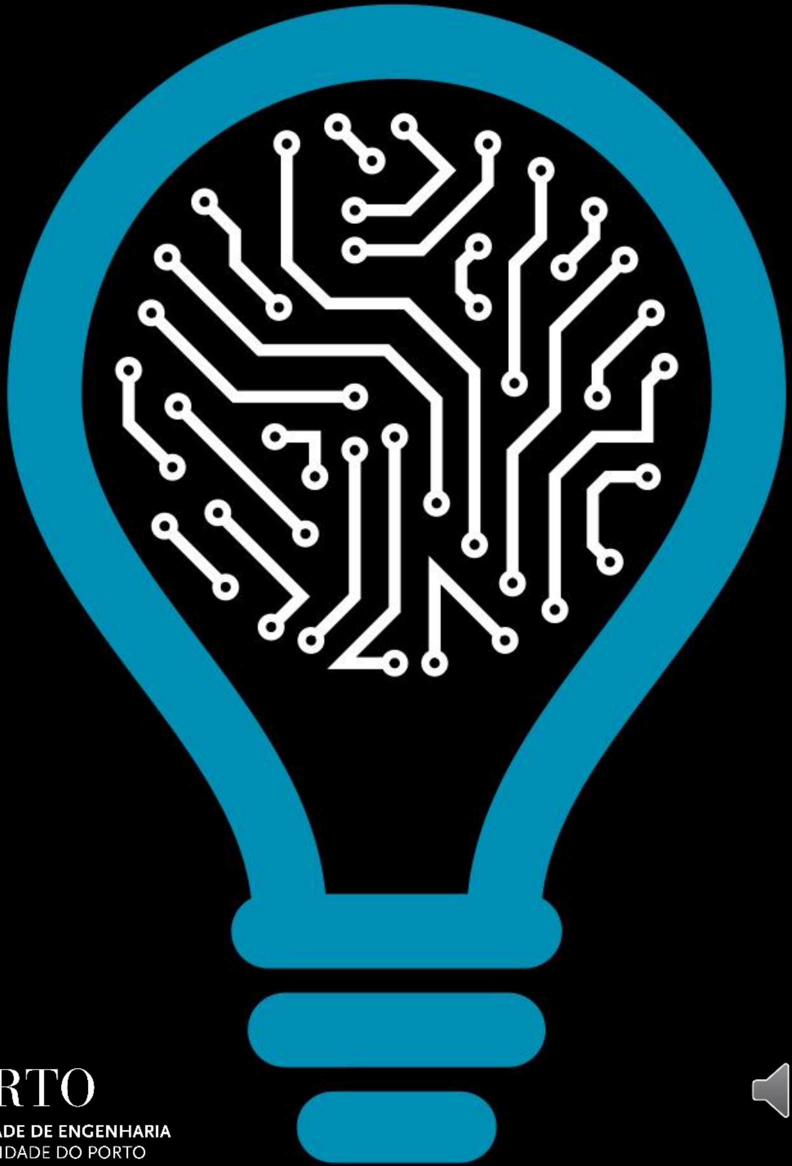

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Presentation Overview

- **Introduction:** Context, Motivation and Contributions
- **Trajectory Aware Rate Adaptation (TARA)**
- **Simulation Results**
- **Conclusions** and Future Work

Introduction

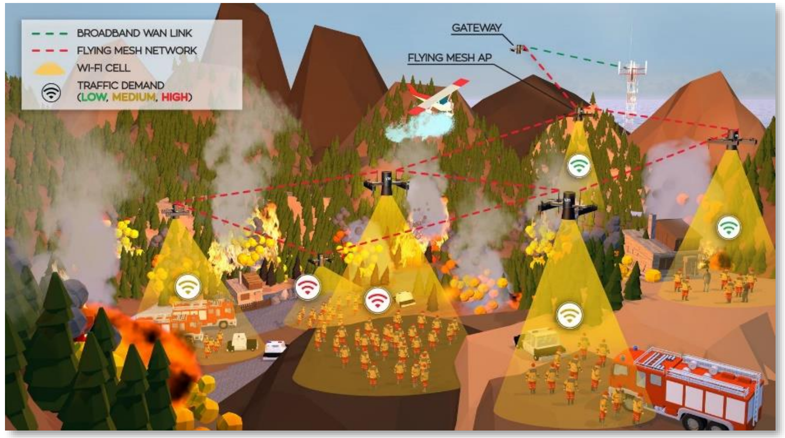
Introduction – Context

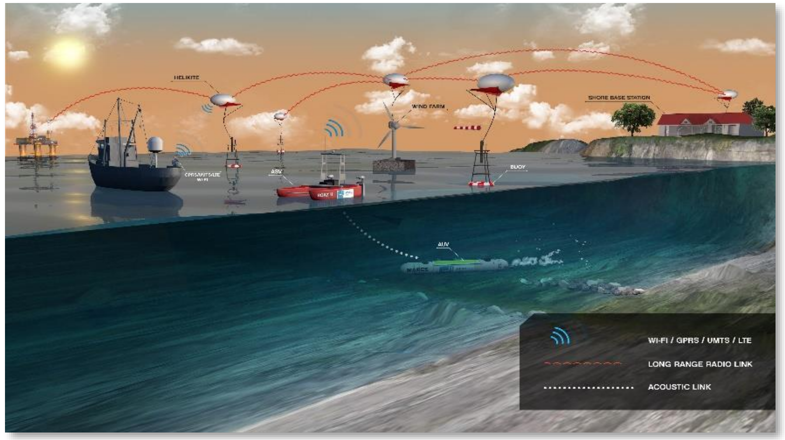
Unavailable Communications Infrastructure

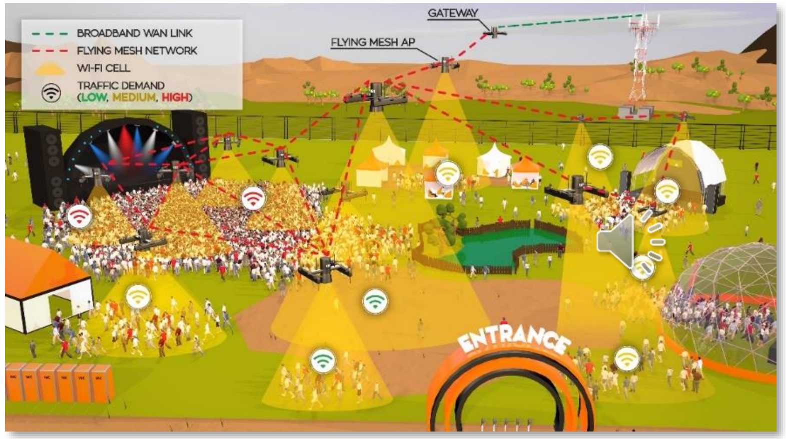
- Natural and man-made disasters
- Offshore maritime activities
- Temporary Crowded Events

On-demand Aerial Networks

- Composed of Unmanned Aerial Vehicles (UAVs)
- Fast, cost-effective and flexible solution
- Network coverage extension and increased capacity







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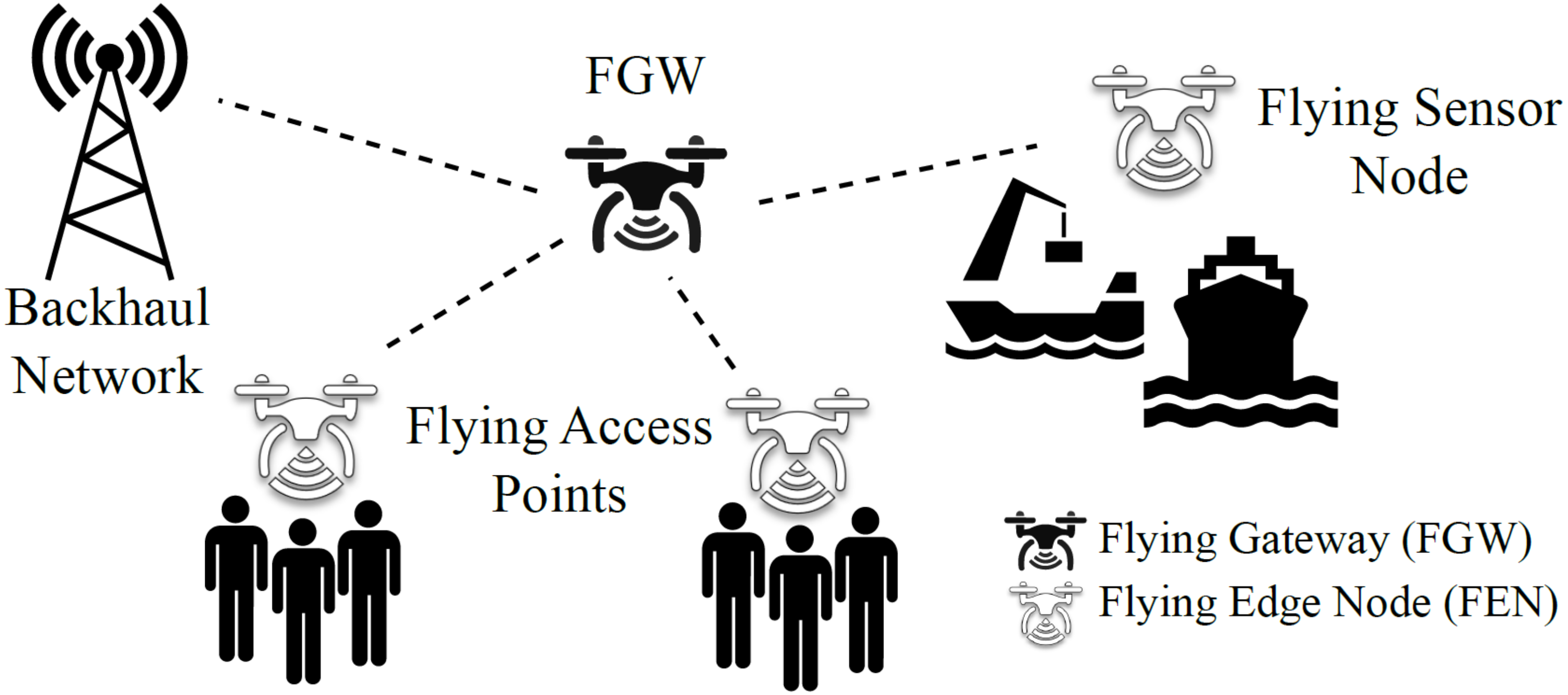
Motivation



Existing works propose **Rate Adaptation** algorithms
that **do not consider** the specific **characteristics of Flying Networks**

Contributions

Trajectory Aware Rate Adaptation (**TARA**) Algorithm

Uses the future trajectories of Flying Nodes

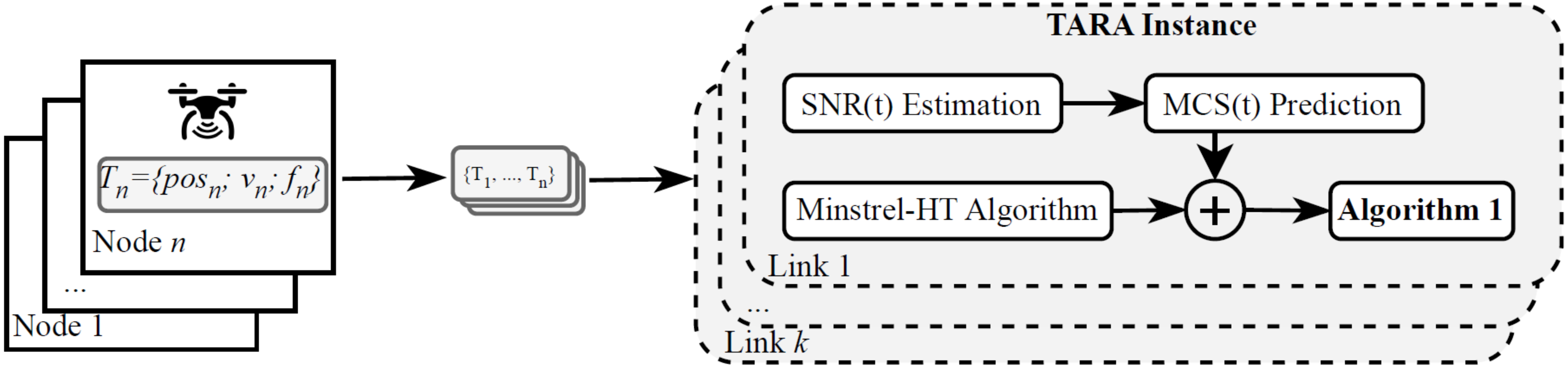
Estimates future changes in Link Quality

Performs Rate Adaptation Accordingly

Extensive ns-3 simulation validation

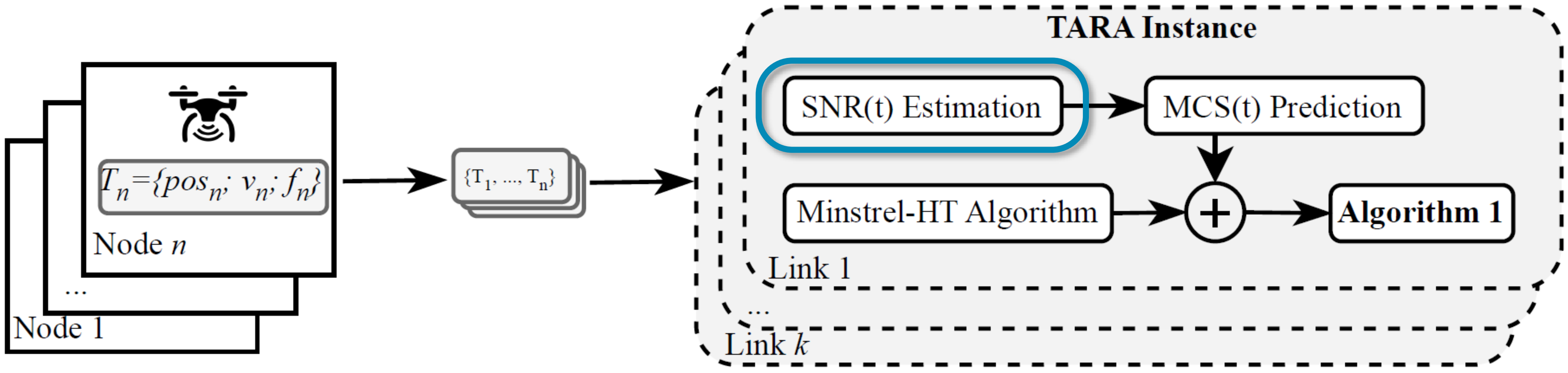
Trajectory Aware Rate Adaptation (TARA)

Trajectory Aware Rate Adaptation: Architecture



- Estimates future link Specific Signal to Noise Ratio (SNR)
- Calculate the optimal MCS prediction
- Modify Minstrel-HT retry chain to include the prediction
- Repeats for every new node trajectory

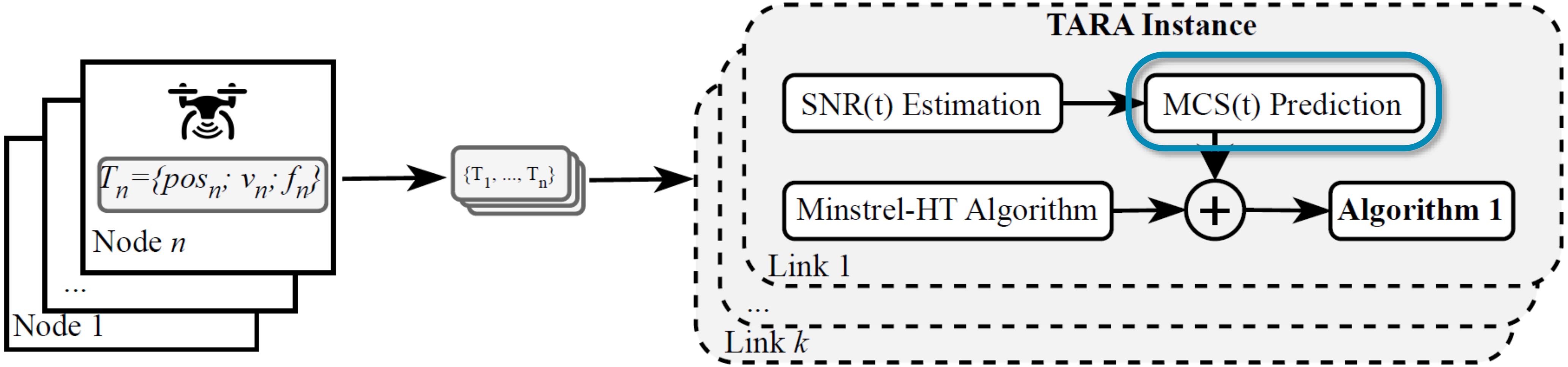
Trajectory Aware Rate Adaptation



Estimating future Link Specific SNR …

- Strong Line of Sight between 2 Flying nodes → **Friis** Path Loss Model
- Trajectory Information → Position Functions
  - we discretize time in 50ms slots
- Distance between nodes of a link → Link Specific SNR

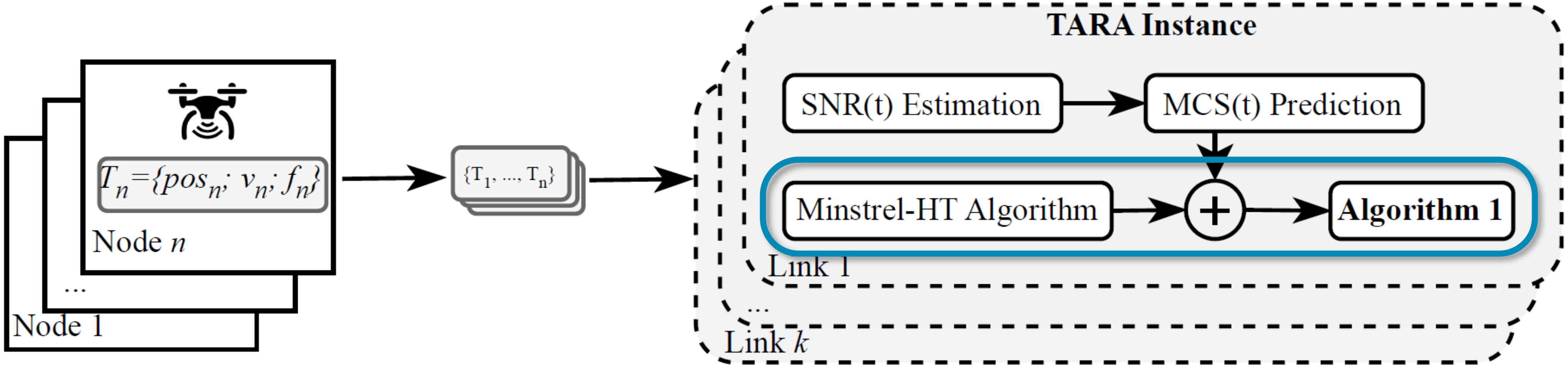
Trajectory Aware Rate Adaptation



Calculating Optimal MCS Prediction …

- Nist Error Rate → Models OFDM (no interference, ±1 dB margin)
- Choose target Bit Error Ratio (BER) → 1.0e-6
- Build a lookup table that maps (MCS, BER) → SNR Threshold
- Optimal MCS → Link SNR satisfies the highest SNR Threshold

Trajectory Aware Rate Adaptation



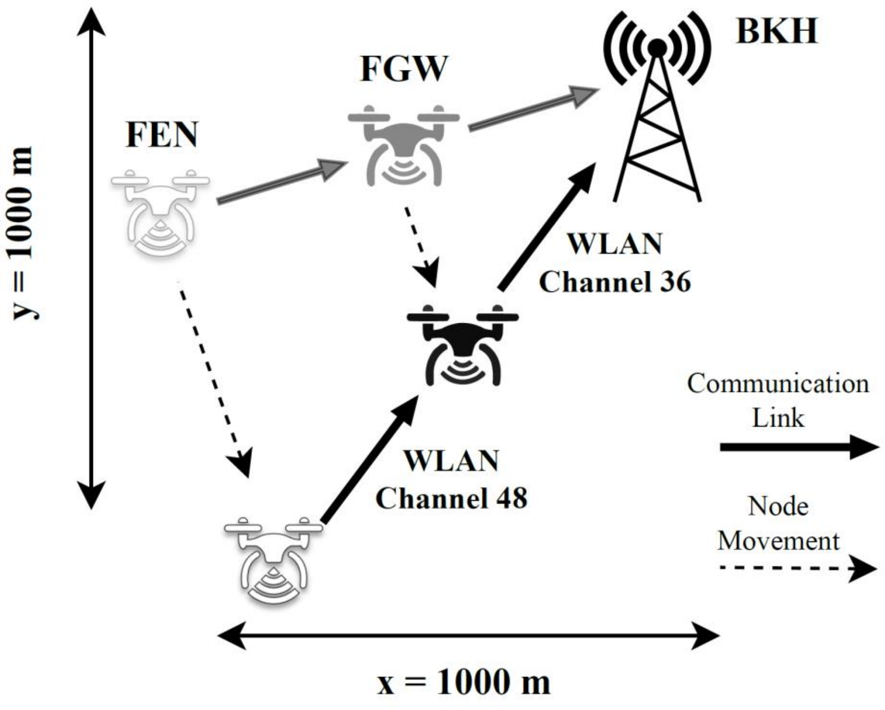
Modifying Minstrel-HT to include Optimal MCS…

- Original Minstrel-HT uses 3 Rates and a Retry Chain Table
  - MaxTP, MaxTP2 and MaxProb → Updated every 50ms based on success metrics
- We modify the Retry Chain Table to include TARA MCS prediction
  - TARA MCS, MaxTP, MaxTP2 ~~MaxProb~~
- If Frames are lost using TARA MCS → falls back to original Minstrel-HT

Simulation Results

Simulation Scenario Setup

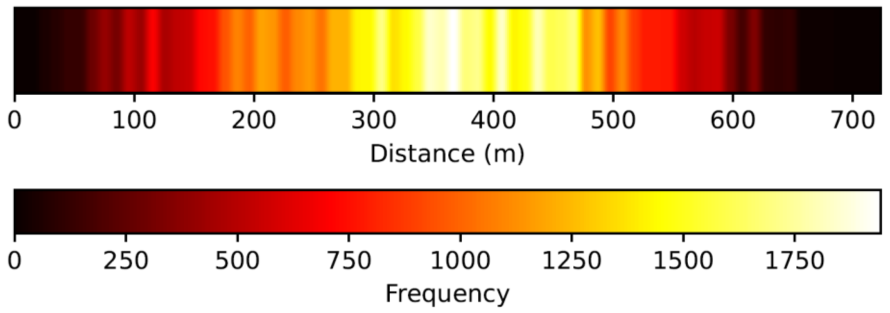
- **Simulator ns-3 (version 3.38)**
- **Different WLAN Channels for each link**
- **UDP Traffic Generation**
  - Above Link capacity
  - Constant Size (1400 bytes)
  - Relayed through FGW
- **Random Initial Positions**
  - Within 1000x1000 m area
- **Random Trajectories**
  - Updated every 30 seconds

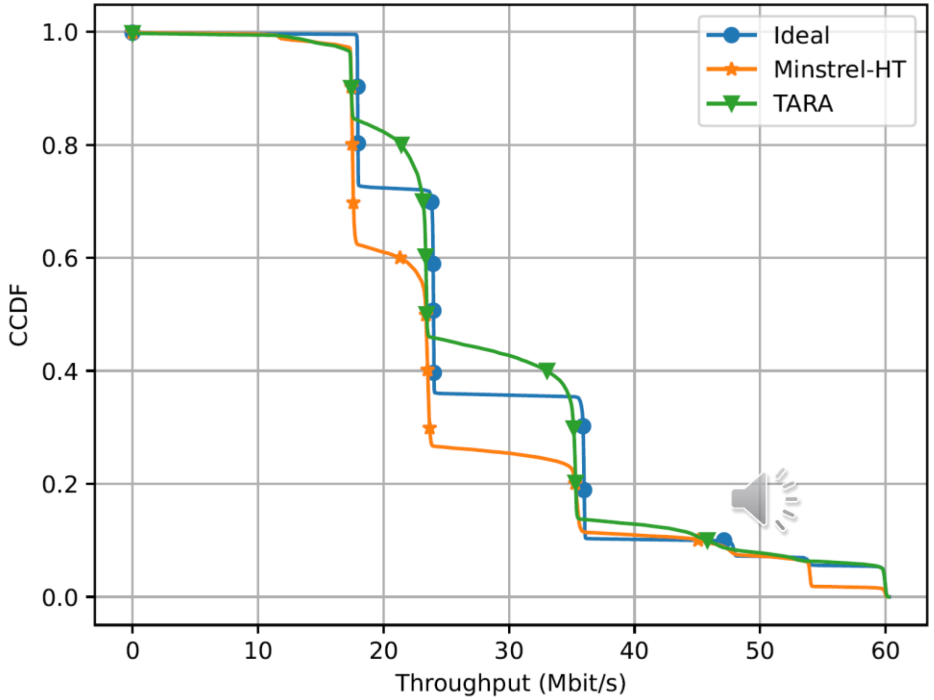


Configuration Parameter	Value
Wi-Fi Standard	IEEE 802.11n
Propagation Delay Model	Constant Speed
Propagation Loss Model	Friis
Error Rate Model	NistErrorRateModel
Channel Bandwidth	20 MHz
Transmission Power	20 dBm
RX/TX antenna gains	0 dBi
Wi-Fi MAC	Ad-hoc
ρ_{BER}	1e-6
τ	50 milliseconds
Δ	30 seconds

Extensive Simulation Results

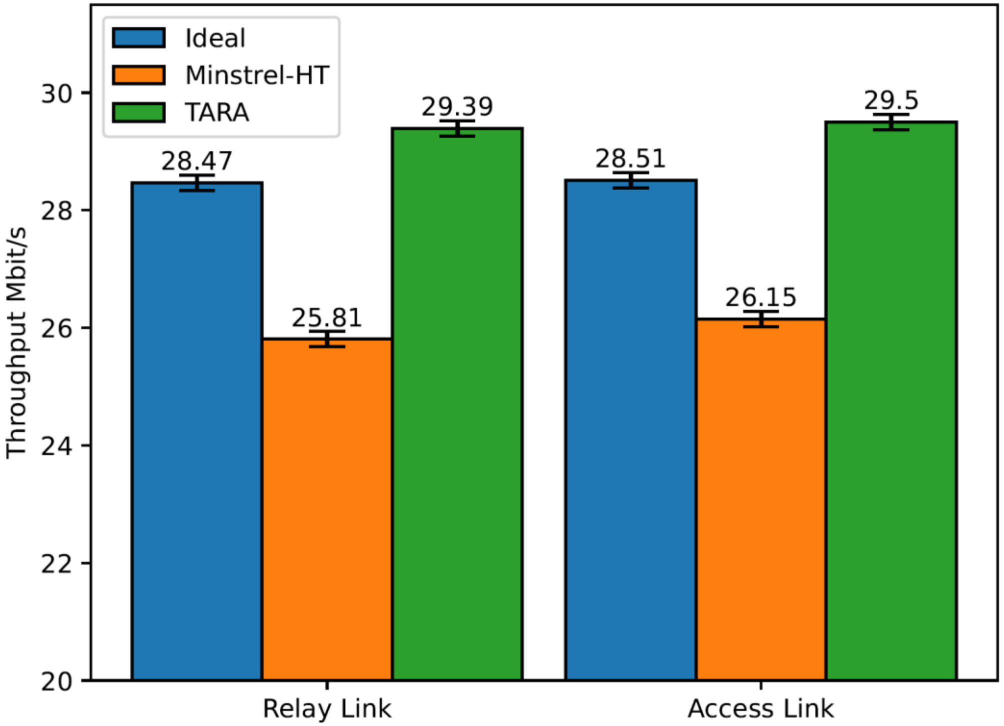
- **100 Simulation runs of 300 seconds each**
- **Comparison with Minstrel-HT and Ideal Rate Adaptation algorithms**
    - **Ideal knows** the **SNR at the receiver** by means of an out of band mechanism
    - **Minstrel-HT** is the default algorithm used in Linux Systems
- **Node Distance Distribution justifies throughput values distribution**
- **Median (50th percentile) throughtput results are all within 2% difference.**
- **Throughput improvement over Minstrel-HT for the 30th and 70th percentiles**



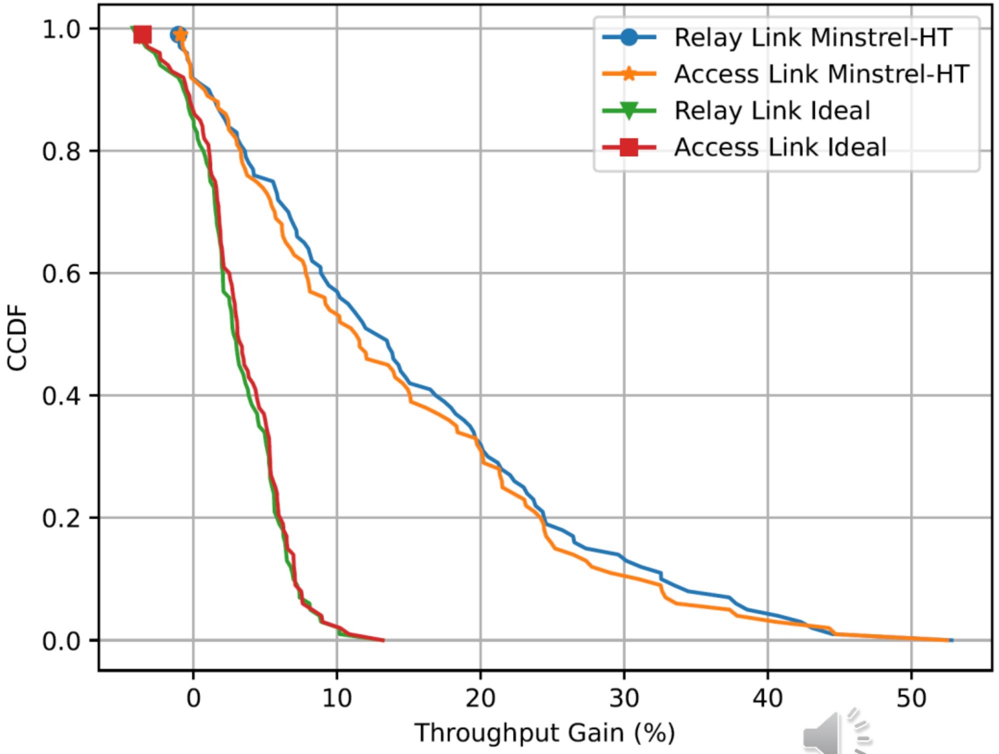


Extensive Simulation Results

Mean Throughput with 99% Confidence Interval



Throughput Gains comparing TARA with Minstrel-HT and Ideal (both links)



TARA achieves a throughput **gain of up to 53%** compared to **Minstrel-HT** and **positive gains in 92%** of the simulation runs

Conclusions

Conclusions and Future Work

- Proposal of a **Trajectory Aware Rate Adaptation Algorithm**
- **Simulation results** show **gains of** up to **53%** when compared with **Minstrel-HT**
- Simulation results and source code is **publicly available**

For Future work…

- Evaluate TARA Experimentally
- Address scenarios with multiple FENs and FGWs
- Stochastic Path Loss Models
- Channel Interference Management

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Thank you!

Questions?

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