Simulation of a Sigfox Based Case Study in NS3

Workshop on ns-3

June 23, 2022

Presented By:
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- All major energy-consuming states and actions of a Sigfox node
- Novel battery model that takes into account the self-discharge current.
- Results comparison with the analysis of the Sigfox protocol performed using Statistical Model Checking.

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Sigfox Protocol
General Transmission Procedure

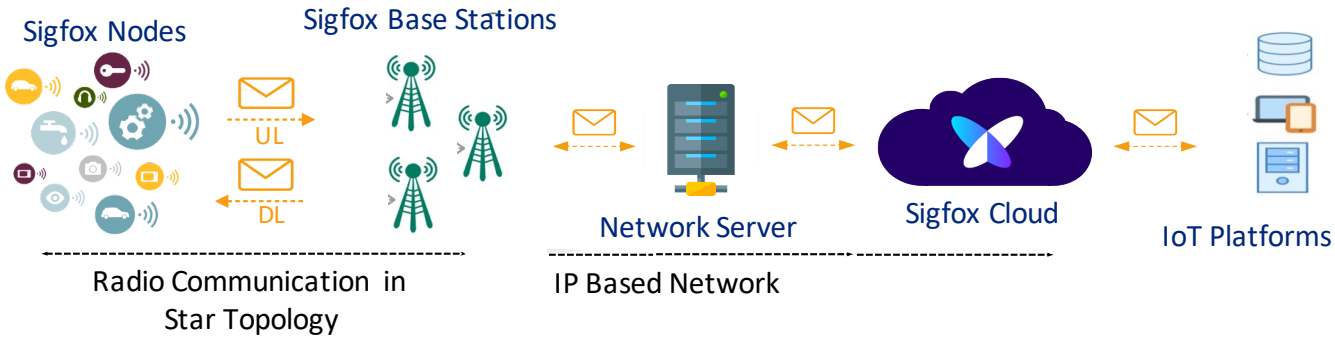

Figure: Basic Architecture of the Sigfox Protocol

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- A Sigfox node can send up to 6 messages per hour (144 messages per day) with up to 12 bytes of payload each, and receive up to 4 8-byte messages per day.

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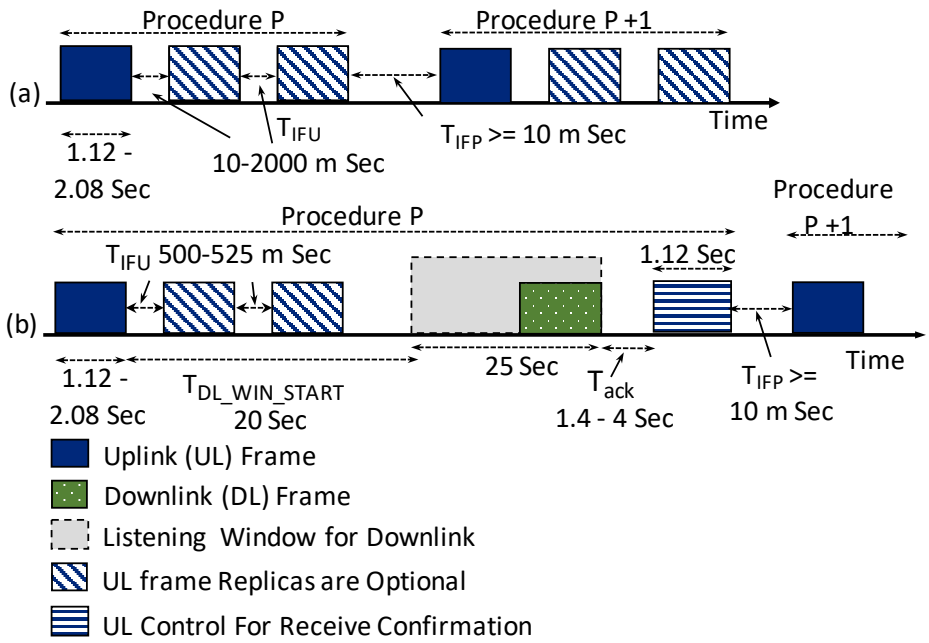

Figure: Sigfox transmission Procedures

Sigfox Protocol
Sigfox Activity Diagram

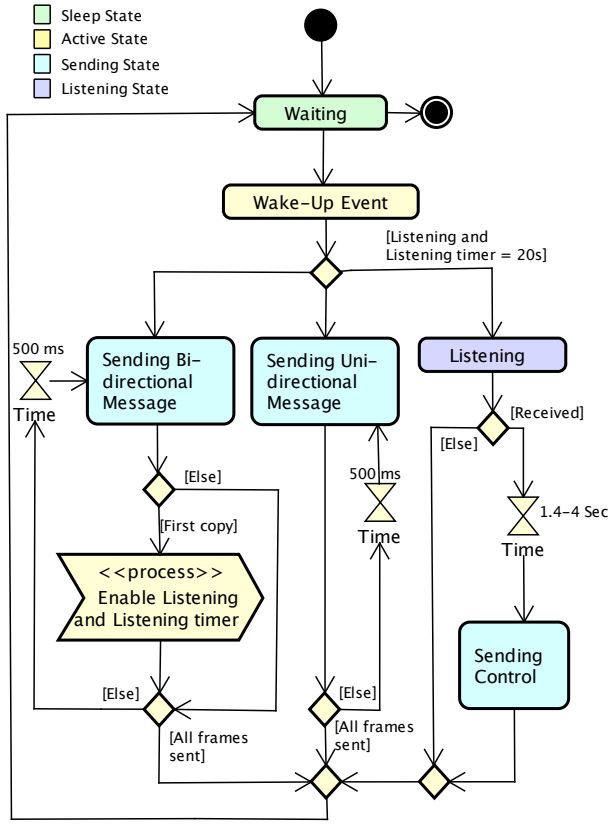

Figure: Activity Diagram of a Sigfox Module

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Implementation in NS3

Applications:

- Sigfox-Large-Network:

- Sigfox-Energy-Model:

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  Analyse the model behaviour especially the physical layer.

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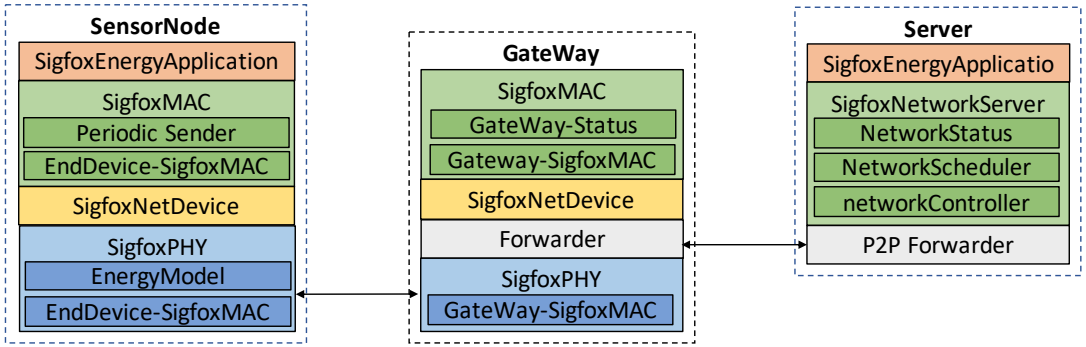

Figure: Block diagram of important models of the designed module

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Network Performance Graph

- Estimating the packet success rate for a network composed of several thousands of devices, both in the cases of 1 and 3 MAC-layer repetitions for each APP-layer packet.

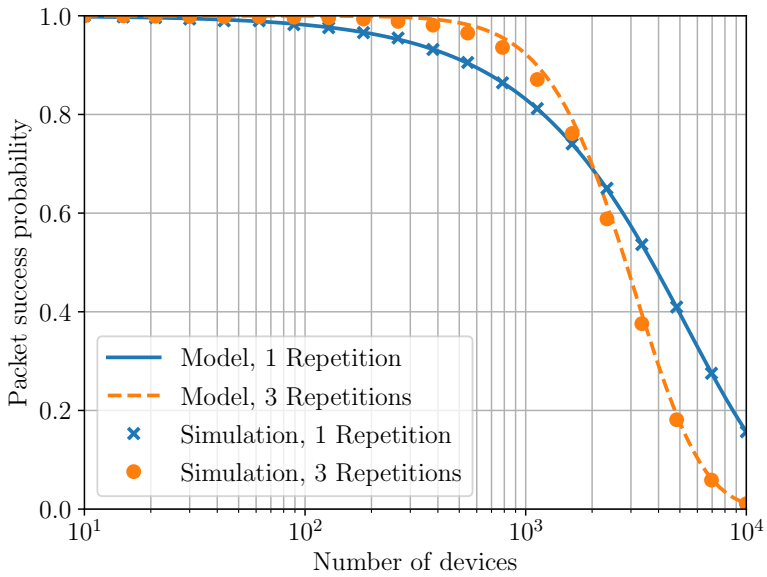

Figure: Packet Success Probability as Computed by Analysis and Simulation

Analytical Model for Energy Consumption

- In our model the energy in a battery satisfies the first order differential equation $E' = -AE - B$, with A and B being parameters that describe the energy dynamics of the system. The general solution to the equation is

$$E = e^{-At}(E_0 + B/A) - B/A$$

E_0 : *Initial energy*

B : *Total current powering the electronics*

A : *Self − discharge*

Case Study

- Distributed ONline monitoring of the Urban waTer cycle (DONUT) Project.

Figure: Urban water monitoring systems

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Case Study
Hardware Architecture

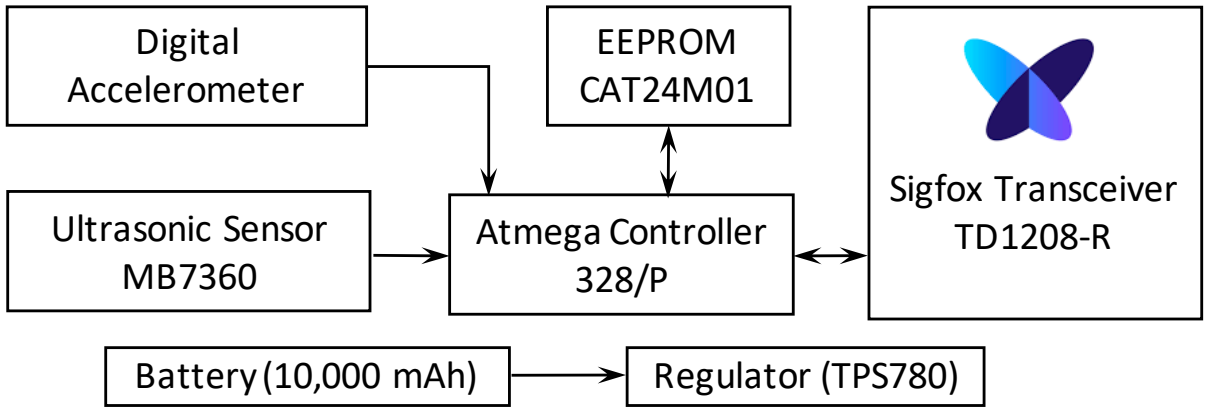

Figure: Basic Hardware Architecture of the Sensor Node

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Case Study
Combined Energy Consumption

Table: DC Power Supply Characteristics

Sym	Parameter	Datasheet Value		Measured value
		Min	Max	Value
V_{DD}	Supply Voltages	3.3 V	-	3.3 V
I_{Sleep}	Power Saving Mode	2.35μA	4.35μA	27.84μA
I_{RX}	Active CPU + RX Mode Current	13mA	16mA	19.05mA
I_{TX}	Active CPU + TX Mode Current	50mA	50mA	47.03mA
I_{App}	Continues Application Current	10.8μA	10.8μA	4300μA
I_{Msr}	Sensor Measuring Current	5.9mA	6.8mA	6.58mA

Simulation Results in NS3
Current Consumption

- The current consumption graph aligned with the Sigfox protocol.

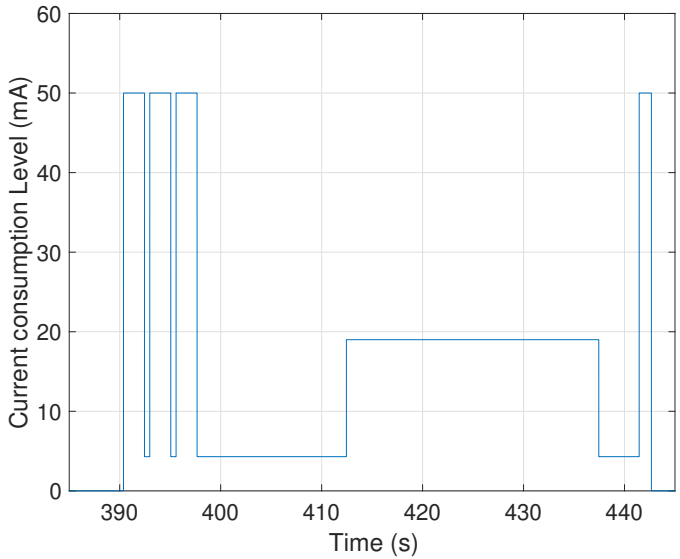

Figure: Sigfox Current Consumption Cycle

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Simulation Results in NS3
Battery Consumption Graphs

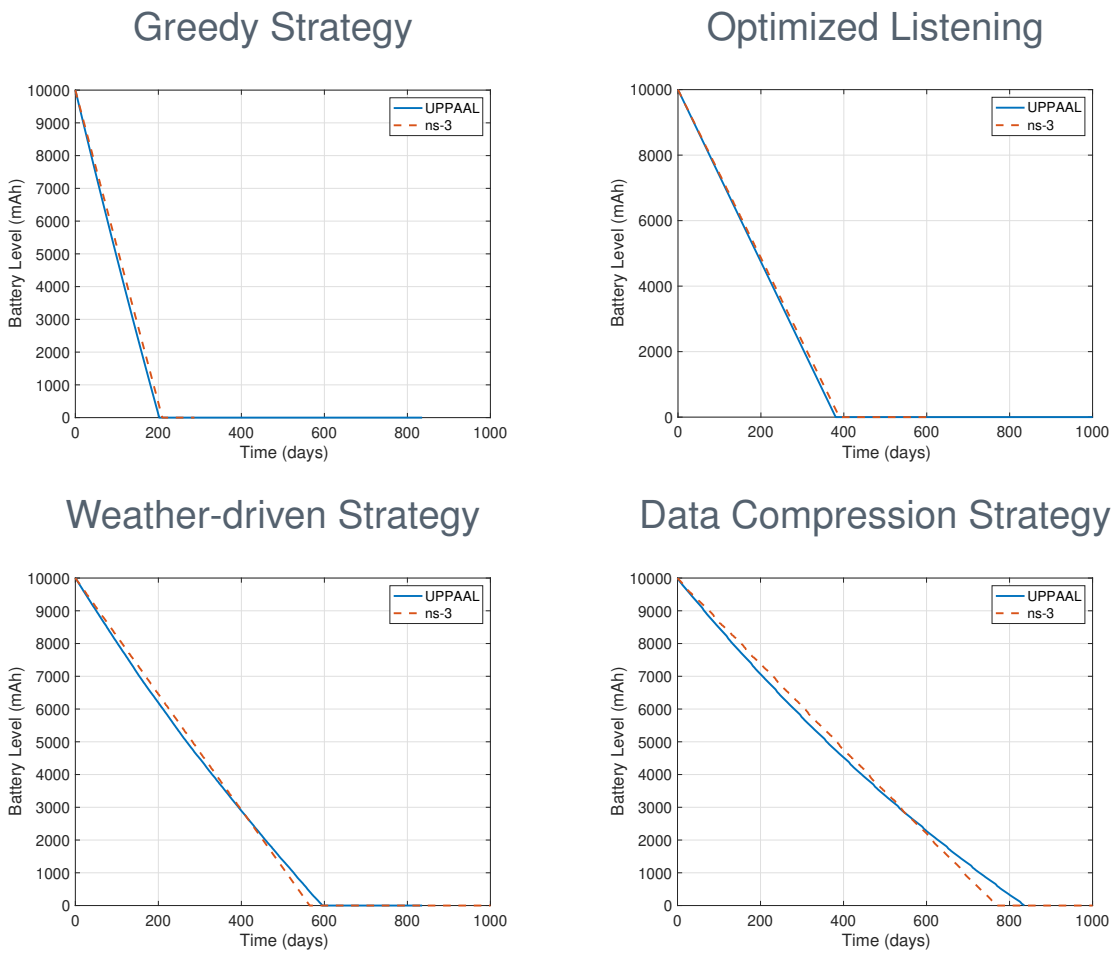

Figure: Battery Charge Consumption for Different Transmission Strategy

Simulation Results in NS3

Data Compression Strategy with Different Thresholds

- Data compression strategy is parametric with respect to the threshold that leads to sending data.
- Slightly increasing threshold avoid waving in water height and optimize lifetime.

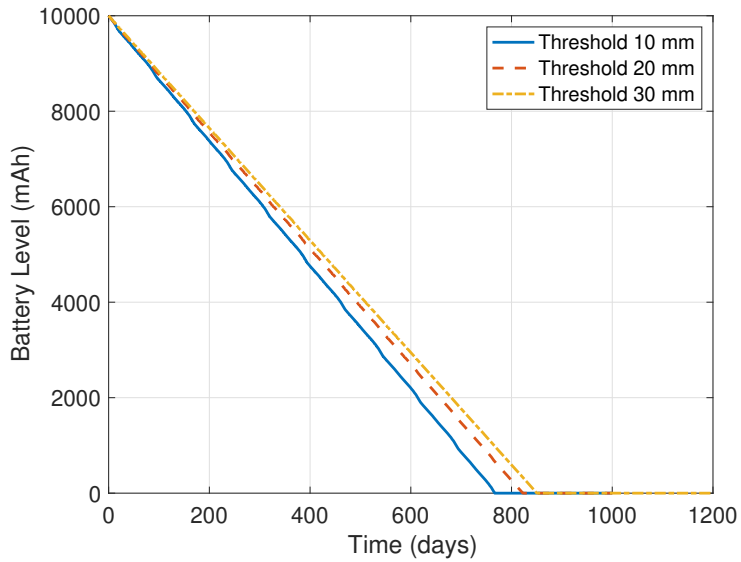

Figure: Battery Charge Consumption for Different Thresholds using Data Compression Strategy

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- Furthermore, we calibrated the model using measurement data from real hardware.

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- To the best of our knowledge, the module is the first implementation of the Sigfox protocol to date.
- The model was used to accurately simulate the power consumption and battery lifetime of a Sigfox node, and it includes the behavior of battery self-discharge.
- Furthermore, we calibrated the model using measurement data from real hardware.
- The results of our simulations allow to select a communication strategy that extends from 202 days to 2.3 years the lifetime of a Sigfox based sensor node powered by a 10,000 mAh battery.

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Future Works

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- Simulation of a complete Sigfox deployment would require to extend the Gateway model with an application layer that transfers received data to a network server or a Sigfox backend.
- This extension is not in the scope of this work.
- Thus, the implementation of a complete Sigfox IoT solution is left as future work.

Feedback
Contact Information

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Code Link:https://github.com/DEIS-Tools/ns3-sigfox
Thank you for your Attention