

# LR-FHSS: Header redundancy optimization

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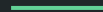
NTN days - Florent Dobler - 17 oct 2024  
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# Summary

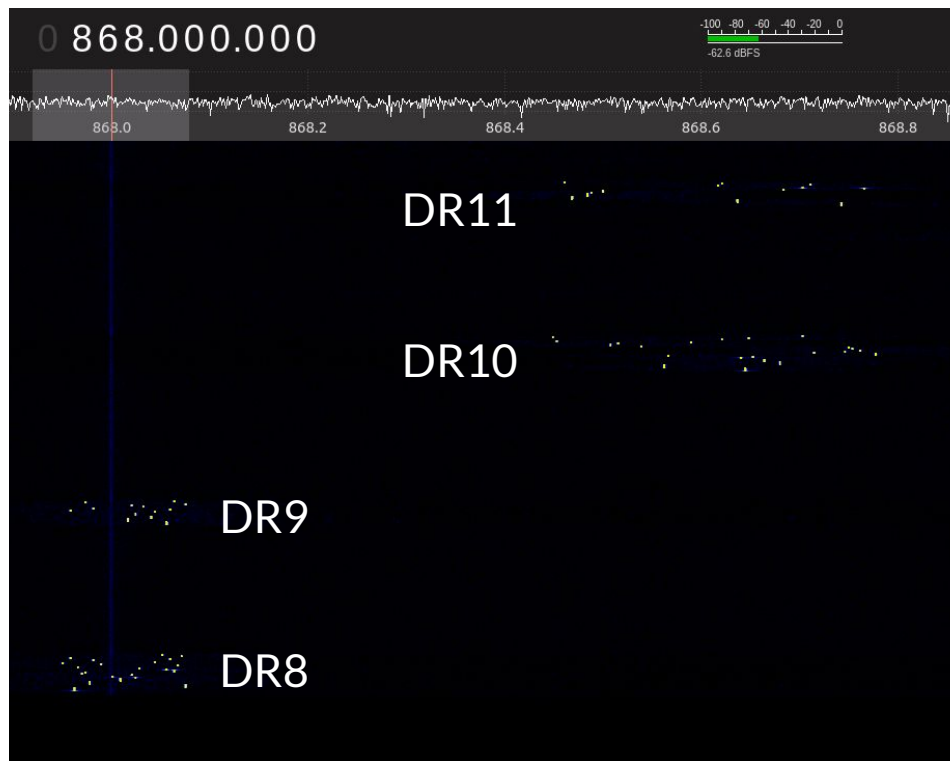
- LR-FHSS
- Header number optimisation
- Conclusion

# LR-FHSS



# Overview

- LR-FHSS: Long Range Frequency Hopping Spread Spectrum is a modulation created by semtech
- FHSS : intra packet frequency hopping
- Suitable for applications with low gateway density and limited spectrum, requiring long range. Satellite applications for example.



# LR-FHSS ETSI configuration

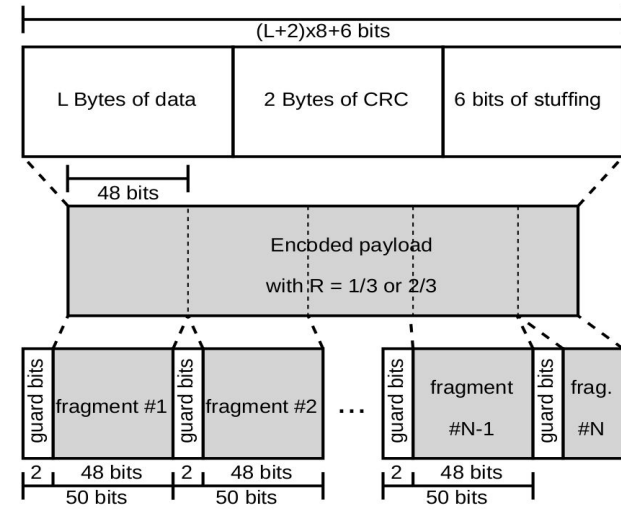
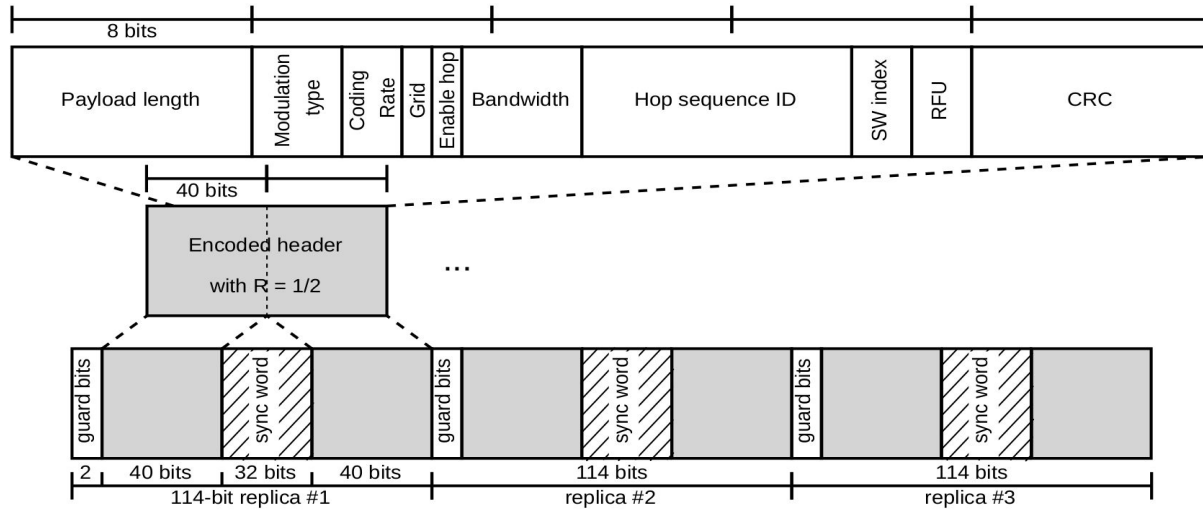
<b>Data Rate</b>	<b>Coding Rate</b>	<b>Bandwidth</b>	<b># header replica</b>
DR8	1/3	137 kHz	3
DR9	2/3	137 kHz	2
DR10	1/3	336 kHz	3
DR11	2/3	336 kHz	2

For DR8 and DR9, there are 8 channels with 35 sub-channels.

For DR10 and DR11, there are 8 channels with 86 sub-channels.



# Frame details



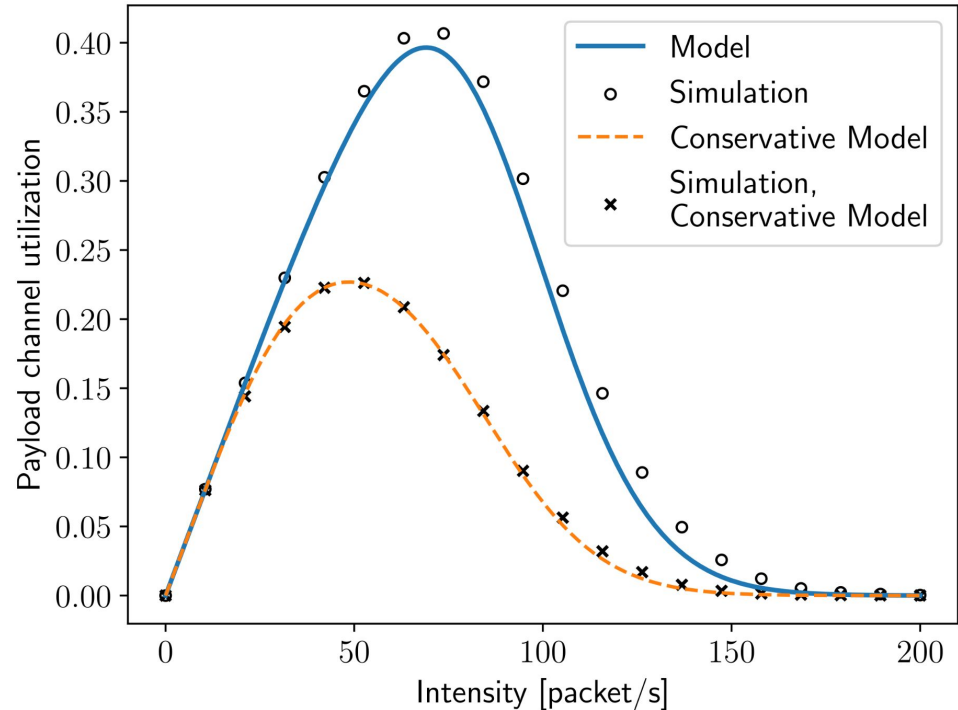
# LR-FHSS analytical model - header number

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# Comparing the model with simulations

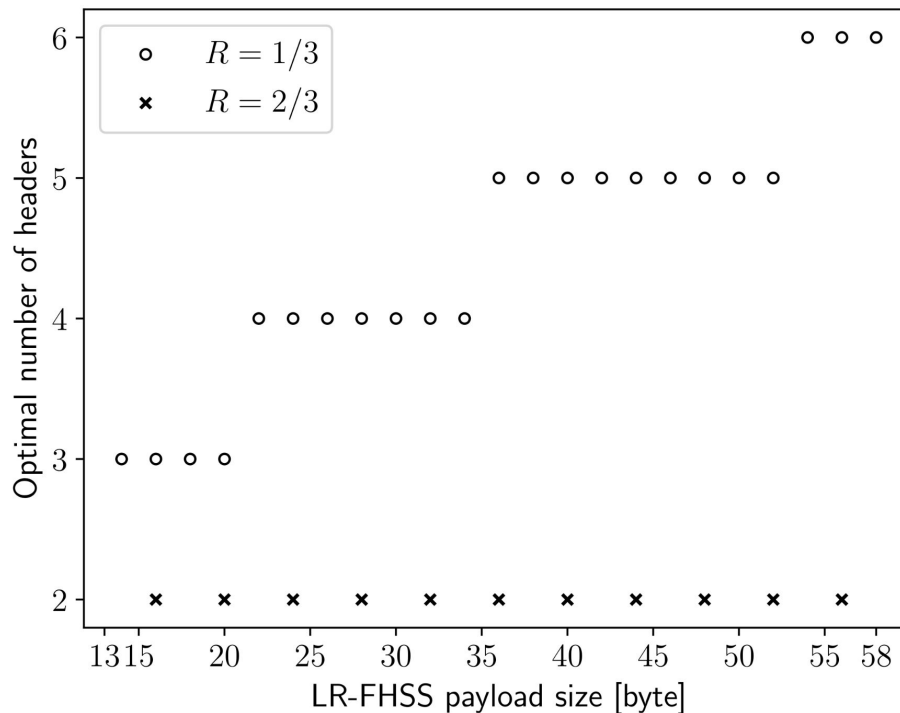
Discrete event simulation  
made with python.

The conservative model  
exists to verify parts of the  
full model



# Optimal header number compared to payload size.

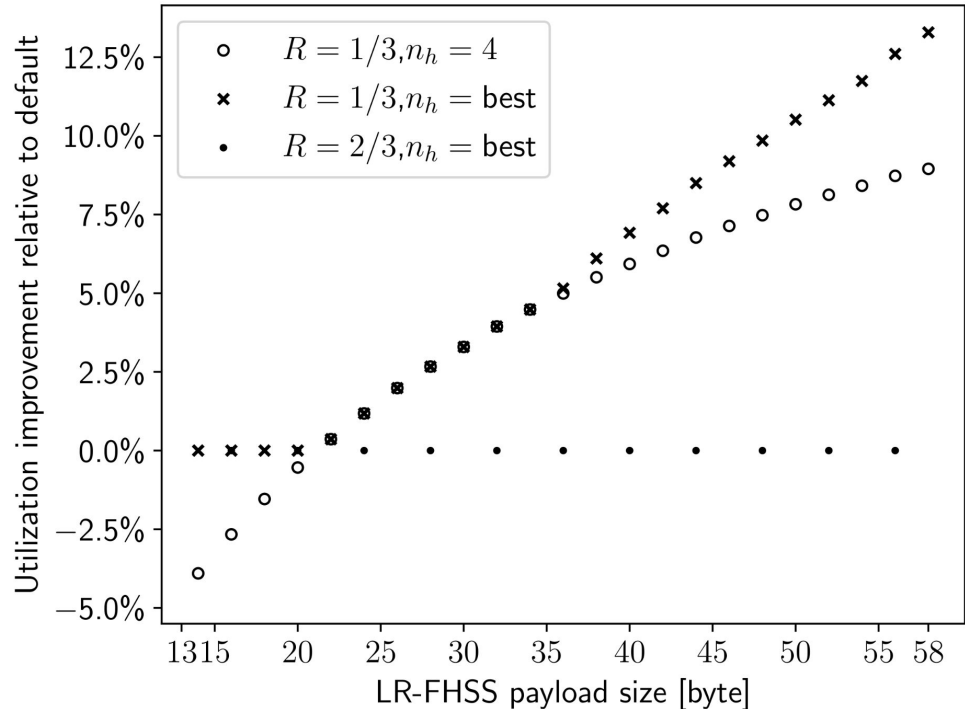
For the  $< 58$  byte payloads, and for a rate of code of  $\frac{2}{3}$ , the default configuration is already optimal. For a  $\frac{1}{3}$  rate of code, more headers are required starting from 20 bytes payloads.



# Improvement on the channel usage relative to default.

4 headers is the maximal amount supported by LR-FHSS.

From our university dataset, we find that using 4 headers is better than default configuration in 75% of cases.

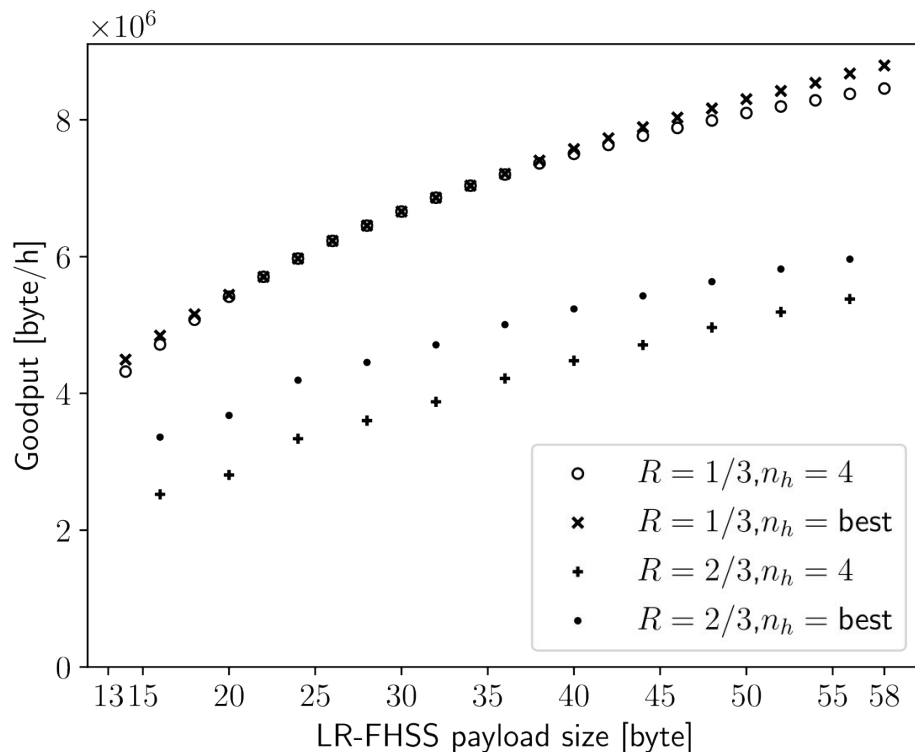


# Goodput compared to payload size

The goodput is computed considering the maximum number of devices operating at the duty cycle, so that we are at maximum channel utilization

Using a rate of code  $\frac{1}{3}$  will always result in better goodput than a rate of code  $\frac{2}{3}$

However, coding rate  $\frac{2}{3}$  will be better for a smaller number of devices benefiting from a larger throughput



# Conclusion

Thanks for your attention!

## Future prospects

- In-vivo load tests with LR-FHSS devices
- Extension of the model by taking other phenomena into account (fast fading, some form of capture effect ... )