

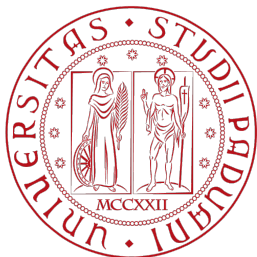
LoRaWAN Simulations Using ns-3

Davide Magrin

Department of Information Engineering

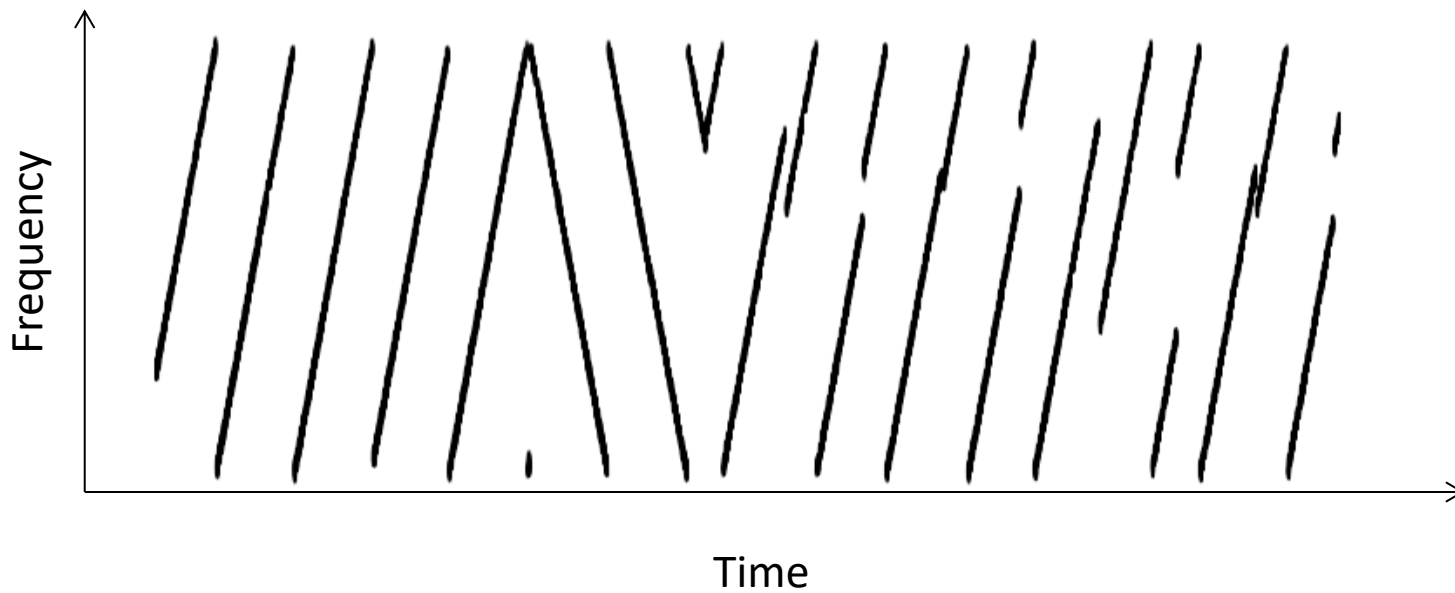
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Chirp Spread Spectrum



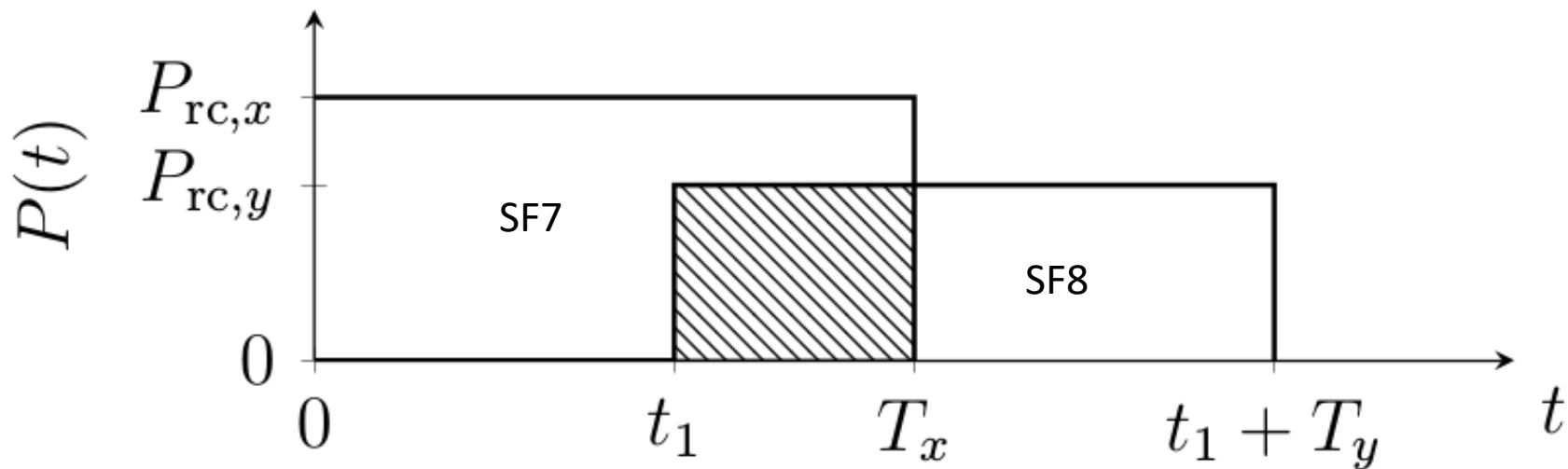
The Spreading Factor Trade-Off

$$SF \in [7, 12]$$

As the SF increases:

- Longer Range
- Lower Data Rate

Spreading Factor Orthogonality



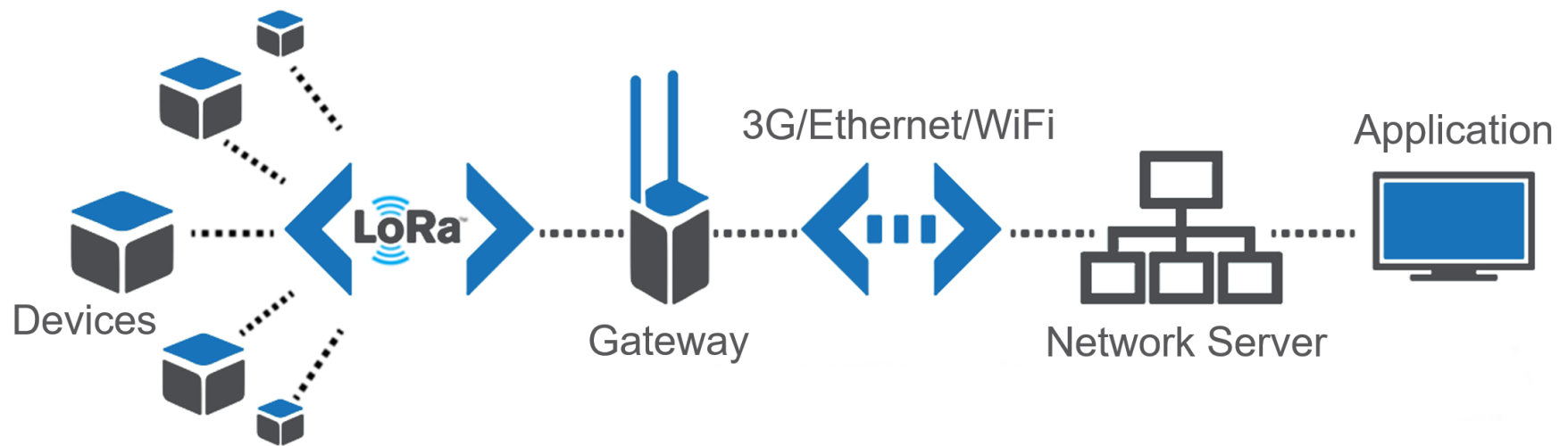
Frequencies

- LoRa operates on ISM bands:
 - Free
 - Unlicensed (\neq Unregulated)
- Pathloss friendly frequencies:
 - 863-870 MHz in Europe
 - 902-928 MHz in the US
 - 915-928 MHz in Australia
 - 779-787 MHz in China

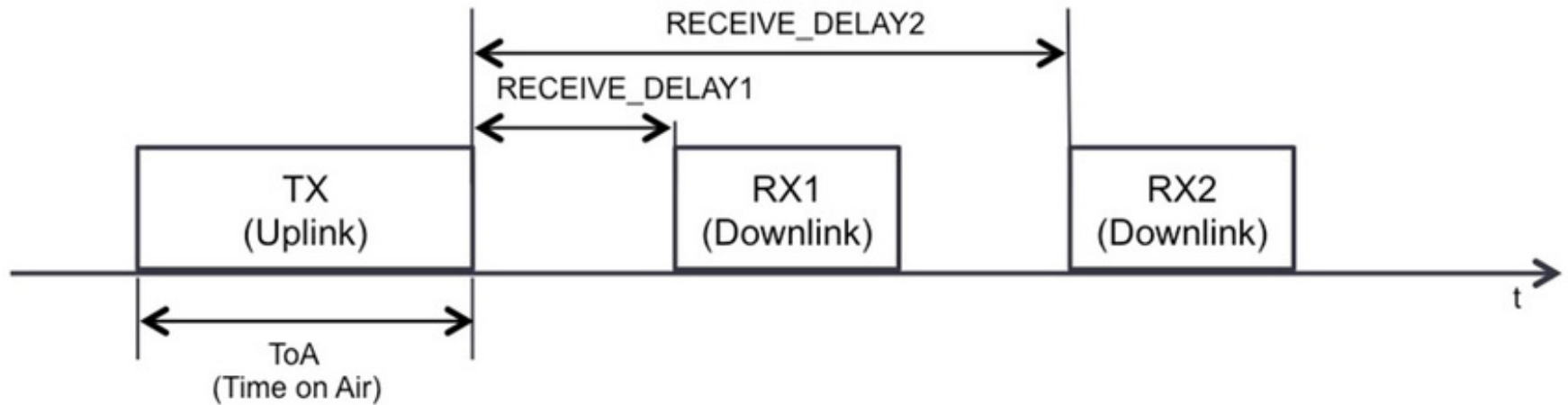
The logo for the LoRa Alliance. It features the word "LoRa" in a bold, black, sans-serif font, with a blue signal icon (three curved lines above and below) positioned over the "o". A small "TM" trademark symbol is located to the upper right of the "a". Below "LoRa" is the word "Alliance" in a larger, bold, black, sans-serif font.

LoRaTM
Alliance

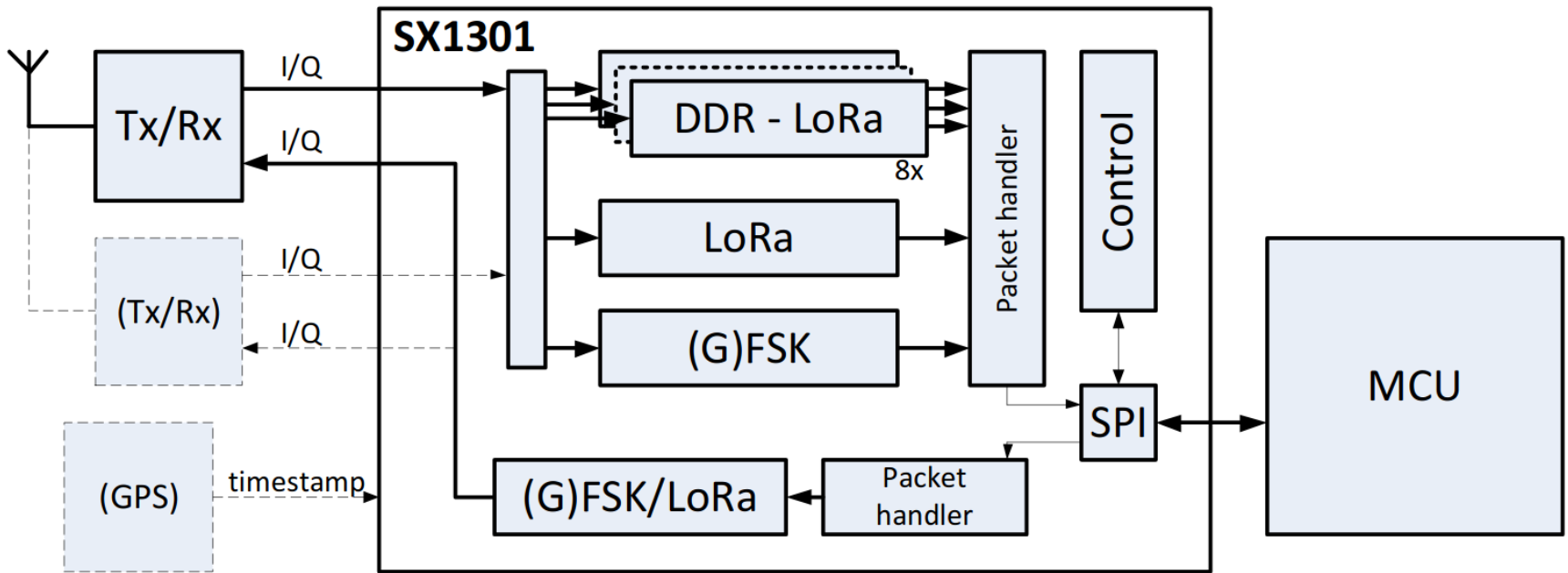
Architecture



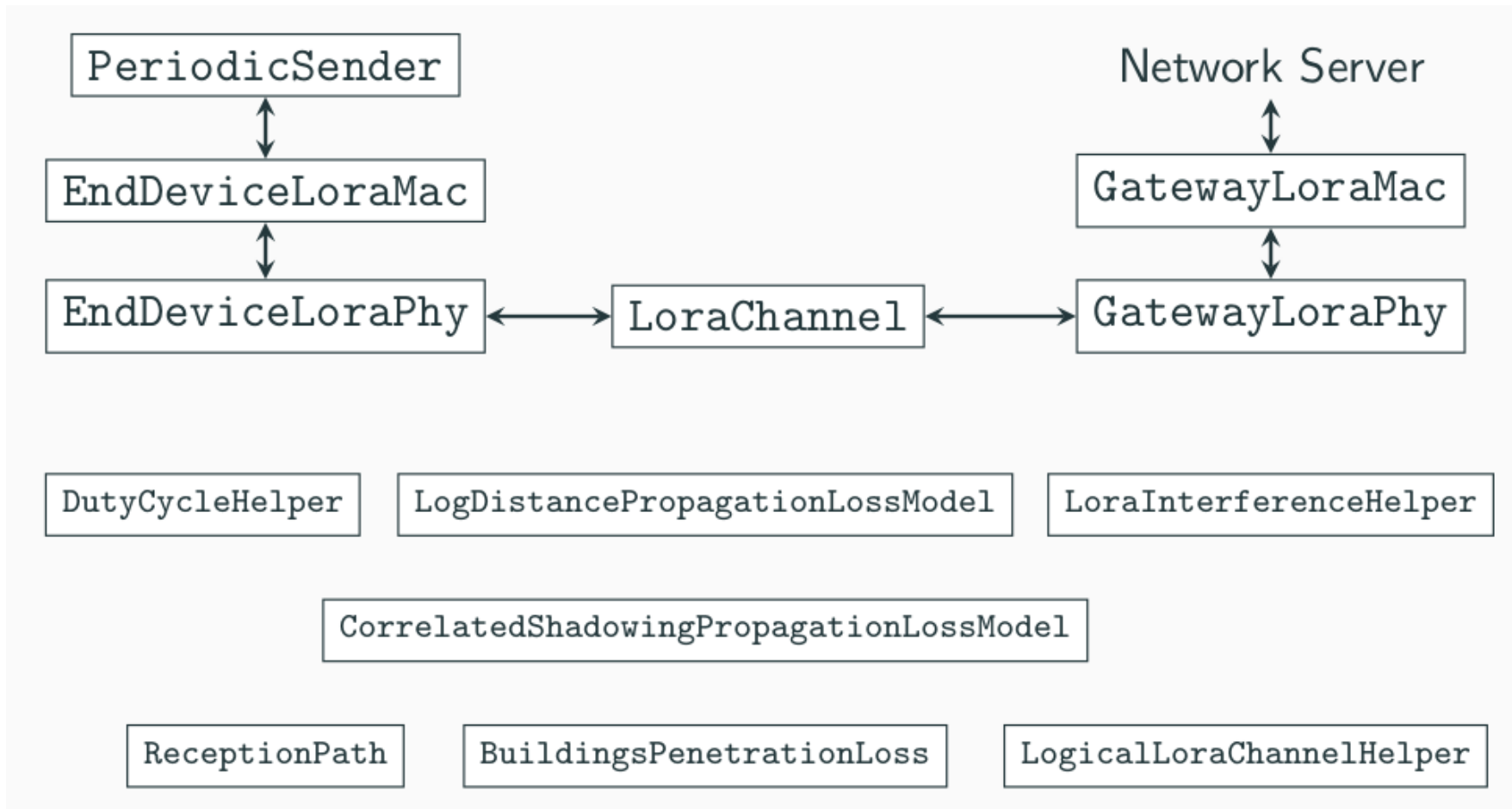
Aloha Based Medium Access



The Gateway Chip



Class structure





Quick example walkthrough

Feature list

We have:

- Class A
- Interference models
- Urban propagation models
- Network Server
 - ADR
 - Confirmed messages
 - Multi Gateway
- Realistic GW chip model
- Energy model integration
- Coherence with a mathematical model

We don't have (yet):

- Class B/C
- Join procedures
- US/Australian/Chinese frequency bands



References

Github page:

- <https://github.com/signetlabdei/lorawan>

Chat:

- <https://gitter.im/ns-3-lorawan>

Relevant papers:

- D. Magrin, M. Centenaro and L. Vangelista, "Performance evaluation of LoRa networks in a smart city scenario," 2017 IEEE International Conference on Communications (ICC), Paris. DOI: [10.1109/ICC.2017.7996384](https://doi.org/10.1109/ICC.2017.7996384).
- M. Capuzzo, D. Magrin and A. Zanella, "Confirmed Traffic in LoRaWAN: Pitfalls and Countermeasures," 2018 Annual Mediterranean Ad Hoc Networking Workshop (Med-Hoc-Net), Capri. DOI: [10.23919/MedHocNet.2018.8407095](https://doi.org/10.23919/MedHocNet.2018.8407095).

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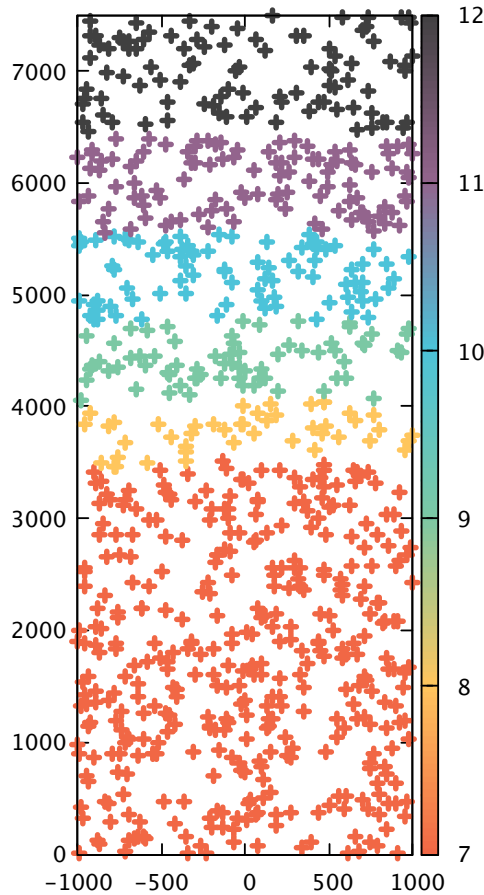
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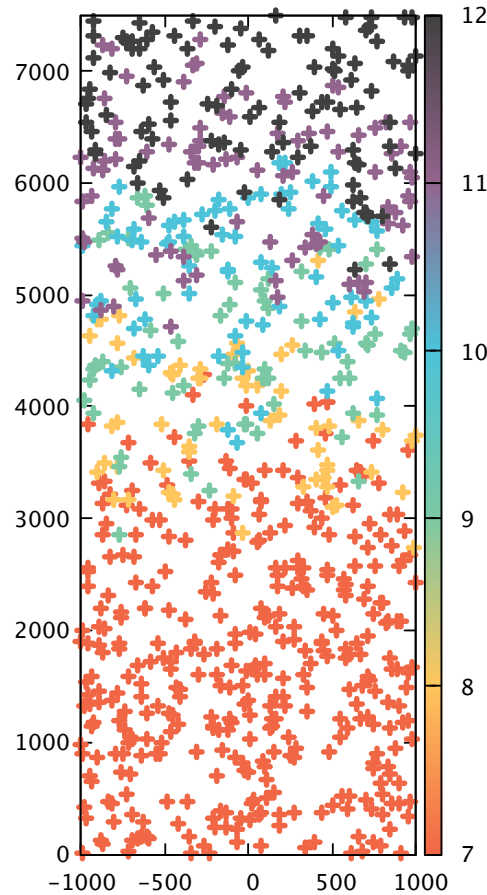
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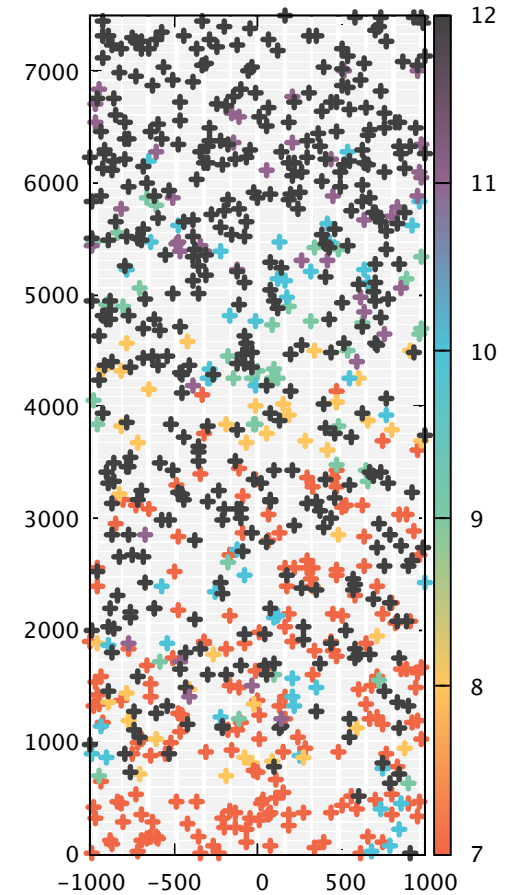
Effect of Propagation Model



Pathloss

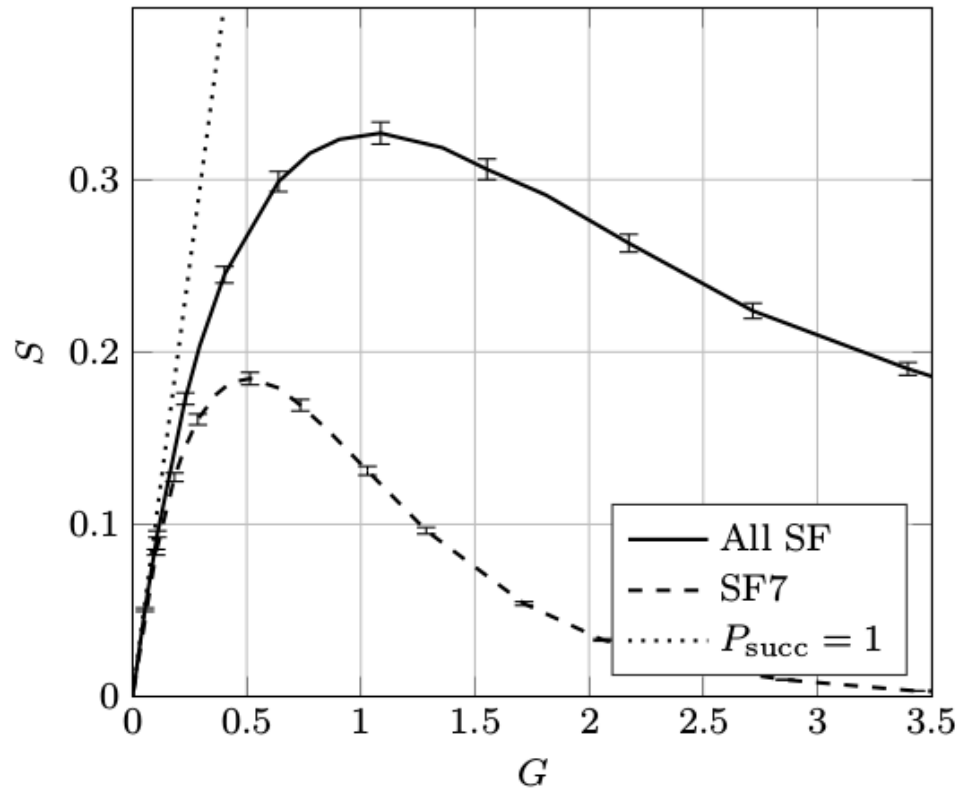


Pathloss and shadowing



Pathloss, shadowing and buildings

Comparison with and Aloha system



Interference model

		Interferer					
		7	8	9	10	11	12
Desired	7	6	-16	-18	-19	-19	-20
	8	-24	6	-20	-22	-22	-22
	9	-27	-27	6	-23	-25	-25
	10	-30	-30	-30	6	-26	-28
	11	-33	-33	-33	-33	6	-29
	12	-36	-36	-36	-36	-36	6

C. Goursaud and J.-M. Gorce, "Dedicated networks for IoT: PHY/MAC state of the art and challenges," EAI endorsed transactions on Internet of Things, 2015.