Modelling received Power and Dimensioning Margins in P2P Microwave Links

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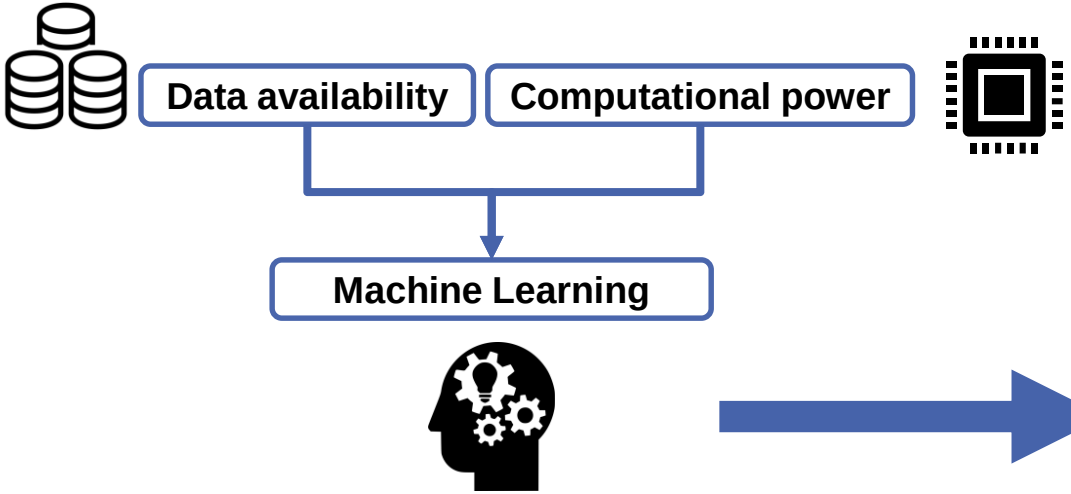
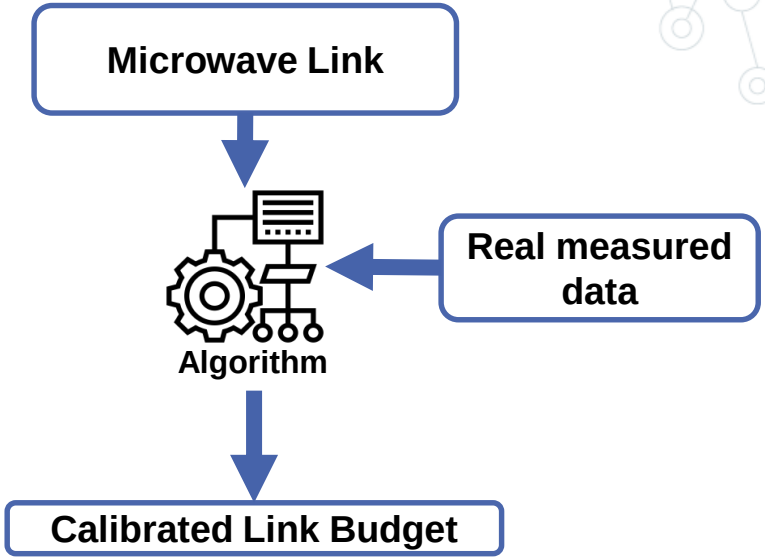
Motivation:


Data availability
Computational power
Machine Learning
Dimensioning tools

Objectives:

Development of an algorithm that performs link budget analysis in P2P microwave links:

- **Estimation of the received power;**
- **Calibration using real data from operators;**
- **Throughput estimation;**
- **Re-dimension of loss margins.**



Practical cases (1/5):

Location parameters

Location	Height [m]	Ptx [dBm]	Frequency [GHz]
A	15	9.4	8.1777
B	32	8.7	7.8663
Q	27	22.9	8.1776
N	34	23.1	7.8662

Link Parameters

Link	Tx and Rx Gain [dBi]	Bandwidth [MHz]
A-D	31.1	28
D-A	31.1	28
Q-N	22.9	14
N-Q	23.1	14

Practical cases (2/5):

Regression Model:

$$P_{RX(Cal.)} = \beta_0 + \sum_{i=1}^{k} \left[\beta_i (P_{RX(Algorithm)})^i\right] + \beta_2 (Pol.Flag) + \epsilon$$

Model's metrics:

k	5
R^2	0.751
RMSE	2.661

Multivariate Polynomial Regression model:

- **Polynomial Estimated Received Power;**
- **Polarization flag;**

Practical cases (3/5):

Results (Initial and Calibrated)

Link	Rx Power (Vertical Pol.)			Rx Power (Horizontal Pol.) [dBm]		
	Measured [dBm]	Predicted [dBm]	Deviation [dB]	Measured [dBm]	Predicted [dBm]	Deviation [dB]
A-D	-56.30	-65.60	9.30	-57.60	-65.60	8.00
D-A	-57.10	-65.96	8.86	-57.50	-65.96	8.46
Q-N	-49.60	-55.48	5.88	-50.10	-55.48	5.38
N-Q	-49.60	-54.93	5.33	-50.10	-54.93	4.83

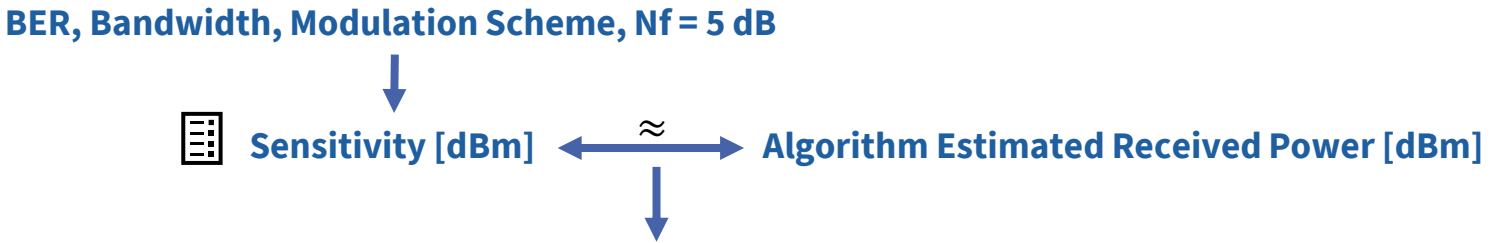
Initial

Link	Calibrated Rx Power (Vertical Pol.)			Calibrated Rx Power (Horizontal Pol.) [dBm]		
	Measured [dBm]	Predicted [dBm]	Deviation [dB]	Measured [dBm]	Predicted [dBm]	Deviation [dB]
A-D	-56.30	-57.31	1.01	-57.60	-58.14	0.54
D-A	-57.10	-56.73	-0.37	-57.50	-57.57	0.07
Q-N	-49.60	-50.63	1.03	-50.10	-51.47	1.37
N-Q	-49.60	-50.53	0.93	-50.10	-51.37	1.27

Calibrated

Practical cases (4/5):

Throughput estimation



Link	Rx Power [dBm]	Throughput (Vertical Pol.)		Rx Power [dBm]	Throughput (Horizontal Pol.)	
		Value [Mbps]	Modulation (BER)		Value [Mbps]	Modulation (BER)
A-D	-57.31	229.15	512-QAM (10^{-5})	-58.14	234.45	512-QAM (10^{-6})
D-A	-56.73	242.13	256-QAM (10^{-7})	-57.57	234.45	256-QAM (10^{-6})
Q-N	-50.63	149.45	1024-QAM (10^{-8})	-51.47	149.45	1024-QAM (10^{-8})
N-Q	-50.53	149.45	1024-QAM (10^{-8})	-51.37	149.45	1024-QAM (10^{-8})

Practical cases (5/5):

Re-dimensioning of margins

Link	Vertical Polarization		Horizontal Polarization	
	Model's Margin [dB]	Rain attenuation exceeded time (%)	Model's Margin [dB]	Rain attenuation exceeded time (%)
A-D	1.01	0.25	0.54	0.71
D-A	-0.37	-	0.07	0.01
Q-N	1.03	0.24	0.22	0.22
N-Q	0.93	0.35	0.27	0.27

Fading margin not applied

Conclusions:

- This algorithm allows to develop a P2P calibrated link simulation;
- Regression shows itself as a valuable alternative in improving estimations ($R^2 \approx 0.75$ and RMSE≈2.66);
- The model's error enables the determination of the necessary loss margin.

Thank you!