

# APPLICATION OF PROGRAMMABLE RADIOS TO ADAPTIVE COMMUNICATIONS

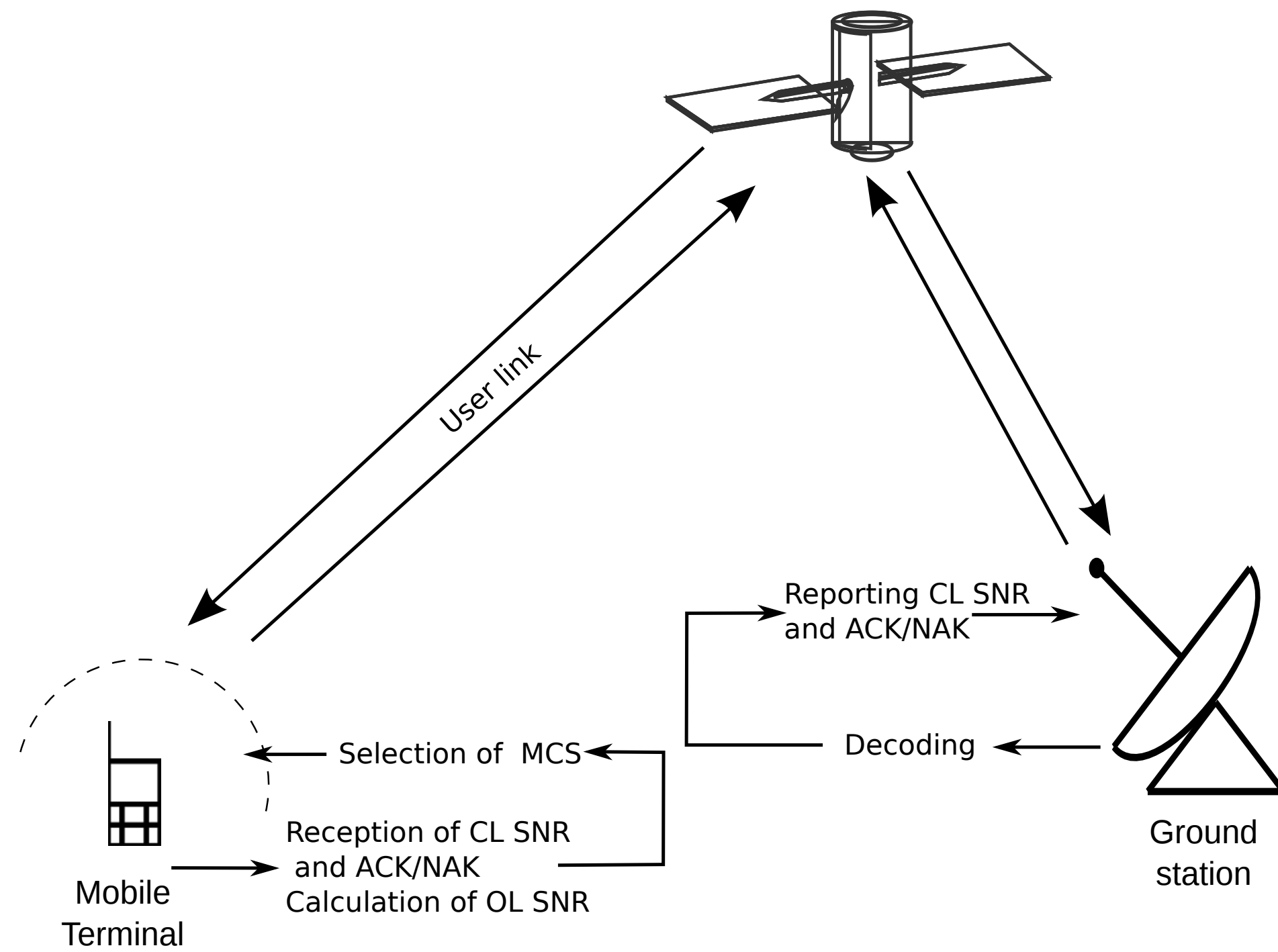
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## MOTIVATION

The increasing demand of mobile data and the scarcity of spectrum in Satellite Communications (SatComs) force systems to be more efficient. Link adaptation techniques aim to increase the spectral efficiency adjusting modulation and channel coding dynamically. The consideration of mobile terminals and the long propagation delays makes link adaptation challenging in SatComs.



Software Defined Radio (SDR) technology makes possible to implement the physical layer in software. The flexibility it provides eases the implementation of adaptive systems and in this thesis SDR will be used to validate algorithms.

## THESIS OBJECTIVES

- **Main objective:** Advance the state-of-the-art in adaptive communications.
- **Specific objectives:**
  - Study of the convergence properties of previously developed algorithms.
  - Propose new link adaptation schemes for point-to-point communications with several users.
  - Propose new link adaptation schemes for satellite communications using double polarization.
  - Validation of the algorithms using SDR technology and thinking in mobile applications such as UAVs.

## RESEARCH PLAN

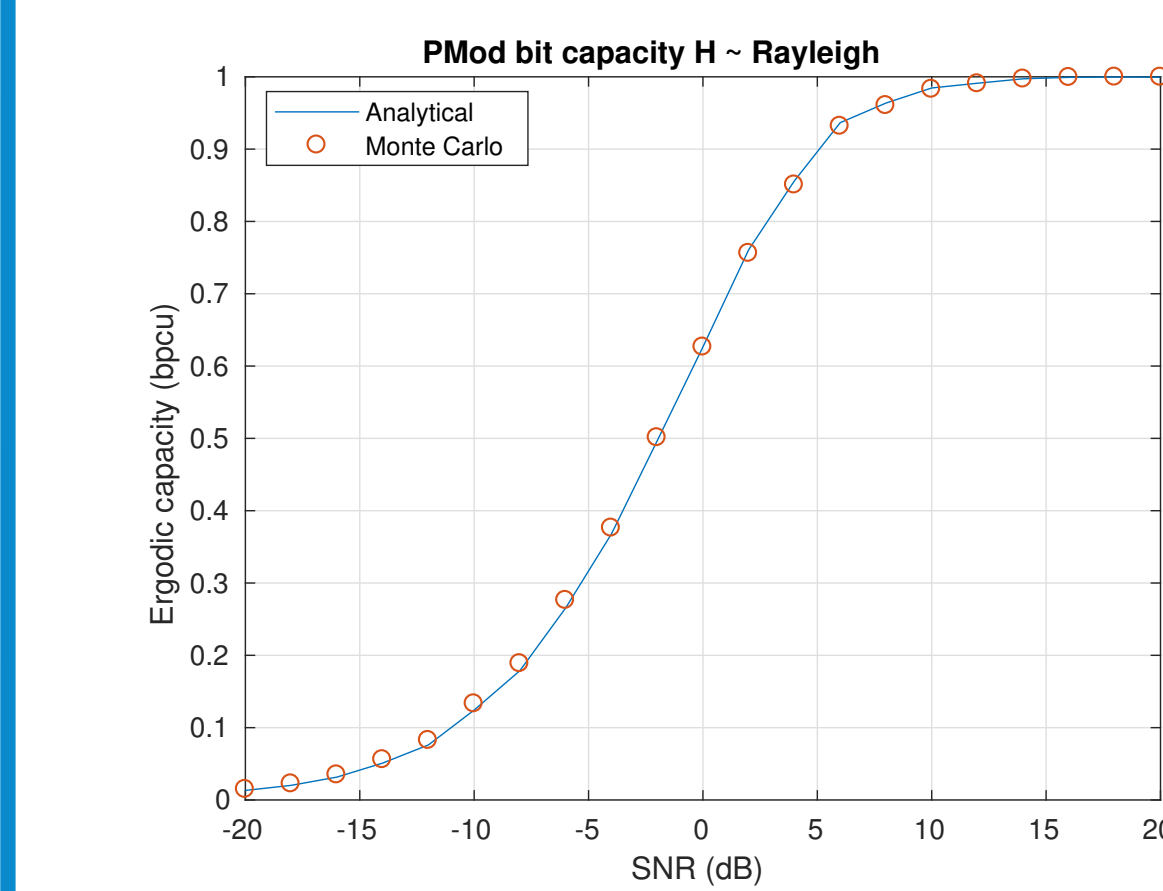
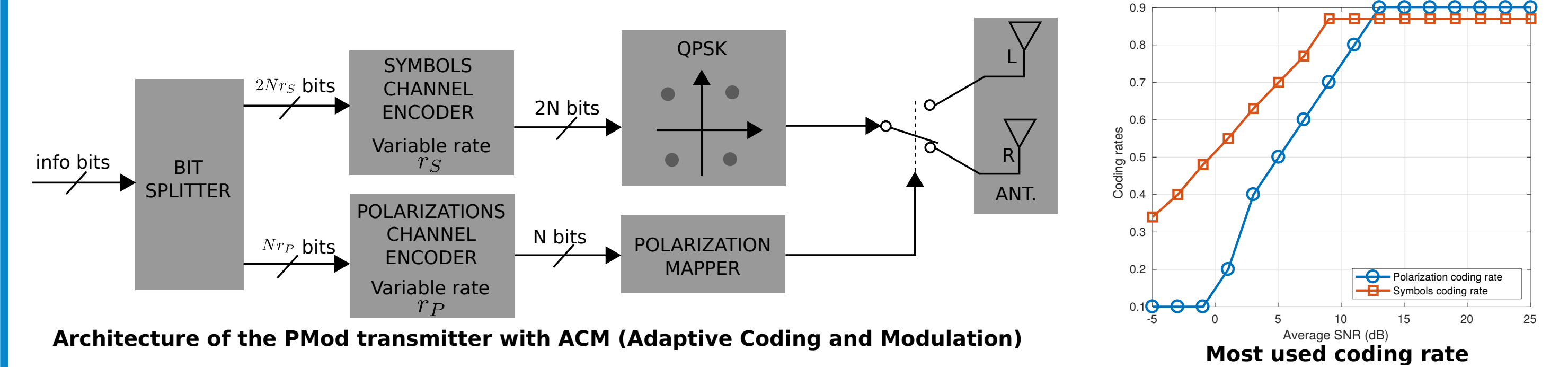
- **Methodology**
  - Be in contact with other actors such as companies, standardisation organisations, technological centres and other universities.
  - Whenever possible, use real measurements and hardware to validate the algorithms developed.
  - Work flow for developing the new algorithms:
    1. Statement of an optimization problem
    2. Derivation of an easily implementable algorithm
    3. Convergence and robustness analysis
    4. Perform simulations comparing it with baseline solution.
  - Use of Matlab for performing simulations of the algorithms and comparing them using metrics such as the spectral efficiency or the Frame Error Ratio (FER).
  - Evaluation of the algorithms applied to satellite communications standards like S-UMTS or DVB-S2X.
- **Means**
  - Workstation at lab A-312 with laptop and software like Matlab, GNU Radio...
  - GPSC servers
  - Ettus and Nutaq SDR platforms
  - Spectrum analyser

## NEXT YEAR PLANNING

Task Description	2018		2019	
	S1	S2	S1	S2
Research stay at SnT (University of Luxembourg)				
EURASIP/IEEE SPS Summer school on Signal Processing for 5G satellite networks				
Teacher assistant in subject CDIX (4º GETT)				
Analysis and modelling of RSSI temporal series (Táctica)				
Letter about Polarized Modulation capacity				
Journal about ACM algorithms for P2M communications (Precoding in SatCom)				
Design of a prototype of a SDR communications system to validate the algorithms				
Development of the prototype and field tests				
Collaboration in research projects about SatCom & SDR				
Writing and defence of the Ph.D. Thesis				

## RESULTS & DISCUSSION

### Link adaptation for Dual Polarized Mobile Satellite Systems [5]



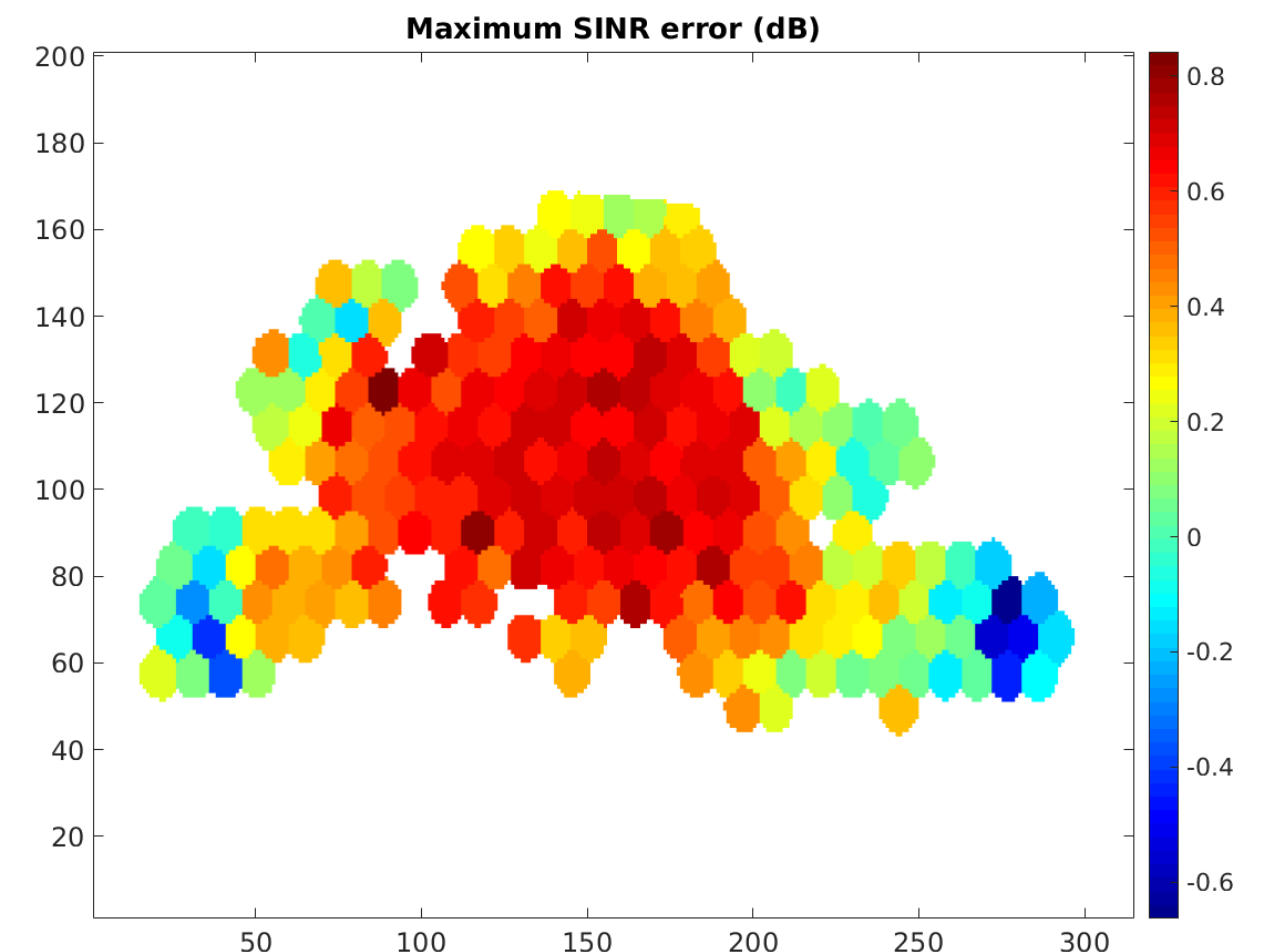
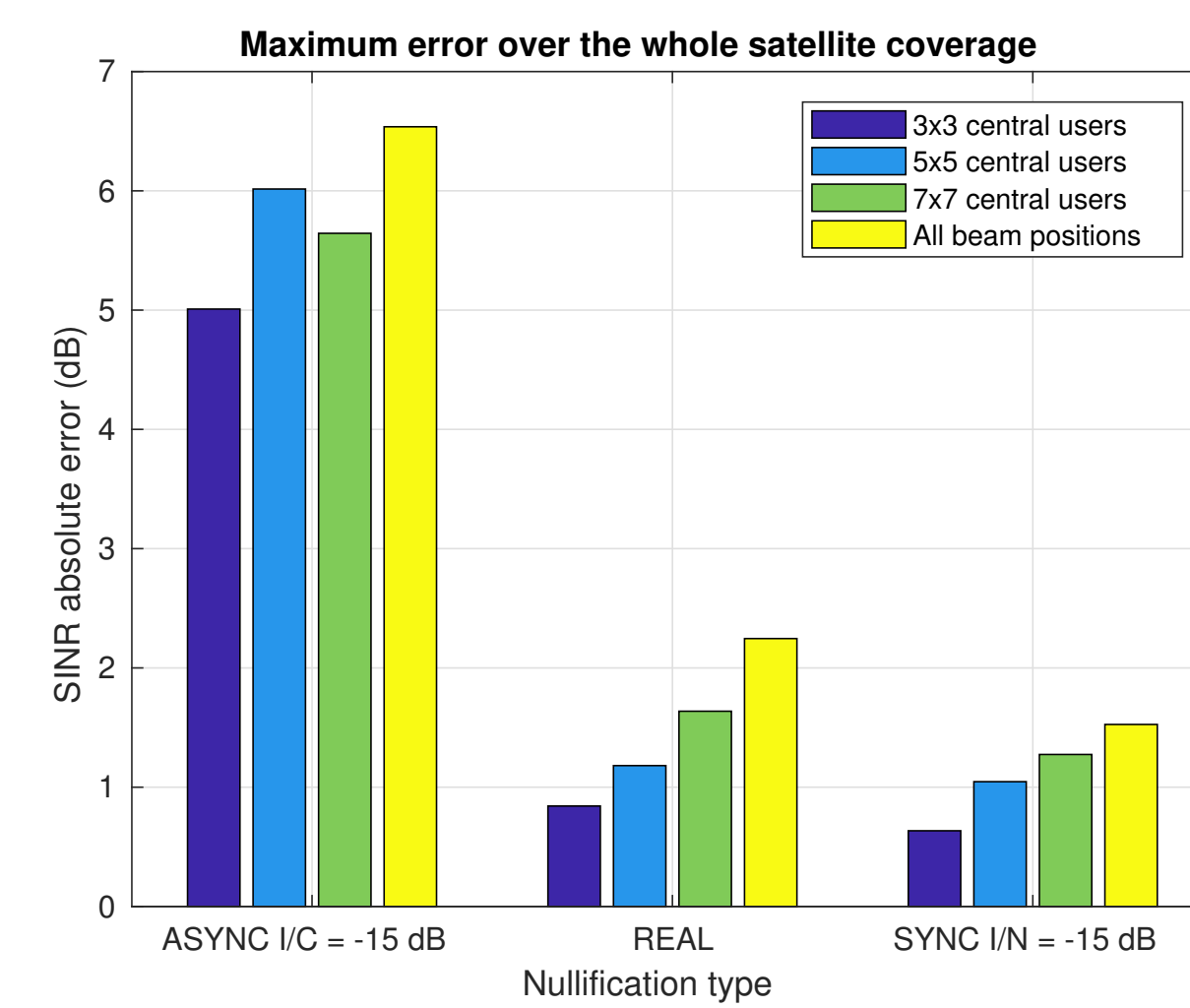
### Analytical approximation of PMod (Polarized Modulation) capacity

$$I_P \approx 1 - e^{-0.65\gamma\|h_1 - h_2\|^2/2}$$

Ergodic capacity (Rayleigh fading):

$$\bar{I}_P = \mathbb{E}_{\mathbf{H}}\{I_P\} \approx 1 - \frac{1}{(1 + 0.65\gamma\sigma_h^2)^2}$$

### Link adaptation in SatCom systems with Precoding and CSI detection errors [6]



- CSI detection error  $\gg$  CSIT matrix becomes sparse  $\gg$  Error in the estimated SINR
- Statistical and geographical characterization of the error
- **Solution:** adaptive margin per user updated with ACK/NAK exchange
- **Results:** reliable communication can be achieved in presence of CSI detection errors minimizing the capacity loss of a fixed global SINR margin.

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