Application of Programmable Radios to Adaptive Communications

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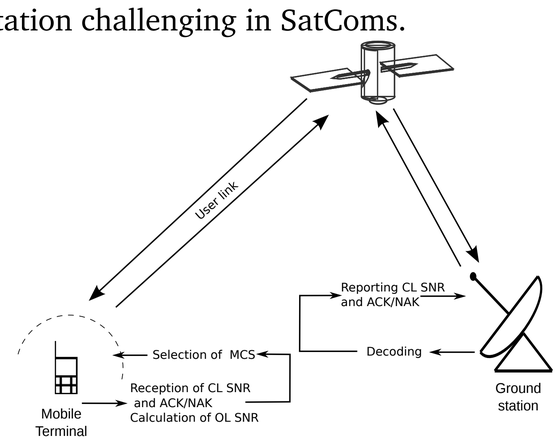
Research topics

Adaptive communications: link adaptation
Software Defined Radio (SDR)
Satellite communications

Motivation of the work

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 measures 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. Analysing of its convergence and robustness
    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

Thesis planning

Task Description	2016 S1	2016 S2	2017 S1	2017 S2	2018 S1	2018 S2
Technology watch about SDR and Adaptive Communications						
Seasonal School of SatNEx-IV						
Research plan defence						
Submission of a conference paper						
Analysing field results of Táctica project						
Studying MIMO and Statistical Signal Processing						
Short stay in CTTC (Catalunya)						
Research in algorithms for dual polarization						
Writing a paper with the results of the previous task						
Research algorithms for point to multipoint communications						
Writing a paper with the results of the previous task						
Long stay in an international research centre						
Writing and presentation of a communication in an international conference						
Preparation of an international scientific paper						
Design of a prototype of a SDR communications system to validate the algorithms						
Development of the prototype and field tests						
Writing and defence of the Ph.D. Thesis						

Preliminary results and discussions

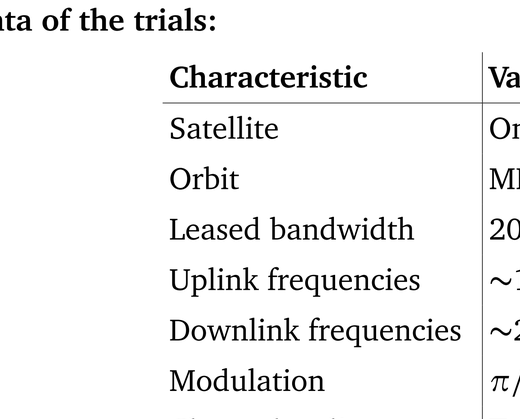
- Initial **field trials** of link adaptation algorithms were realized in Táctica Project with a car and an UAV using a MEO satellite.

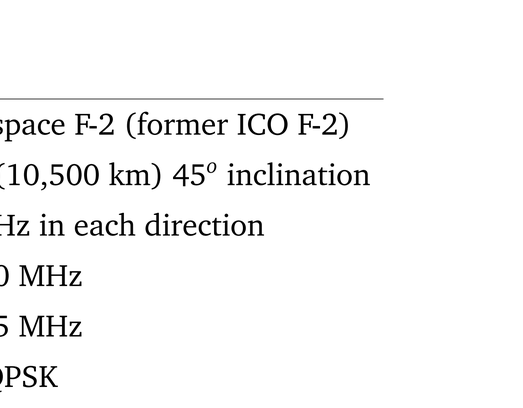
- **Data of the trials:**

Characteristic	Value
Satellite	Omnispace F-2 (former ICO F-2)
Orbit	MEO (10,500 km) 45^o inclination
Leased bandwidth	200 kHz in each direction
Uplink frequencies	∼1990 MHz
Downlink frequencies	∼2175 MHz
Modulation	$\pi/4$-QPSK
Channel coding	Turbo-codes
Physical layer	Standard S-UMTS family SL

Table: Main parameters

- **Spectral efficiency and Frame Error Ratio (FER).** Highway, speed of 120 Km/h and objective FER of 0.1.





- **Discussion**
  - All algorithms achieve the target FER and perform similarly in terms of spectral efficiency.
  - The inclusion of the open loop SNR seems to be useful in link adaptation.
  - It is difficult to compare the algorithms due to the changing elevation of the satellite.
  - SDR technology proved to be a good option for the development of an adaptive satellite communication system.

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