“On the integration of terrestrial and satellite systems in future 5G networks: a waveform perspective"

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- Satellite and Terrestrial Communications
- Waveform design
- Interference Management
- Synchronization and Estimation
- Impairment countermeasures
- Signal processing
- Cognitive Radio

Coordinator and Responsible for
- European Space Agency studies
- European projects
- ...
In 5G, very different use cases are converging, which pose mixed requirements:
- eMBB, mMTC, uRLL

New Air Interfaces and waveforms are required to address:
- Frequency assignments from 300 MHz up to 100 GHz
- Single- and multi-carrier solutions
- Licensed/shared/unlicensed spectrum access
- Orthogonal vs. non-orthogonal access
- ...

5GPPP, ETSI-SCN, and ITU (WG4B-4/40-E) groups advise for the integration of a satellite component into the 5G Architecture:
- e.g., coverage extension, backhauling/fronthauling, C-plane handover, etc.
SatCom in 5G

Thanks to their inherent characteristics, satellites can contribute to enhance 5G service capabilities and to address major challenges

- Ubiquitous coverage for areas/applications where terrestrial delivery not possible/efficient
  - Rural areas, emerging countries, etc.
  - 5G network management, synchronization, signalling,...
  - Efficient hierarchical backhauling
  - Multimedia delivery

- M2M communications
- Mission critical scenarios
SatCom: current systems and future trends

SatCom scenarios

GEO constellations - HTS
- Currently operating at 100 Gbit/s
- 100 beams in Ka-band
- Future GEO-HTS systems
  - Use of exclusive & shared Ka-bands, flexible power distribution, dynamic beamforming, beam hopping, etc.

Non-GEO constellations
- Existing LEO constellations target lower capacity global services
- Mega-constellations are being developed (services foreseen by 2020)
  - Global market with high capacity, low latency services
  - Interference issues with GEO
  - OneWeb (640), LeoSat (80-100), SpacEx (4000), Samsung (4600), SSI (80), etc.

Satellite channel characteristics

- There are several impairments on a satellite channel to be dealt with
  - Phase Noise
  - Non-linearities (not-colocated with the transmitter)
  - On-board filtering

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SatCom Waveforms: SoA

- **DVB-S2(X)**
  - Single-carrier waveform

- Regular framing structure

- Multiple MODCODs from very low SNR to high spectral efficiency
  - BPSK, QPSK, 8-PSK
  - 8-APSK, 16-APSK, 32-APSK, 128-APSK, 256-APSK
  - Rate 1/4, 1/3, 2/5, 1/2, 3/5, 9/10, 9/20,…

Sources
- “White Paper on the use of DVB-S2X for DTH applications, DSNG & Professional Services, Broadband Interactive Services and VL-SNR applications”
- Newtec white paper “DVB-S2X demystified”
5G discussed waveforms

- Single- and multi-carrier waveforms
  - Multi-carrier: optimal equalization efficiently performed in the frequency domain
  - Single-carrier: development of high-performance and low-complexity equalizers

- Orthogonal and non-orthogonal approaches
  - Orthogonality ensures the absence of interference
    - OFDM-like waveforms
    - Limited spectral efficiency: CP, OOB
  - Non-orthogonality to improve efficiency
    - Interference shall be then dealt with
      - Faster-than-Nyquist/Time-Frequency Packing
      - Non orthogonal multicarrier
      - ...

- Several waveforms proposed and to be considered for SatCom
  - e.g., P-OFDM, F-OFDM, UF-OFDM, FBMC, etc.
Question to be addressed

- Satellite positioning in the 5G architecture for
  - integrated satellite terrestrial network management and control approaches
  - Hierarchical backhauling

- Compatibility studies on radio interface (waveform, framing structure, etc.) and developed impairments countermeasure
  - How do the proposed air interface(s) perform in the presence of typical satellite channel impairments?
  - How do proposed countermeasures devised for terrestrial channel impairment fit satellite architectures?
  - Which are the complexity/flexibility/efficiency/costs trade-offs?
    - A single air interface/multi RAT including satellite

- Channel models and interference management models

- Feasibility and demonstrations of efficient integration of Satellite and Terrestrial networks
THANK YOU

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