Testing waveforms, beamforming and applications for a next generation of mobile communications

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Towards 6G

5G Usage scenarios

- Enhanced Mobile Broadband
  - Gigabytes in a second
  - 3D video, UHD screens
  - Work and play in the cloud
  - Augmented reality
  - Industry automation
  - Mission critical application, e.g., e-health
  - Self Driving Car

- Smart Home/Building

- Voice

- Smart City

- Massive Machine Type Communications

- Future IMT

- Ultra-reliable and Low Latency Communications

Digital World

Physical World

Human World

- Sustainability
- Global coverage
New challenges call for new technologies

• Waveforms
• Frequencies
• Adaptation and flexibility – new degrees of freedom
• Need realistic simulations, prototyping and measurements to design and analyse new physical layer techniques and their suitability to support emerging applications.
Three examples

Massive machine-type communications
- waveforms

Enhanced mobile broadband
- mmWaves

New degrees of freedom
- Liquid antennas

4G 5G 6G
Example 1 - Multicarrier waveforms for MTC

Need to reduce the out-of-band emissions

- Filter Bank Multi Carrier (FBMC)
- Generalised Frequency Division Multiplexing (GFDM)
- Universal Frequency Division Multiplexing (UFDM)
Filtered OFDM

Idea

Simulations

Kun Chen Hu, Ana García Armada, “SINR Analysis of OFDM and f-OFDM for Machine Type Communications”, IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC), Sep 2016
Testing f-OFDM with OpenAir Interface

• Will it work in real life?
Testing OFDM with OpenAir Interface

• Will it work in real life?
Example 2 – mmWaves for eMBB

- AMATISTA project: Immersive music therapy based on virtual reality in a nursing home using 5G NR at mmWaves
  - Simulator to understand best MCS, numerology, beamforming configurations
  - Validation with measurements
  - Immersive music therapy application
An example – AMATISTA project

Immersive music therapy based on virtual reality in a nursing home
Validating the simulator

![Graph showing RSRP (dBm) vs Distance (m)]

- **Measured**
- **Simul**
- **Difference**

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Example 3 – Arrays of liquid antennas

• Reconfigurability
• Changing the channel rather than adapting to its characteristics
• New degrees of freedom

Can we build an array of liquid antennas?

eGain is liquid at room temperature
Experiments in the lab

https://agarcia.webs.tsc.uc3m.es/experiments-with-liquid-antenna/
Conclusions

• Importance of simulations, prototyping and measurements to evolve mobile communications

• Three illustrative examples
  – MTC
  – eMBB
  – New degrees of freedom ..
Thank you!

Projects: AMATISTA, TeamUp5G, TERESA, IRENE-EARTH

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