UNIVERSITY OF PELOPONNESE
Department of Informatics and
Telecommunications

Wireless and Mobile Communication Lab
http://wmclab.uop.gr/

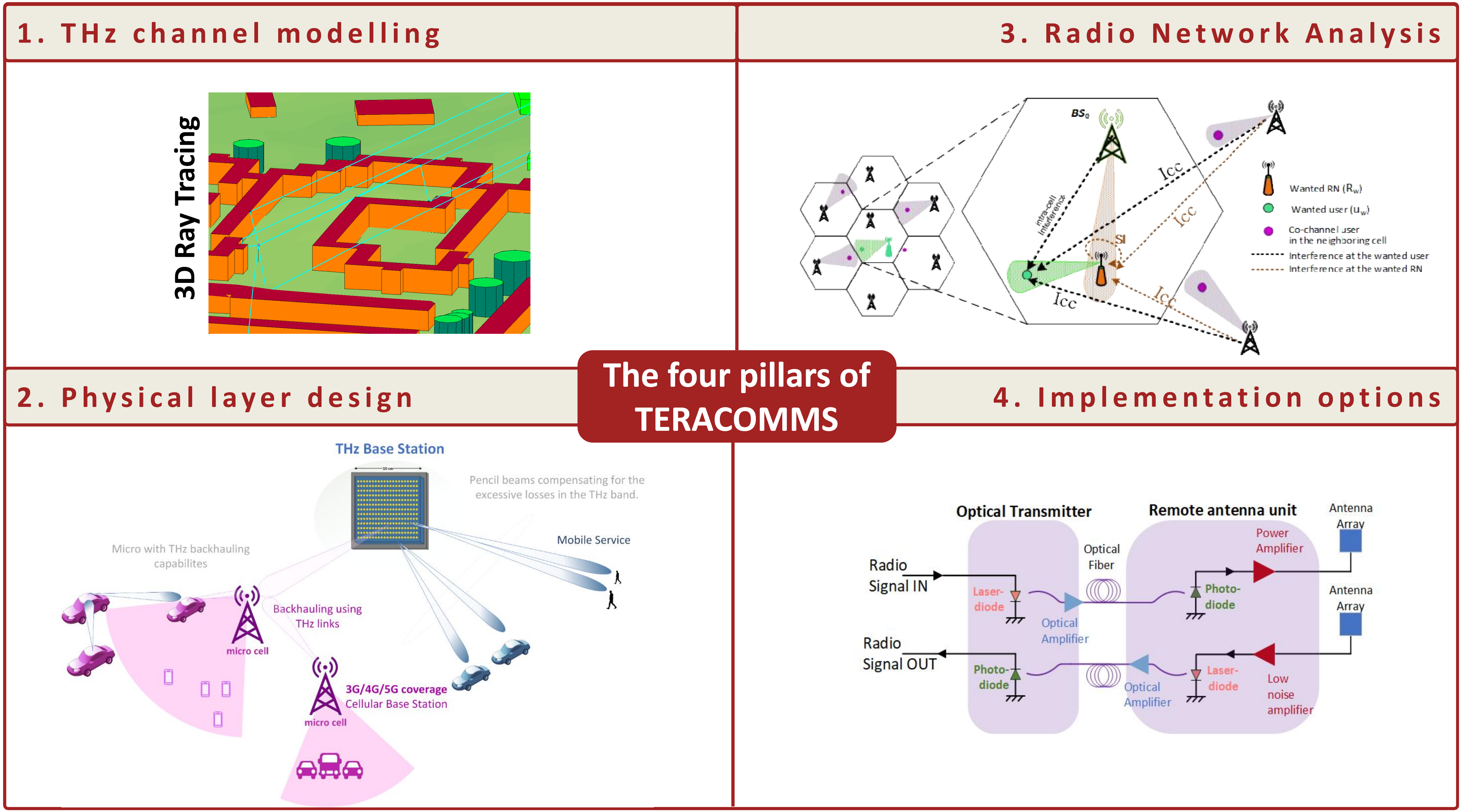
TERACOMMS vision for TERAFLAG

Prof. George Tsoulos

TERAFLAG Workshop
Cassis, France, 6th Sept. 2018

Our Vision

- ***Our vision for the next ten years is to study fundamental aspects that will accelerate the development of new exponential disruptive technologies such as THz wireless communications or TERACOMMS.***
- TERACOMMS is the complete paradigm shift required to provide the high data rate connectivity that is the core lubricant of digital society and its renewal. TERACOMMS will be the platform to support over 7 trillion wireless devices gathering data everywhere and serving over 7 billion people by 2025, and also support in the 2030’s brain-to-brain communication, 'Google on the brain', scalable intelligence and downloadable expertise applications.



1. THz channel modelling
3D Ray Tracing
3. Radio Network Analysis
BS
Icc
Icc
Icc
Icc
SI
Intra-cell interference
Wanted RN (R_w)
Wanted user (u_w)
Co-channel user in the neighboring cell
Interference at the wanted user
Interference at the wanted RN
The four pillars of TERACOMMS
2. Physical layer design
THz Base Station
Pencil beams compensating for the excessive losses in the THz band.
Mobile Service
Micro with THz backhauling capabilites
Backhauling using THz links
micro cell
3G/4G/5G coverage
Cellular Base Station
micro cell
4. Implementation options
Optical Transmitter
Remote antenna unit
Antenna Array
Power Amplifier
Optical Fiber
Radio Signal IN
Laser-diode
Optical Amplifier
Photo-diode
Antenna Array
Radio Signal OUT
Photo-diode
Optical Amplifier
Laser-diode
Low noise amplifier

Why?

- Members have performed pioneering work & have significant experience since the early 90's on:
  - **Deterministic & statistical propagation modelling**
  - **Wireless systems Smart antennas, Beamforming, SDMA, MIMO**

- G. Tsoulos, J. McGeehan and M. Beach, "Space division multiple access (SDMA) field trials. I. Tracking and BER performance," *Radar, Sonar and Navigation, IEE Proceedings,* 145 (1), pp. 73-78, 1998.
- G. Tsoulos, J. McGeehan and M. Beach, "Space division multiple access (SDMA) field trials. 2. Calibration and linearity issues," *Radar, Sonar and Navigation, IEE Proceedings,* 145 (1), pp. 79-84, 1998.
- G.E.Athanasiadou, A.R.Nix, J.P.McGeehan, 'A Microcellular Ray-Tracing Propagation Model and Evaluation of its Narrowband and Wideband Predictions', IEEE Journal on Selected Areas in Communications, Wireless Communications series, 18 (3), pp. 322-335, 2000.
- G.V.Tsoulos, G.E.Athanasiadou, 'On the application of adaptive antennas to microcellular environments: Radio channel characteristics and system performance', IEEE Transactions on Vehicular Technology, 51 (1), pp. 1-16, 2002.
- N.C. Sagias, G.K. Karagiannidis, 'Gaussian class multivariate Weibull distributions: Theory and applications in fading channels', IEEE Transactions on Information Theory, 51 (10), pp. 3608-3619, 2005.
- MIMO System Technology for Wireless Communications, G.V.Tsoulos (ed.), CRC Press, 2006.
- K. Peppas, N.C. Sagias, A.M. Maras, 'Physical layer security for multiple-antenna systems: A unified approach', IEEE Transactions on Communications, 64 (1), pp. 314-328, 2016.

Full list of publications available @ http://wmclab.uop.gr/publications/

- TERACOMMS work already underway

Key Research Personnel

FACULTY

Professor G. Tsoulos
Director
Wireless systems, smart antennas

Associate Professor
N. Sagias
Fading channels, optical wireless, satellite

Assistant Professor
G. Athanasiadou
Propagation, Wireless systems

Assistant Professor
A. Kaloxylos
Wireless networks

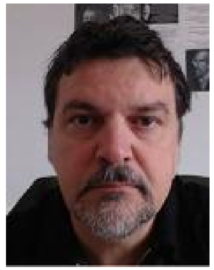
Lecturer
K. Peppas
Statistical communications

Teaching Staff
Dr D. Zarbouti
RRM, relay & full duplex systems

ASSOCIATE MEMBERS

Assistant Professor
K. Yiannopoulos
Optical wireless networks

Dr D. Kontaxis
MIMO, wireless communications



Dr S. Nikolopoulos
Cryptology, non-linear systems

Assistant Professor
K. Valagiannopoulos
Electromagnetics, metamaterials, graphene

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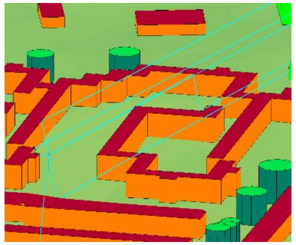
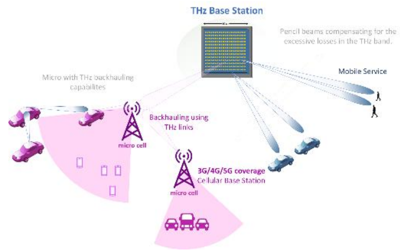
APPENDIX

1. THz channel modelling



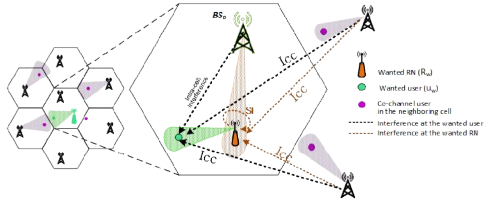
- The problem
  - The directional radio channel characteristics and statistics across the THz band play a more crucial role in the system and network design options, than in cellular communications, but are unknown todate.
  - Measurements are extremely time consuming and expensive. There are very limited measurements available and this is not expected to change in the next few years.
- Our approach
  - Develop a deterministic propagation model that will be able to take into account all the appropriate propagation mechanisms, different operational environments, antenna array directional patterns, polarization, multiple wideband carriers etc., and produce the 3D impulse response as well as space and time statistics. Tune the model with available measurements.

2. Physical layer design



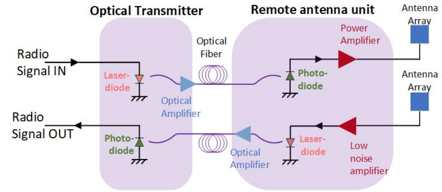
- The problem
  - Major challenge is the control algorithms for very large antenna arrays that maximize the utilization of the THz-band channel. The need to control the frequency, amplitude and phase at each element and dynamically create groups of virtual sub-arrays, introduces many degrees of freedom for this massive communication system.
- Our approach
  - A multi-objective optimization resource allocation problem with different optimization goals and constraints the operational scenario, the radio environment, QoS, grade of service, datarate, distance and options for the massive MIMO mode, single and multi-band operation with adaptive modulation and coding , etc. Sensitivity analysis and counter-measures for issues such as beam misalignment.

3. Radio Network Analysis



- The problem
  - Multi-user/cell interference limits the achievable throughput . Very narrow beams result in very low interference, unless aligned, when they cause very high interference.
  - The requirement for high-gain antennas both in transmission and reception, increases the complexity of broadcasting and relaying.
- Our approach
  - The impact of intra/inter-cell interference is analyzed in the context of the previous multi-objective optimization problem for a multicellular heterogeneous network that includes ground and flying relays as a means to reduce energy consumption and increase datarates.
  - Broadcasting with directional beam scanning, iterative search with increasing directivity, orthogonal grid of beams. Optimal relaying distances that balance shorter links with the overhead associated to beam steering and the relay costs.

4. Implementation options



- The problem
  - Possibly the main reason for slow progress in THz wireless communications is the presence of a unique technical challenge with signal generation, the so-called “THz gap”.
- Our approach
  - The physical layer wireless system is simulated with Matlab Simulink in order to provide the necessary platform for follow on prototype development. Design issues will be considered for key system elements such as the antenna array (metallic vs graphene), beamforming (optical vs phased, analogue vs digital vs hybrid), RF over fiber concept (electrical and optical design issues such as amplifiers, filters, processing, optical combiners, detectors, etc.).