THz end-to-end wireless systems
supporting ultra-high data Rate applications

ThoR project newsletter #1
December 2018

Welcome to the first ThoR project newsletter!

This project has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation, under grant agreement No. 814523. ThoR has also received funding from the National Institute of Information and Communications Technology in Japan (NICT).

ThoR is a joint EU-Japan project to provide technical solutions for beyond 5G (B5G) data networks based on 300 GHz RF wireless links. Data traffic densities of several Tbps/km^2 are already predicted for 5G networks. To service a fully mobile and connected society, B5G networks must undergo tremendous growth in connectivity, data traffic density and volume as well as the required multi-level ultra-densification.

Image courtesy of Deutsche Telekom.

The ThoR project will provide technical solutions for the backhauling and fronthauling of this traffic at the novel spectrum range near 300 GHz, which is able to cover the data rates of 200+ Gbps required for B5G systems. The use of currently unused spectrum for wireless links operating at disruptive bandwidths of 70 GHz, will be a critical key enabler for the introduction of B5G networks.

More information is available on the project website www.thorproject.eu

This introductory newsletter includes:

- A brief overview of the project and its objectives
- An outline of the ICT-09-2017 Cluster of related projects
- Information on an EC THz communications workshop in Mar-2019
- Results from spectrum sharing studies relevant to WRC 2019
- World first experimental demonstration of a superheterodyne 300 GHz wireless link!

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ThoR project introduction

The ThoR consortium brings together the leading Japanese and European players from industry, R&D and academia, whose prior work defines the state-of-the-art in high data rate long range point-to-point THz links. This team has been instrumental in defining and implementing the new IEEE 802.15.3d Standard "100 Gbps Wireless Switched Point-to-Point (P2P) Physical Layer."

Image courtesy of the University of Stuttgart

ThoR's technical concept builds on this standard, in an innovative combination using state-of-the-art chip sets and modems operating in the standardized 60 and 70-80 GHz bands, which are aggregated on a bit-transparent high performance 300 GHz RF wireless link offering >100 Gbps real-time data rate capacity.

ThoR will apply these European and Japanese state-of-the-art photonic and electronic technologies to build an ultra-high bandwidth, high dynamic range transceiver operating at 300 GHz combined with state-of-the-art digital signal processing units in two world-first demonstrations:

- >100 Gbps P2P link over 1 km at 300 GHz using pseudo data in indoor and outdoor controlled environments
- >40 Gbps P2P link over 1 km at 300 GHz using emulated real data in a live operational communication network

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This will require specific THz PHY technology advances in photo-mixers, amplifiers (including travelling wave tube amplifiers), receivers, up-converters and channel aggregation. The success of ThoR will represent the first operational use of THz frequencies in ICT.

ThoR's technical concept is scalable for full exploitation of the new IEEE 802.15.3d standard. It employs a parallelization of eight THz channels in the IEEE 802.15.3d frequency range from 252-325 GHz, where the four aggregated sub-channels in the 60 or 70-80 GHz bands are up-converted to one of the eight photonic-generated THz frequencies. Such an extended architecture would achieve the maximum data rate of 200+ Gbps as foreseen in the new THz standard in a bit-transparent, real-time data link. The ThoR demonstration will comprise two of these eight THz channels. The scalability of the ThoR solution to 200+ Gbps will be shown by software simulation, which will also integrate the measured characteristics of the hardware developed and used in ThoR.

With its targeted demonstration in a real network environment ThoR will bring THz communications closer to the market. The building blocks developed within ThoR will be useful for other applications, including mm-wave imaging, fibre-to-the-home (FTTH) and kiosk downloading. This will open new prospects for wireless technologies in terms of applications and use of novel spectrum.

ICT-09-2017 cluster

Several B5G projects were funded in the H2020 call ICT-09-2017 "Networking research beyond 5G." These projects are working together to share and disseminate information among themselves and to a wider audience, and since the ThoR topics are so closely related, it has been added to the group. There will be a range of Cluster events including workshops and conferences. The other six cluster members are:

DREAM www.h2020-dream.eu

D-band Radio solution Enabling up to 100 Gbps reconfigurable Approach for Meshed beyond 5G networks

Through the exploitation of the radio spectrum in D-band (130-174.4 GHz) with beam steering functionality, DREAM will enable wireless links with data rates exceeding current V-band and E-band wireless backhaul solutions by at least a factor of ten and thus, it will bring wireless systems to the speed of optical systems. The DREAM project vision and objectives rely on a power efficient and silicon based BiCMOS transceiver analog front end, operating in D-band and enabling cost efficient deployment of meshed networks with seamless fiber performance. A beam steering integrated antenna array using an intelligent low-cost packaging technology prototype will be developed for the implementation of the B5G network proof of concept in a realistic environment.

EPIC www.epic-h2020.eu

Enabling Practical Wireless Tbps Communications with Next Generation Channel Coding

EPIC aims to develop a new generation of Forward Error Correction (FEC) codes in a manner that will serve as a fundamental enabler of practicable B5G wireless Tbps solutions. The project also aims to develop and utilise a disruptive FEC design allowing to advance state-of-the-art FEC schemes and to obtain the principal channel codes for B5G use cases. The design framework developed within the project will offer new ways to conduct research and development and has the potential to affect the development of all future B5G communication systems.

TERAPOD https://terapod-project.eu/

Terahertz-based ultra-high bandwidth wireless access networks

TERAPOD will investigate and demonstrate the feasibility of ultra-high bandwid access networks operating in the terahertz band. The project will focus on end-to-end demonstration of the THz wireless link within a data centre in a proof of concept deployment, while also investigating other use cases applicable to beyond 5G such as wireless personal area networks, wireless local area networks and high bandwidth broadcasting

TERRANOVA www.ict-terranova.eu

Terabit/s Wireless Connectivity by TeraHertz innovative technologies to deliver Optical Network Quality of Experience in Systems beyond 5G

TERRANOVA envisions to extend the fibre-optic systems' Quality of Experience to wireless links by exploiting frequencies above 275 GHz. This means reliable connectivity at extremely high data rates in the Tbp/s regime and almost 'zero-latency' for networks

B5G. The consortium will employ breakthrough technology concepts, namely: the design of baseband signal processing for the complete optical and wireless link and the development of THz wireless frontends and their integration with photonic components. A network information theory framework, caching techniques, channel and interference models, all tailored to the particularities of the THz regime and extremely large bandwidths will achieve the successful co-design of components and network solutions.

ULTRAWAVE www.ultrawave2020.eu

Ultra capacity wireless layer beyond 100 GHz based on millimeter wave Traveling Wave Tubes

The ULTRAWAVE project is aimed at developing a high capacity backhaul that enables 5G cell densification by exploiting bands beyond 100 GHz. New travelling wave tubes delivering high power will allow the creation of an ultra capacity layer providing more than 100 Gbps per kilometer square in point-to-multi-point at D-band (141-174.8 GHz) fed by novel G-band (300 GHz) point-to-point high capacity links. The ULTRAWAVE system is empowered by the convergence of three main technologies: vacuum electronics, solid-state electronics and photonics. This ULTRAWAVE layer will enable backhaul of hundreds of small and pico cells, no matter the density, opening scenarios for new network paradigms aiming at a full 5G implementation.

WORTECS www.wortecs.cms.orange-labs.fr

Wireless Optical/Radio TErabit CommunicationS

WORTECS will explore the Tbps capability of the spectrum above 90 GHz, combining radio and optical wireless technologies. The primary challenge of WORTECS is to propose scientific and technology advances for novel use of the spectrum, de-risking technological building blocks at frequencies above 90 GHz up to THz communications backed by innovative usage scenarios, for instance, virtual reality. It will also address visible light communications and develop radically new approaches for spectrum efficiency. WORTECS aims to offer: optical wireless communication and radio over 90 GHz proof of concept with several Gbps throughput: innovation on antennas, coding and heterogeneous wireless network studies with new architectures and protocols for routing, latency and caching.

2nd Towards THz Communications workshop

Registration open!!

The ICT-09-2017 Cluster will be organising the 2nd Towards THz Communications Workshop with the support of the EC.

THU 07-Mar-2019

Albert Borschette Congress Centre Rue Froissart 36, 1040 Brussels, Belgium

The preliminary agenda has been announced and is available on the workshop webpage:

http://terapod-project.eu/events/ec-thz-workshop

Conclusions from 275-450 GHz sharing studies

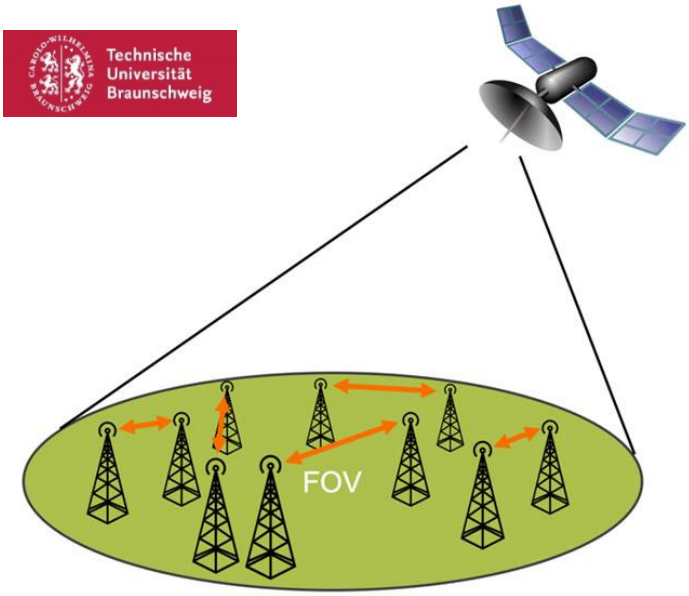

Illustration of an EESS satellite's field of view (FOV) with several front- and/or backhaul links in sight.

The upcoming World Radiocommunication Conference 2019 (WRC-19) is evaluating the possibility to identify frequency bands in the range 275 to 450 GHz for fixed and land mobile services with minimised restrictions under Agenda Item 1.15. Such an identification will secure the availability of spectrum to enable future wireless front- and backhaul links with data rates beyond 100 Gbps with a bandwidth in the order of 50 GHz. A critical issue in this context is the potential interference with Earth Exploration Satellite Services (EESS). ThoR has performed simulation studies considering the possible sharing of spectrum for backhaul/fronthaul links with EESS in the frequency range 275 GHz to 450 GHz. A comparison with other International Telecommunication Union - Radiocommunication Sector (ITU-R) studies highlights slight differences which are due to different simulation methods and assumed distributions of the elevation angle for the fixed service. As a result, the maximum bands that can be shared, without any restrictions to the fixed service in regards to EESS are: 275-296 GHz, 306-313 GHz, 318-333 GHz and 356-450 GHz. The total bandwidth is 137 GHz and this well exceeds the estimated spectrum requirement of 50 GHz. With the existing allocation of 252-275 GHz for fixed services, a consecutive band of 44 GHz is available even at the lower frequency end.

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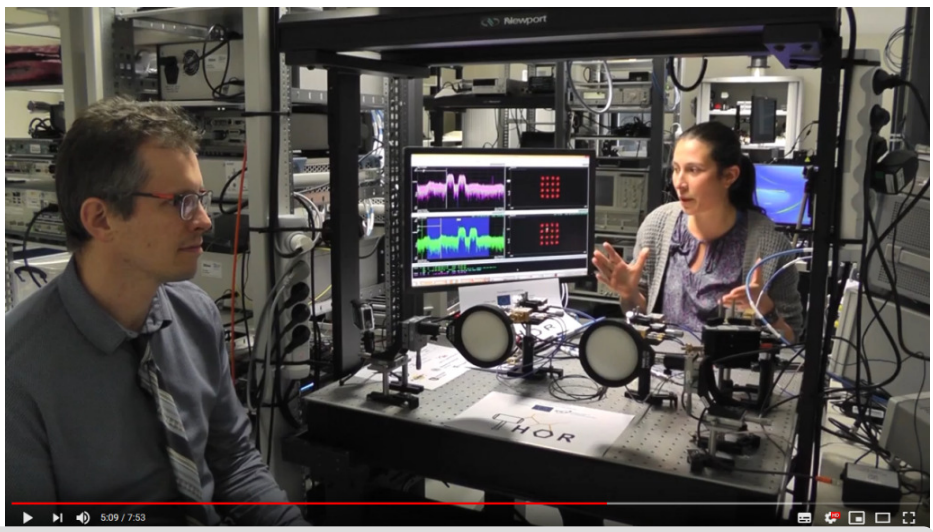
ThoR DEMO-1: Superheterodyne 300 GHz wireless link

Experimental proof of principle of the ThoR super-heterodyne approach has already been demonstrated. A publication is in progress so no details can yet be provided, but a video giving an overview of the laboratory set-up (held at University of Lille/ IEMN CNRS, France) is available on the link below:

https://youtu.be/U1zatU6Gfbk



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