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

THOR

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ThoR project newsletter #3

December 2019

Welcome to the third ThoR project newsletter!

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

The project has had a very busy period with some exciting progress and great events. This newsletter includes the following:

- ThoR workshop in Japan (20-Sep-2019; University of Waseda)
- Save the date! The B5G Cluster is organising the 3rd Towards THz Comms Workshop on 12-13 Mar-2020 at IMEC
- Overview of 5G/beyond 5G requirements wireless transport links from Deutsche Telekom
- Review of the ThoR parallelisation of 70/80 GHz transceiver modules from Siklu
- An update on measurement of 300 GHz band high-gain antennas at CIT

ThoR Workshop held at Waseda University

The first ThoR workshop was organised and hosted by Waseda University on FRI 20-Sep-2019. The agenda and further details may be found on the website: https://thorproject.eu/events/thor-workshop-sep-2019 The workshop included three invited keynotes, presentations from the ThoR partners and a poster session. In addition, there was a small exhibition during the lunch and coffee breaks. Over seventy attendees were present, and the event was very well received. Based on this success, a follow-up event in Japan is under discussion in addition to an EU workshop planned at the end of the project.

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WASEDA University 早稲田大学 · Technische Universität Braunschweig · 千葉工業大学 CHIBA INSTITUTE OF TECHNOLOGY · University of Stuttgart Germany · Université de Lille · NEC · Siklu · HRCP · Fraunhofer IAF · T · · · GIFU UNIVERSITY · VIVID COMPONENTS · NICT National Institute of Information and Communications Technology

SAVE THE DATE

3rd Towards THz Comms Workshop
12-13 Mar-2020; IMEC (Leuven)

Third Towards Terahertz Communications Workshop

An ICT Beyond 5G Cluster Workshop

https://terapod-project.eu/links/b5g-cluster/

SAVE the date: *12th – 13th March 2020, IMEC, Leuven, Belgium*

dream terapod EPIC TERRANOVA ULTRAWAVE THOR WORTECS

BEYOND5G

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There will be an evening reception on THU 12-Mar, and a workshop on FRI 13-Mar-2020 including guest speakers and a panel session. Full agenda will be released soon!

The requirements of 5G and beyond 5G wireless transport links

The volume of data traffic consumed by the 5G and beyond 5G (B5G) use-cases, services and applications is expected to significantly grow in comparison to today's 4G/LTE generation. The experienced 5G user data rate depends on the targeted application/use case, and ranges from few kbps in case of massive Internet of Things to hundreds of Mbps (up to a peak of several Gbps) in the case of broadband access. These consumer performance requirements should also be reflected and supported in access and transport networks.

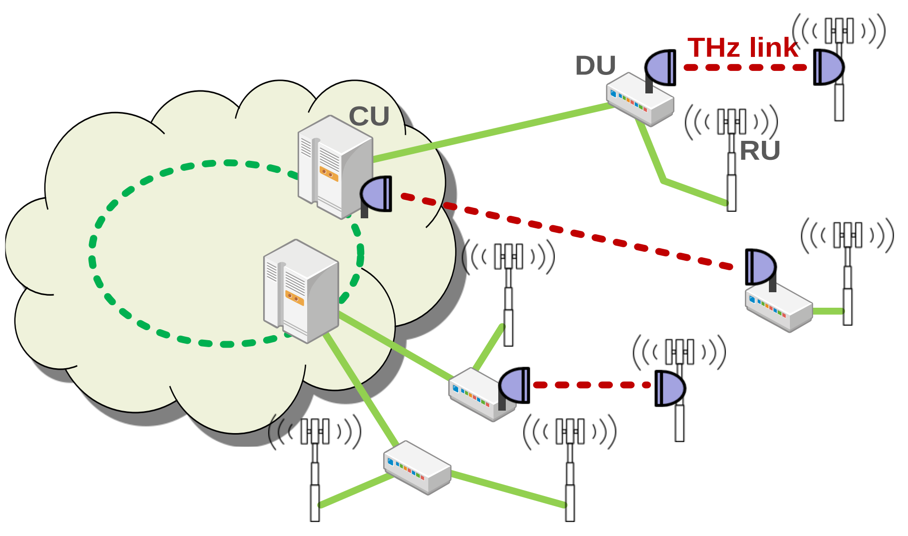

Fig. 1: Centralised architecture with functional split

Evolving from 4G/LTE to 5G network architectures, the main change is that the original single-node baseband functions (protocol stack) in 4G/LTE are split between the Central Unit (CU), Distributed Units (DUs) and Radio

Units (RUs) resulting in a so-called **centralized network architecture with functional split** (Fig. 1). The choice of functional split points depends on the specific use case and application and determines the performance requirements for the transport network and consequently the capability of the mobile access network and user experience. The specific performance requirements for the transport network due to a certain functional split option were elaborated in ThoR public deliverable D2.1; available from the project website: https://thorproject.eu/results/deliverables.

As can be observed from D2.1, the required throughput of the transport network (namely the link between DU and CU) depends greatly on the particular split option. The lower the split point the higher the required throughput, and consequently the more difficult and costly the deployment in large-scale networks. At the lowest split point (Option 8 in D2.1), the typical configurations of 5G macro BS (with three sectors/cells) require hundreds to thousands of Gbps of throughput. In this case, optical fibre will be the only transport solution. If the wireless transport connection is needed (*e.g.* to ensure fast, flexible, and low-cost deployment), a lower layer split point requiring throughput of tens to hundreds of Gbps must be assumed. Nevertheless, even when assuming a lower layer split point, the current V- or E-band products providing maximum throughputs of 10 Gbps cannot serve most of the configurations of 5G macro base stations. Such throughputs could be served in future by terahertz-based products targeting throughputs beyond 100 Gbps, a focus of ThoR project.

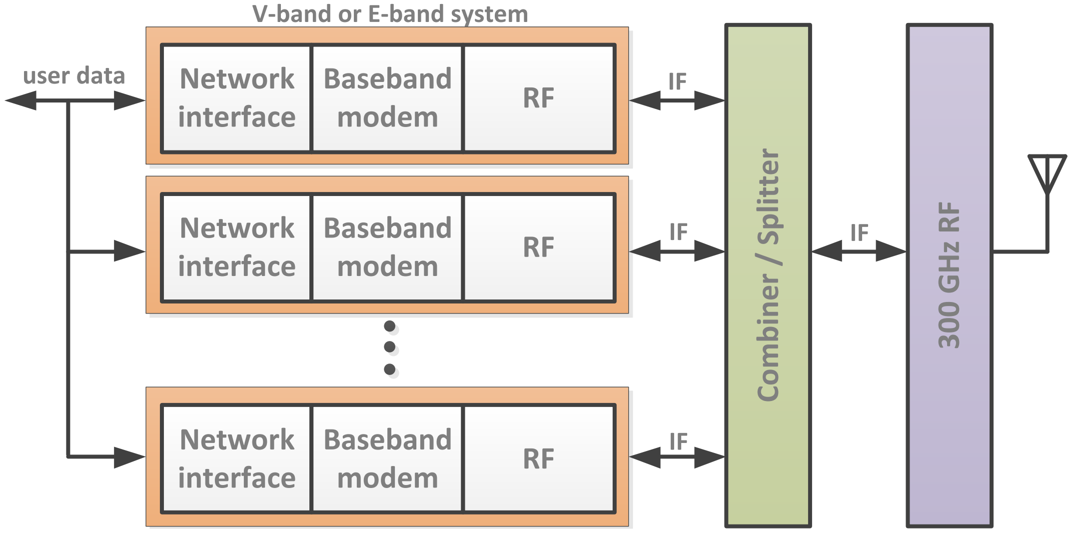

Fig. 2: Functional block diagram of ThoR multi-carrier system

ThoR's system design leverages and exploits the new IEEE 802.15.3d standard which is expected to lead to affordable solutions based on deep silicon integration. The design targets a parallelisation of up to eight narrow band THz channels in the IEEE 802.15.3d frequency range from 252-325 GHz. To demonstrate this multi-carrier concept, aggregated sub-channels in V-band (60 GHz) or E-band (70-80 GHz) are utilised and converted to THz frequencies. This scalable architecture can achieve data rates above 200 Gbps.

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Parallelisation of 70/80 GHz transceiver modules

In the ThoR project Siklu's role is to develop 70/80 GHz transceiver (TRX) modules. The ThoR approach is to split the task of processing a multi-GHz signal between a bank of modem devices. By using mature E-band technology as a building block, an ultra-high throughput system may be delivered which supports frequency division duplexing (FDD).

The Siklu E-band TRX module has a number of advantages:

- Supports channels from 250 MHz up to 2 GHz
- Data throughput up to 10 Gbps
- FDD operation at 70/80 GHz
- 10 Gbps network interface to copper or fibre.

Fig. 3: Siklu E-band TRX module

In the ThoR approach (Fig. 4), four modems are parallelised in order to handle the wide spectrum available. Combining is done with the aid of diplexers to prevent Tx-to-Rx self-interference. Each modem handles 2 GHz of spectrum and can provide 10 Gbps of throughput (bi-directional), *i.e.* the total throughput is 40 Gbps. The 10 Gbps SFP+ interfaces on the modems are combined by an external switch.

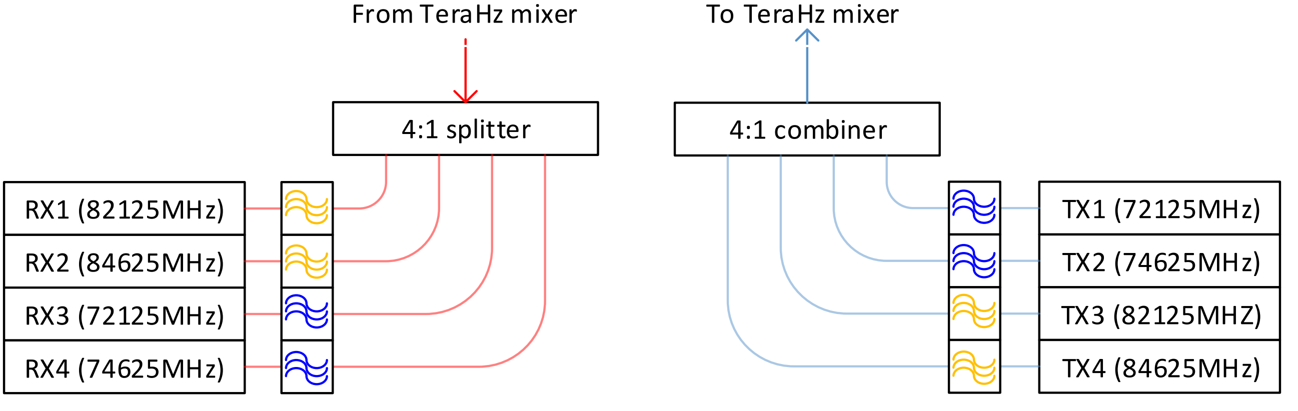

Fig. 4: Four E-band modems combined for up/down conversion.

This modem parallelisation concept enables a trade-off between cost and modem performance. The use of E-band modems enables the application of mature RF and modem technology to bring THz communication rapidly to the market.

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Special Issue of Applied Sciences on "THz Communications"

Dr. Mira Naftaly of NPL, one of the B5G Cluster members through the TERAPOD project, is preparing a Special Issue of Applied Sciences (an MDPI journal; ISSN 2076-3417; CODEN: ASPCC7) on "THz Communications."

If you are interested in contributing to this issue, please see the following link for more info:

https://www.mdpi.com/journal/applsci/special_issues/Terahertz_Communications_

Measurement of 300 GHz band high-gain antenna

An accurate antenna pattern model is important in order to evaluate the potential interference of THz wireless signals with passive services, such as earth exploration satellite services (EESS). However, there is no ITU-R model of radiation pattern that covers up to 300 GHz. Therefore, the sharing studies on WRC Agenda Item 1.15 employed the existing Recommendation ITU-R F.699 and F.1245 that covers up to 87 GHz. Moreover, there is very little experimental characterisation data for high-gain antenna in the THz range available in the literature. It is difficult to measure accurate antenna patterns in the THz frequency range, because the output power of THz transmitters and the sensitivity of THz receivers is restricted because of the limitations of semiconductor devices operating in this frequency range.

The team at CIT measured the radiation pattern of a high-gain Cassegrain antenna with a diameter of 150 mm (45 dBi). The antenna patterns were measured in an anechoic chamber at NITC with a transmission distance of 20 m. The experimental results are shown in Fig. 5. The antenna pattern models described in Recommendation ITU-R F.699-8 and F1245-3 are also shown. A small dip was observed at the top of the main lobe. The transmission distance (20 m) was smaller than the boundary of far field (45 m). Therefore, the shadowing effect of the secondary reflector is observed. (It is difficult to set the transmission distance over 45 m in an anechoic chamber.)

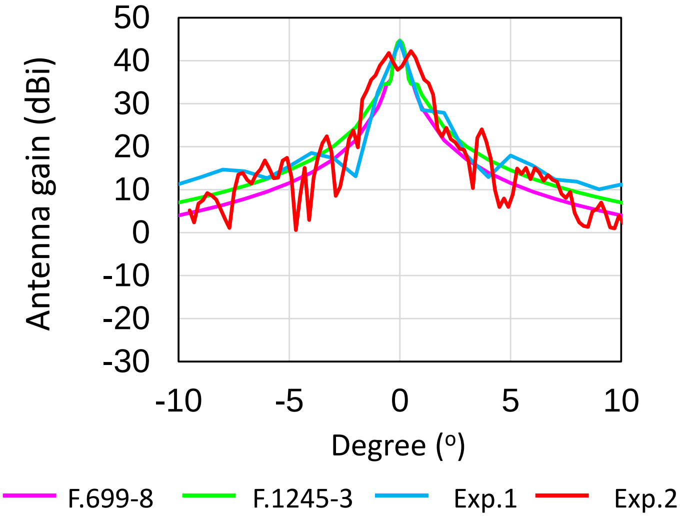

Fig. 5: Measured radiation patterns of Cassegrain antenna at 300 GHz, and the ITU-R Recommendations.

Fig. 6: Photograph of the 300 GHz band transmitter.

The sidelobes of the measured radiation patterns are larger than that of ITU-R antenna pattern models. These results indicate that new antenna pattern models for the 300 GHz band are necessary. CIT is now making a transmitter (Fig. 6) and plans to obtain an experimental radio station license. Using this transmitter, outdoor transmission experiments will be conducted in order to measure the accurate radiation pattern of high-gain antennas.

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