Terahertz technology for ultra-broadband and ultra-wideband operation of backhaul and fronthaul links in systems with SDN management of network and radio resources

Information & Communication Technologies (ICT)
Research and Innovation Action (RIA)
G.A. no: 871668
Start Date: 01.11.2019 [M01]
Duration: 36 Months

Funded by the Horizon 2020
Framework Programme of the European Union

Deliverable D8.1
Project Announcement

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Date due of deliverable | 30.11.2019 [M01]
Actual submission date | 13.12.2019
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Participants | ICCS, FhG-HHI
Work-package | WP8
Dissemination level | Public
Type | Websites, patents filling, etc.
Version | 1.0
Total number of pages | 30
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<th>EC</th>
<th>European Commission</th>
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<td>ICT</td>
<td>Information and Communication Technology</td>
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Executive Summary

The following document reports on the preparation of basic material for the announcement of TERAWAY project through the official tools of the European Commission (EC) and through the dissemination channels of the consortium partners. More specifically, the document reports on the preparation of the project factsheet and the preparation of a short presentation of the project for the official website of the EC, the preparation of two press-releases (by Fraunhofer-Heinrich Hertz Institute and Institute of Communications & Computer Systems).

Keywords: Dissemination, Project presentation, Press release, Factsheet
1 Introduction

The 5G vision for a fully mobile and connected society drives today the herculean efforts worldwide on designing, developing and commercializing the next generation of wireless networks that can address the huge requirements in terms of coverage, traffic capacity, reliability, latency and network energy efficiency. Main results of these efforts designate that a wireless technology with high agility, but optical fiber-like capacity is necessary in order to act as a natural extension of the core (optical fiber) network and deliver this massive capacity to the gNB or to the radio part of it.

TERAWAY comes as a technology intensive project aiming to develop a new generation of THz transceivers that can overcome these limitations and enable the commercial uptake of THz technology. Leveraging optical concepts and photonic integration techniques, TERAWAY will develop a common technology base for the generation, emission and detection of wireless signals with selectable symbol rate and bandwidth up to 25.92 GHz within an ultra-wide range of carrier frequencies covering the W-band (92-114.5 GHz), D-band (130-174.8 GHz) and THz band (252-322 GHz).

TERAWAY is a 3-year Research and Innovation Action project that brings together twelve (12) leading European research centers and companies. The project was launched in November 2019 and is expected to finish in October 2022. TERAWAY project is funded by the European Commission through the Horizon 2020 programme under the Photonics Public Private Partnership (www.photonics21.org). The initial announcement of the project launch to the general public and the scientific and technical community is pursued through the publication of the project factsheet and the project presentation through the cordis website of the EC and through two press-releases from an industry-oriented research institute (FhG-HHI) and an academic partner (ICCS) of the consortium. This dissemination material is presented below.

2 Project Factsheet

The 2-page long project factsheet follows a typical format and provides standard information about the project (call identifier, consortium, time-line, budget, contact persons and project website), a short description about the motivation behind the project, a short description about the main technical concepts and the main objectives, and an overview about the exploitation plans and the expected impact. The factsheet will go public and will be made available through the project website (ict-teraway.eu), which is under development during the time of writing this deliverable and will be also available through the cordis website. The project factsheet is appended to the present report as Appendix I.

3 Project short presentation

The short presentation of the project includes fourteen (14) slides that provide the same information as the project factsheet with stronger emphasis on the technical scope and the technical concepts of the project. The short presentation of the project will be made available through the project website (ict-teraway.eu) and will be also available through the cordis website. This presentation is appended to the present report as Appendix II.
4 Press releases

Within the first month of the project, two (2) press releases were prepared to announce TERAWAY to the general public and the scientific and technical community. The first one by the Fraunhofer Heinrich Hertz Institute was wired through the News section of the Institute’s website (https://www.hhi.fraunhofer.de/en/departments/pc/projects/teraway.html) addressing the German and international general public and technical community (see Figure 1).

Figure 1. The Press Release of TERAWAY project at FhG-HHI’s official website.
The second press release by Institute of Communications and Computers Science (ICCS) was wired through the Projects section of the Photonics Communication Research Laboratory website and a second announcement about the Project Launch published to the News Section just after the official Kick-off meeting of the project (3-4 December 2019).

The content of the specific press release- Project announcement has been distributed to all partners of the project and is expected to be launched to the official websites of their organization within the following days (for the content of this announcement please go to Appendix III).

Link
https://www.photonics.ntua.gr/teraway-project-launch-kick-off-meeting/

**Figure 2. Project Announcement and Kick-off Press release at ICCS-PCRL website.**
5 Conclusions

Dissemination material for the project has been prepared. It is in the form of a 2-page factsheet that contains a brief overview of the motivation of project, its objectives, the exploitation strategy and the expected impact. The content of the factsheet has been elaborated in a short presentation, presenting also in more detail the role of the partners and the underlying technology. The project has been announced through the websites of the organizations participating, through their websites and two press releases have be prepared and issued.
Appendix I – TERAWAY Factsheet
TERAWAY Factsheet

**Call identifier:** H2020-ICT-2019-2  
**Contract No.:** 871668  
**Timeline:** 1 November 2019 – 31 October 2022  
**Overall budget:** € 5 999 498.88  
**EC contribution:** € 5,999,498.75  
**Contact**  
Institute of Communications & Computer Systems  
Photonics Communication Research Lab  
Prof. H. Avramopoulos  
Dr. Maria Massaouli  
Christos Tsakos  
**Project Website:** http://ict-teraway.eu/  
**Consortium:** 12 Partners (6 EU countries)

TERAWAY is a H2020 5GPPP Phase III project funded by the European Union aiming to develop a disruptive generation of THz transceivers for high-capacity BH and FH links in 5G networks.

**Motivation**

The 5G vision for a fully mobile and connected society drives today the herculean efforts worldwide on designing, developing and commercializing the next generation of wireless networks that can address the huge requirements in terms of coverage, traffic capacity, reliability, latency and network energy efficiency. Main results of these efforts designate that a wireless technology with high agility, but optical fiber-like capacity is necessary in order to act as a natural extension of the core (optical fiber) network and deliver this massive capacity to the gNB or to the radio part of it.

Terahertz (THz) wireless communication technology with carrier frequencies in the 300 GHz regime has been designated as a possible candidate for this extension due to the abundance of bandwidth that can be found there. However, despite the technical progress and the individual achievements that have been made in the field, THz technology appears still to be short in turning its indisputable potential at the conceptual level into true industrial impact. Reasons for that include i) the challenge to take advantage of the available bandwidth and generate broadband signals of high quality in a practical way, ii) the challenge to develop a common technology base and iv) the challenge to overcome the difficulties in the handling and the propagation of the THz waves.

TERAWAY project has received funding from the European Union’s Horizon 2020 Research and Innovation Programme under GA No 871668 and it is an initiative of the Photonics Public Private Partnership.
Concept - Objectives

TERAWAY comes as a technology intensive project aiming to develop a new generation of THz transceivers that can overcome these limitations and enable the commercial uptake of THz technology. Leveraging optical concepts and photonic integration techniques, TERAWAY will develop a common technology base for the generation, emission and detection of wireless signals with selectable symbol rate and bandwidth up to 25.92 GHz within an ultra-wide range of carrier frequencies covering the W-band (92-114.5 GHz), D-band (130-174.8 GHz) and THz band (252-322 GHz).

In this way TERAWAY steps into providing for the first time the possibility to organize the spectral resources of a network within W/D/THz bands into a common pool of radio resources that can be flexibly coordinated and used.

The use of photonics will enable the development of multi-channel transceivers with amplification of the wireless signals in the optical domain and with multi-beam optical beamforming in order to have a radical increase in the directivity of each wireless beam.

In parallel, aiming to take the most out of the THz technology and enable its commercial uptake, the project will develop a new software defined networking (SDN) controller and an extended control hierarchy that will perform the management of the network and the radio resources in a homogeneous way with obvious benefits for the network performance and energy efficiency and with possibilities for the provision of network slices in order to support heterogeneous services.

Impact

TERAWAY is expected to have a disruptive effect on the usability of the THz band (252-322 GHz), which can be considered today still as unexplored, by developing a technology base that will facilitate the thorough investigation of the THz transmission solutions and their incorporation inside a meaningful system environment, creating the conditions for their actual use inside next generation networks.

It will have a disruptive effect on the usage of the radio spectrum in three different ways and is expected to develop valuable knowhow and methodologies regarding the placement of the moving nodes and the management of their resources and have a disruptive impact on the dynamic scalability of the network capabilities.
Appendix II – TERAWAY Project Presentation
Terahertz technology for ultra-broadband and ultra-wideband operation of backhaul and fronthaul links in systems with SDN management of network and radio resources

**Topic:** 5G Long Term Evolution  
**Type:** RIA  
**Call:** H2020-ICT-2019-2  
**Contract No:** 871668  
**Start date:** 1 November 2019  
**Duration:** 36 Months  
**EC contribution:** € 5 999 498.75  

Funded by the Horizon 2020 Framework Programme of the European Union under the Photonics Public Private Partnership
TERAWAY Consortium

12 Partners
6 EU countries

3 Large Companies
4 SMEs
2 Industry-oriented Research Institutes
3 Academic Organizations

TERAWAY (RIA GA. No. 871668)
TERAWAY Project

A new disruptive generation of photonic-enabled THz transceivers for high-capacity BH and FH links in 5G networks.

Vision-Concept

"enabling industrialization of THz wireless communication technology"

- Development of a common technology base for the generation, emission and detection of wireless signals in the THz (252–322 GHz) and W/D bands

- Multi-channel, ultra-wide band transmitters: Generation/emission of THz/W/D signals with selectable symbol rate, high bandwidth and of high transmission reach

- Multi-channel, ultra-wide band receivers: Detection of THz/W/D band signals and their direct down-conversion to baseband

- Integration of the nodes inside a functional network system of high-flexibility and efficiency: New network management platforms (based on SDN) and an extended control hierarchy to perform the management of the network and radio resources.
TERAWAY Project

A new disruptive generation of photonic-enabled THz transceivers for high-capacity BH and FH links in 5G networks.

Application- Demo scenarios

Communication and surveillance coverage of outdoor mega-events using fixed and moving nodes in the form of heavy-duty drones, carrying either gNBs or solely their radio parts.

TERAWAY Technology
Enabling new applications of commercial and societal interest
TERAWAY high-capacity W/D/THz transceivers

**Hybrid photonics-based platform** for ultra-wideband signal generation and emission

### Objective 1

1. **Optical carrier generation unit**
   Tunable Lasers (TLs): Free selection of the emission wavelength over a range of more than 10 nm

2. **Optical phase locking unit**
   Optical Frequency comb generator (OFCG) + optical circuit: low phase noise

3. **Optical modulation unit**
   Phase Modulators for • low-capacity links (2.16 GHz bandwidth) and • IQ Modulators for high-capacity links (25.92 GHz)

4. **Optical filtering unit**

5. **Optical multi-beamforming unit**
   Independent steering of the transmitted wireless beam

6. **Optical amplification, frequency up-conversion and wireless emission unit**
   Use of semiconductor optical amplifiers, PIN-photodiodes as photonic mixer and bow-ties antennas
TERAWAY high-capacity W/D/THz transceivers

Hybrid photonics-based platform for ultra-wideband signal detection and reception

Objective 3

1. Optical carrier generation unit
   Same as transmitter

2. Optical frequency comb generator unit
   Same as transmitter

3. Optical phase shift unit
   Introduction of $90^\circ$ phase difference between copies of the same optical carrier

4. Wireless detection and IQ photonic mixing unit
   Use of bow-tie antennas with silicon lenses and photoconductive elements for down-conversion to the baseband
   Development of low-noise and high bandwidth TIAs
**TERAWAY Modules**

**Multi-channel transceiver Modules** with total capacity up to 241 Gb/s

**Objective 4**

Development and integration of 4 Transceiver Modules

- Modules -1, -2 (Precursor units)
- Modules -3, -4 (Main Transceiver Modules)

<table>
<thead>
<tr>
<th>TERAWAY Module</th>
<th>Tx Module-1 (Precursor)</th>
<th>Tx Module-2 (Precursor)</th>
<th>Tx Module-3 (Main Module)</th>
<th>Tx Module-4 (Main Module)</th>
</tr>
</thead>
<tbody>
<tr>
<td># of channels</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>IF or baseband</td>
<td>IF</td>
<td>Baseband</td>
<td>1 IF / 1 Baseband</td>
<td>2 IF / 2 Baseband</td>
</tr>
<tr>
<td>Symbol rate (Gbaud)</td>
<td>~1.5</td>
<td>18</td>
<td>1.5 / 18</td>
<td>2x1.5 / 2x18</td>
</tr>
<tr>
<td>Modulation format</td>
<td>Up to 256-QAM</td>
<td>Up to 64-QAM</td>
<td>256-QAM / 64-QAM</td>
<td>256-QAM / 64-QAM</td>
</tr>
<tr>
<td>Total bit rate (Gb/s)</td>
<td>~ 12.5</td>
<td>108</td>
<td>120.5</td>
<td>2x120.5</td>
</tr>
<tr>
<td>OBFN</td>
<td>NO</td>
<td>1x4 Blass matrix</td>
<td>2x16 Blass matrix</td>
<td>4x16 Blass matrix</td>
</tr>
<tr>
<td>Electrical units</td>
<td></td>
<td>Modem, CU</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operation band</td>
<td></td>
<td>W/ D/ THz</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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D8.1 – Project Announcement
TERAWAY Nodes (Fixed & Moving)

**Network Nodes** for BH and FH connectivity

**Objective 5**

**Fixed Nodes**

**Module-4**

to core network

**Moving Nodes**

- Module-3
- Ethernet Switch
- Cameras
- Drone navigation system
- gNB
Objective 6

THz propagation model & localization techniques

Development of 3D path-loss map

- Development of a simulator for the generation of path-loss maps for THz signals inside realistic propagation environments
- Development of modeling tools for effects such as Doppler spread, shadowing effects and the interference effects from co-channels or adjacent channels
- Enable the optimization of the link geometries via the selection of the optimum positions of the moving nodes

Development localization algorithms

- Calculation of the distance between two nodes by combining the symmetrical double-sided two-way ranging method and the beam steering capabilities of the TERAWAY nodes
Network management and application tools

Objective 7 Optimum use of network and radio resources and accommodation of eMBB and URLLC services

SDN platform
- Re-organization of the network traffic flows based on the path-loss maps and the positions of the drones
- Configuration of the system parameters of the TERAWAY transceivers (e.g. frequency band, channel bandwidth, modulation format/rate)
- Development of SBIs and NBIs

Slicing manager
- Identification/ categorization of the network slices that will be created and allocation of the network and radio resources (End-to-End slices)

Platform for processing of surveillance data
- Local processing of the surveillance data at the edge of the network (Critical latency reduction)
Evaluation strategy of TERAWAY technology

Stage 1 – Benchtop evaluation

Phase 1 – Lab settings
- Validation of ultra-wideband operation in the W/D and THz bands
- Validation of multi-beam beamforming operation
- Generation of low-bandwidth signals
- Generation of high-bandwidth signals

Phase 2 – Outdoor experiments
- Use of drones for carrying the TERAWAY modules
- Validation of link initialization process
- Transmission reach up to 400 m
- Extraction of experimental results for the THz channel modeling activities
- Localization methods

Stage 2 – Field trials at 5G demo site

Phase 1 – Planning phase
- File applications for drone lights
- Arrangements of any legal issues
- Securing local spectrum licenses for radio transmission

Phase 2 – Field trials
- Execution of the two main demonstration scenarios for BH and FH connectivity
- Provide communication and surveillance coverage
- Network topology reconfiguration
- Network and radio resources optimization
- End-to-end connections to the users below the drones
- Local processing of surveillance data
Work Plan - Timeline

**WP1. Project management & WP9. Ethics**
WPL: ICCS, Contribution: All partners

**WP2. System Design, specifications and definition of software, hardware interfaces**
WPL: ICCS, Contribution: All partners

**WP3. Optical part of TERAWAY transceivers**
WPL: FhG-HHI, Contribution: UC3M, LXI, PHIX

**WP4. Electrical part and packaging of transceivers**
WPL: PHIX, Contribution: FBH, FhG-HHI, UC3M, LXI

**WP5. Development of network management systems and extension of network slicing tools**
WPL: CMC, Contribution: SIAE, AALTO, ICCS

**WP6. System integration of TERAWAY modules, nodes and network system**
WPL: ICOM, Contribution: ICCS, Optagon, UC3M, AALTO, FhG-HHI, SIAE, CMC

**WP7. Testing of TERAWAY modules and demonstration of TERAWAY system (Field trials)**
WPL: AALTO Contribution: ICCS, Optagon, UC3M, AALTO, FhG-HHI, SIAE, CMC

**WP8. Dissemination, exploitation, standardization and roadmapping**
WPL: TID Contribution: FhG-HHI, ICCS, UC3M, PHIX, ICOM, AALTO, Optagon, SIAE, CMC
Work plan - Roles of partners

Modules development, DSP toolbox
- Development of the transceivers
- Integration and packaging of the transceivers
- Integration and packaging of the Modules
- Development of DSP tools and algorithms
- Testing of Modules in lab

Network management, Nodes development, System experiments & Field trials
- Network management & slicing techniques
- Development of SDN agents
- THz propagation models, localization techniques, link establishment
- Integration and packaging of the Nodes
- Testing of Nodes in campus
- System Field trials

Partners:
- Fraunhofer Heinrich Hertz Institute
- Lion/International
- UC3M
- Optagon Photonics
- ATHENa
- INTRACOM TELECOM
- FBN
- Aalto University
- Telefonica
- Cumucore
- Optagon Photonics
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Appendix III – TERAWAY Press release @ PCRL-ICCS
TERAWAY

Terahertz technology for ultra-broadband and ultra-wideband operation of backhaul and fronthaul links in systems with SDN management of network and radio resources

Project Launch – Kick-off meeting

The implementation of TERAWAY project was officially inaugurated with the kick-off meeting that took place on 3rd and 4th of December 2019. All the twelve (12) members of the consortium were gathered for a two-day productive meeting at the premises of Fraunhofer Heinrich Hertz Institute (HHI) in Berlin in order to analyze TERAWAY’s workplan in depth, specify in detail the role of each partner in the project’s deployment and define the next actions.

TERAWAY is a H2020 5GPPP Phase III project funded by the European Union coming as a technology intensive project aiming to develop a disruptive generation of THz transceivers for high-capacity BH and FH links in 5G networks.

Leveraging optical concepts and photonic integration techniques, TERAWAY will develop a common technology base for the generation, emission and detection of wireless signals with selectable symbol rate and bandwidth up to 25.92 GHz within an ultra-wide range of carrier frequencies covering the W-band (92-114.5 GHz), D-band (130-174.8 GHz) and THz band (252-322 GHz).

In this way, TERAWAY steps into providing for the first time the possibility to organize the spectral resources of a network within these bands into a common pool of radio resources that can be flexibly coordinated and used.

The use of photonics will enable the development of multi-channel transceivers with amplification of the wireless signals in the optical domain and with multi-beam optical beamforming in order to have a radical increase in the directivity of each wireless beam. In parallel, aiming to take the most out of the THz technology and enable its commercial uptake, the project will develop a new software defined networking (SDN) controller and an extended control hierarchy that will perform the management of the network and the radio resources in a homogeneous way with obvious benefits for the network performance and energy efficiency and with possibilities for the provision of network slices in order to support heterogeneous services.

At the end of this development, TERAWAY will make available a set of ground breaking transceiver modules including 4-channel modules operating from 92 up to 322 GHz with possibility to offer 241 Gb/s total data rate, to have more than 400 m transmission reach in the THz band (and few Km in the lower bands), and with 4 wireless beams that can be independently steered and establish BH and FH connections between fixed terrestrial and moving network nodes. The TERAWAY transceivers will be evaluated at the 5G demo site of AALTO and HOKIA in Finland, under an application scenario of communication and surveillance coverage of outdoor mega-events using moving nodes in the form of heavy-duty drones.
TERAWAY project comprises twelve (12) partners from six (6) European countries among which:

three vendors: Telefónica Investigación y Desarrollo (ES), Intracom S.A. Telecom Solutions (GR) and SIAE Microelettronica S.p.A. (IT);

two industry-oriented research institutes: Fraunhofer Heinrich-Hertz Institute (DE) and Ferdinand-Braun-Institut Leibniz-Institut fuer Hochfrequenztechnik (DE);

four SMEs: LionIX International BV (NL), Optagon Photonics (GR), PHIX Photonics Assembly (NL), Cumucore OY (FIN) and

three academic organizations: Universidad Carlos III de Madrid (ES), Aalto University (FIN) and the Institute of Communications & Computer Systems of the National Technical University of Athens (GR) that coordinates the action.

For more info, visit TERAWAY website ict-teraway.eu

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