Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: TERRANOVA: Terahertz Wireless Access Technologies – System and Hardware Architecture Options

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Re: none

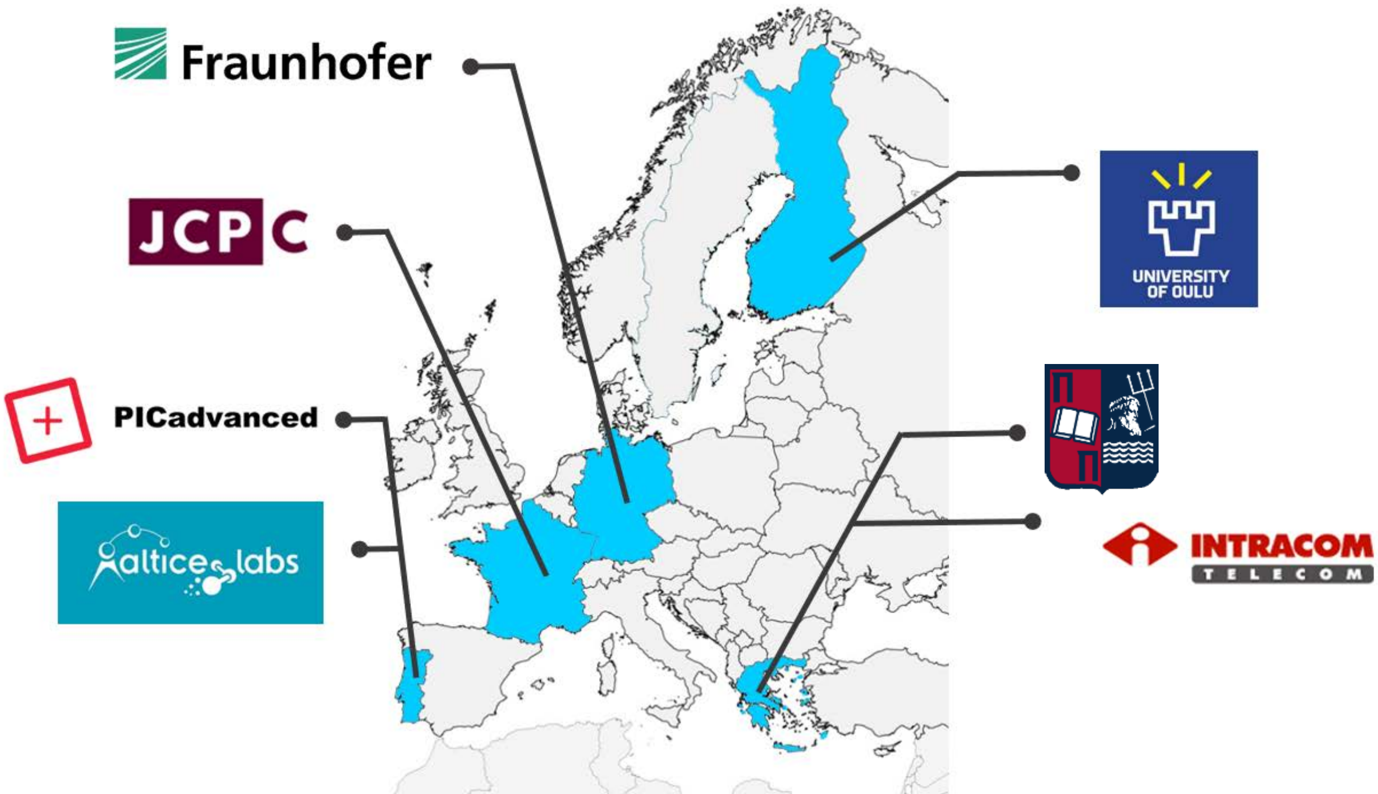
Abstract: The presentation introduces the planned activities in the European Union funded research project TERRANOVA. It discusses at an early project stage the considered hardware options and the envisioned system applications.

Purpose: To give an overview about the planned activities in the project TERRANOVA and to enable potential collaborations.

Outline

- Overview TERRANOVA
- Hardware Options
  - Optical Transponder
  - DSP Testplatform
  - THz Frontend
- System Architectures
  - Point-to-point
  - Point-to-Multipoint
  - Indoor quasi-omnidirectional

TERRANOVA consortium

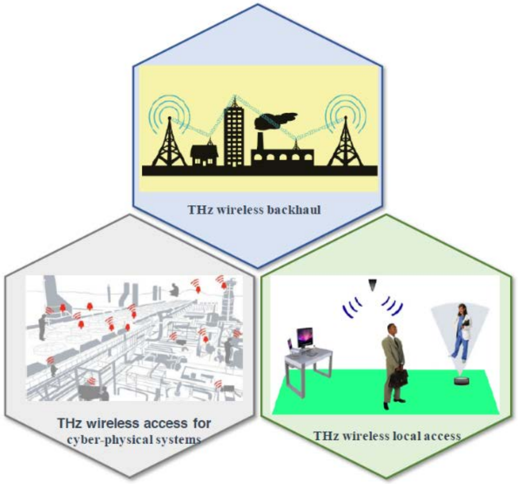


Project duration: July 2017 - December 2019

Vision for Systems Beyond 5G

Systems Beyond 5G - expectations:

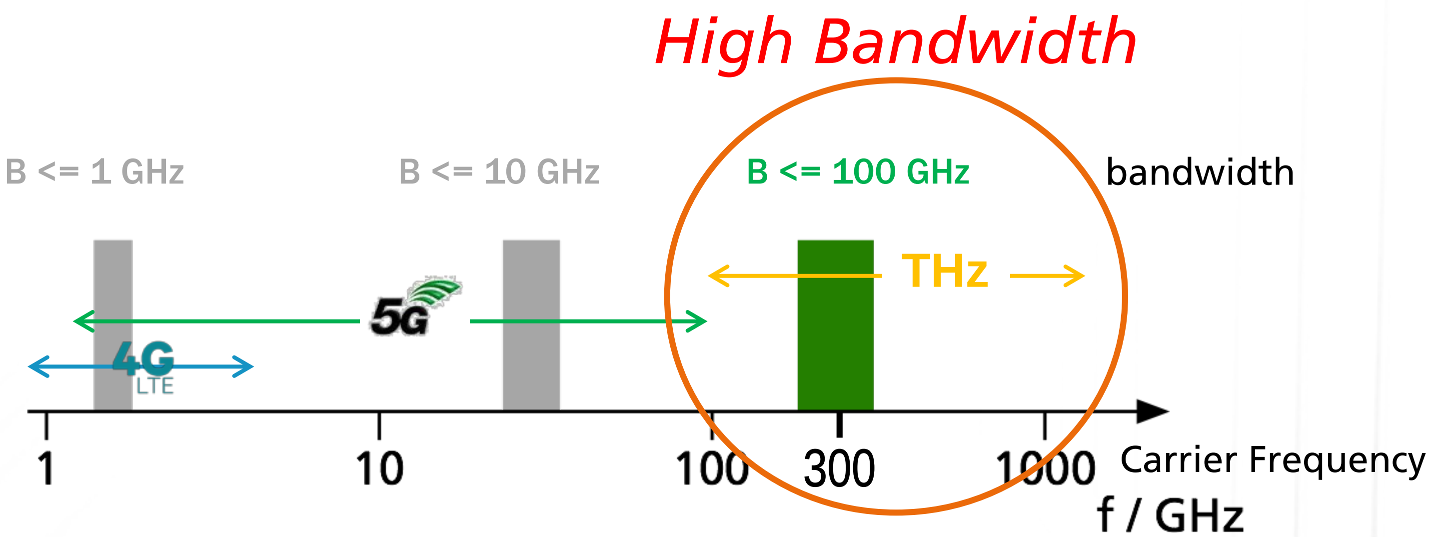
- Unprecedented performance excellence, in the Tbps regime
- Inherently support a large dynamic range of novel usage scenarios that combine extreme data rates with agility, reliability, zero response time and AI
- Cost-efficient and flexible provision of high-speed data connections guaranteed, zeroing the 'digital divide'



Vision:

- Extend the fibre optic systems QoE and performance reliability to wireless, by exploiting frequencies above 275GHz for access and backhaul links

THz Opportunity



- THz wireless bandwidth fits to optical bandwidth / bitrate in current transponder solutions (20..30 GHz/100..200 Gbit/s)
- Challenges: THz-optical interface, high fractional bandwidth (15..25%)

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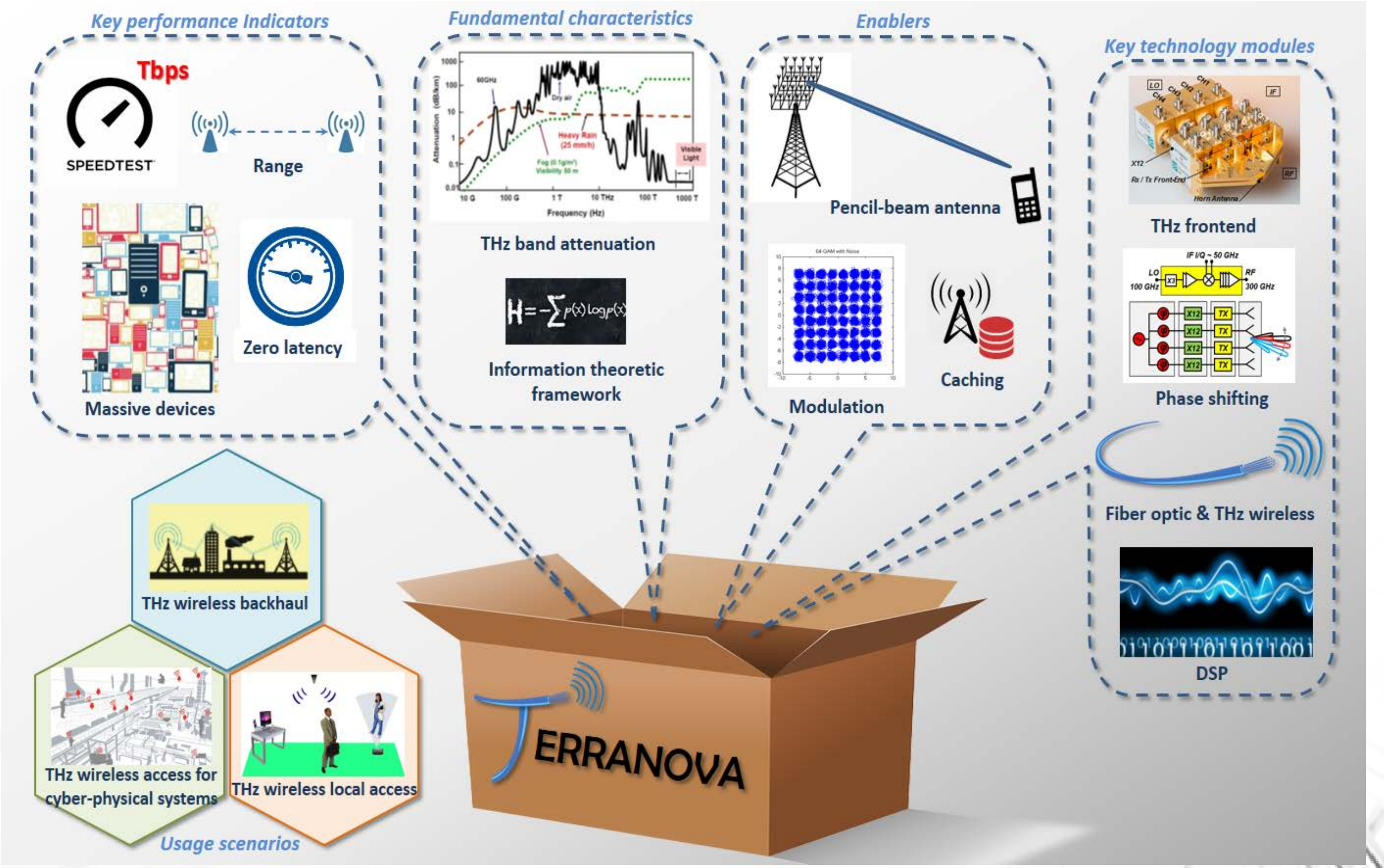
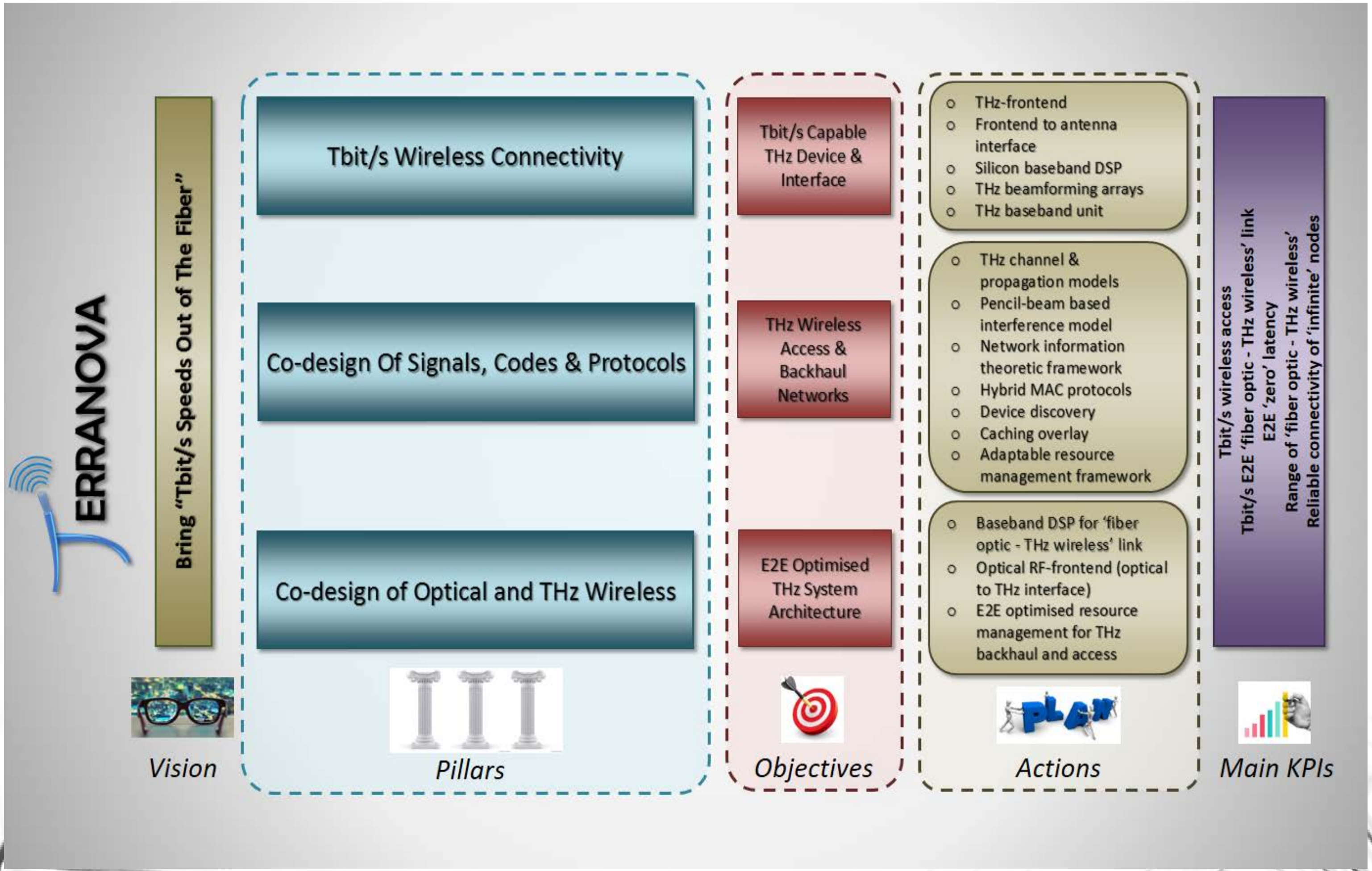
THz unique Challenges

- Bridge the THz ‘gap’
- Tackle the THz propagation characteristics
  - Ultra wideband and extremely directional wireless links
  - Absorption Loss
  - Attenuation with distance
- Devise a new network information theoretic framework imposed by the new disruptive characteristics of the channel
- Design MAC protocols tailored to ‘pencil-beam’ access, coordinate MAC and caching strategies

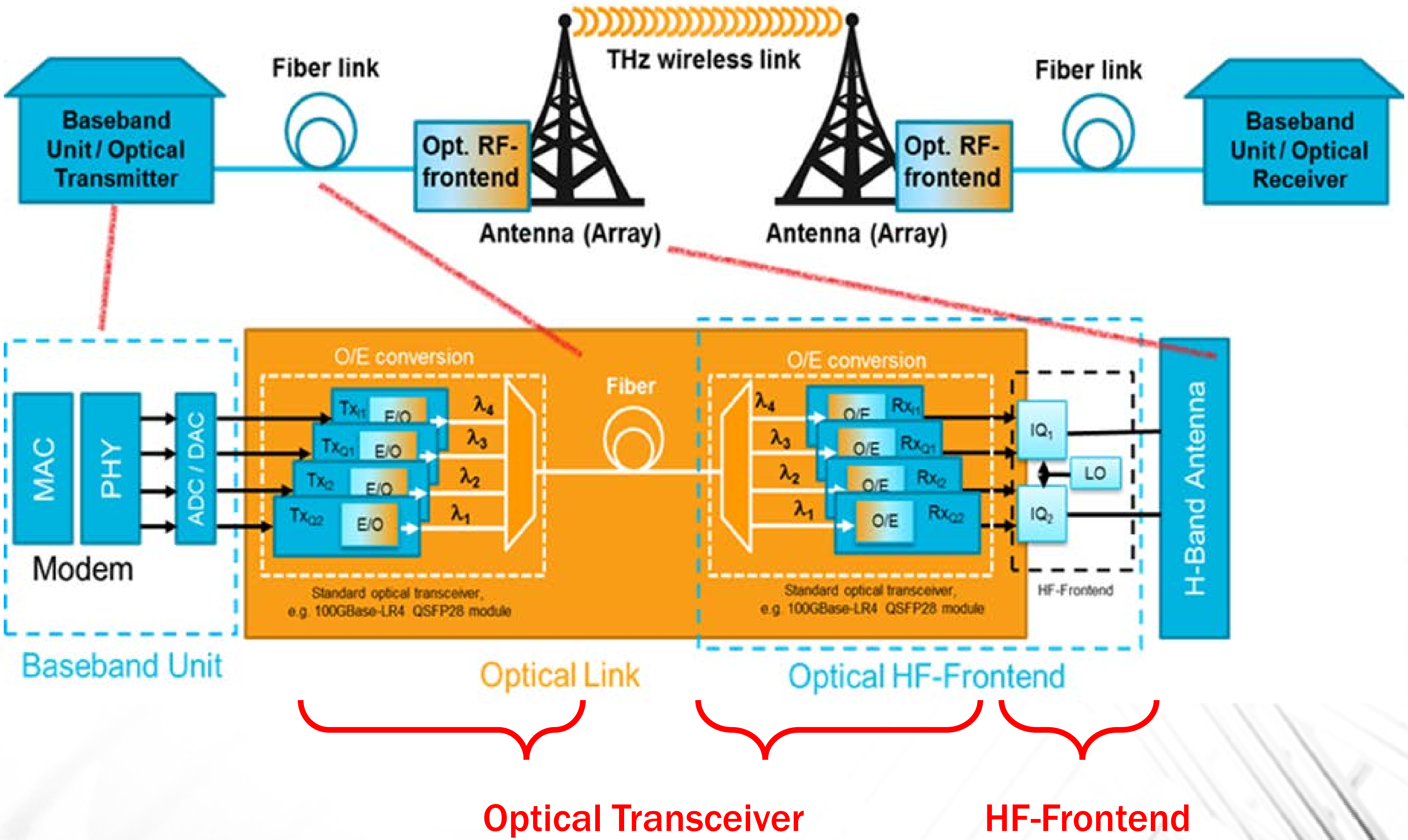
TERRANOVA System Concept



TERRANOVA Vision and Objectives



System Overview



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Optical Transponder

Coherent Module Segmentation

	Fixed	Pluggable
DSP on Line Card	Discrete 	ACO 
DSP in Module	Transponder 	DCO 

- Support up to 100/200 Gbit/s, single wavelength (32 GBaud DP-QPSK/16QAM)
- Next generation 400/600 Gbit/s, single wavelength (64 Gbaud DP-16QAM/64QAM)

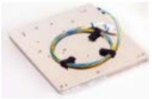
OIF OPTICAL INTERNETWORKING FORUM

ACO = Analog Coherent Optics

DCO = Digital Coherent Optics

Optical Transponder

State-of-the-art Modules

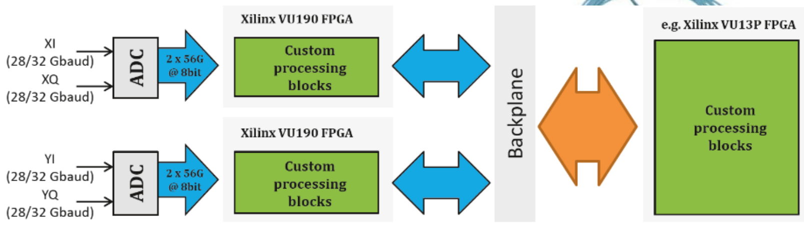




Aspect	OIF 4"x5"	CFP	CFP2	CFP4	QSFP28
W × L × H, mm³	101.6 x 127x 25.4	82 x 145 x 14	41.5 x 106 x 12.4	21.5 x 92 x 9.5	18.4 x 72 x 8.5
Power class	45W	8W	3W	1.5W	1.5W
		16W	6W	3W	2.0W
			9W	4.5W	2.5W
		24W	**12W**	**6W**	**3.5W**
		32W	15W	7.5W	4.0W
			18W	9W	4.5W 5W
Electrical interface	**168 pins**	148 pins 10x10G / 4x25G	104 pins 10x10G / 4x25G / 8x25G	56 pins 10x10G / 4x25G	38 pins 4x25G
Telecom application	**C-band DCO 100G-400G Single/Dual-carrier for metro, long-haul and subsea**	C-band DCO 100G Single carrier for metro, long-haul	C-band ACO 100G/150G/ 200G		
Datacom application			100G CWDM4 (2km) 100G LR4 (10km) and ER4 (40km)		

DSP Testplatform

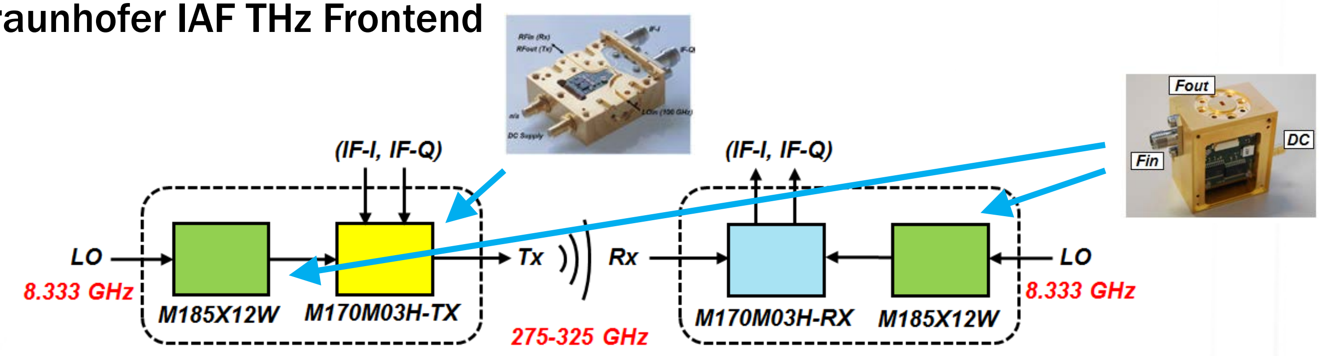
- Hardware-platform for real-time testing of digital signal processing algorithms
- Emulation of a THz baseband unit



	DSPP 124x plug-in board	DSPP 144x plug-in board
Type of board	Analog-to-Digital Converter	FPGA processor
Number of channels per board	up to 2	-
Sampling rate per channel	56 GSa/s	-
Nominal resolution	8 bit	-
Analog 3dB-bandwitdh	15 GHz	-
Internal FPGAs	Virtex Ultrascale (XCVU190)	Virtex Ultrascale Plus (XCVU13P)**
Total* available CLB LUTs	1,074,240	1,728,000**
Total* available CLB Flip-flops	2,148,480	3,456,000**
Total* available Block RAMs (36 Kb each)	3,780	2,625 + 10,000 UltraRAM**
Total* available DSP slices	1,800	12,288**
Interface speed	up to 560 Gb/s (backplane)	up to 560 Gb/s (backplane)

THz Frontend

Fraunhofer IAF THz Frontend



	FhG-IAF	Analog Devices HMC6300/6301	Infineon BGT80
Frequency Band (GHZ)	275 - 325	57 - 64	71 – 76, 81 - 86
RF signal bandwidth (GHz)	50	up to 1.8	0.05 - 1
Psat (dBm)	0 dBm	17 dBm	21 dBm

State-of-the-art reference

- 1st generation THz frontend prototypes
- THz generation by direct conversion

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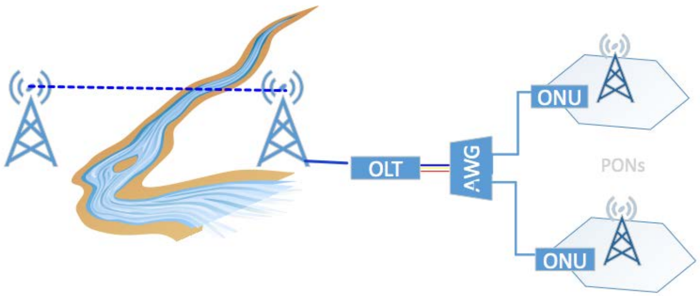
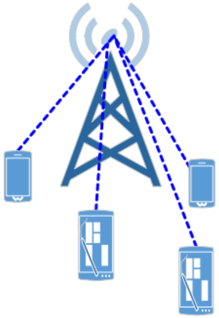
Application Scenarios

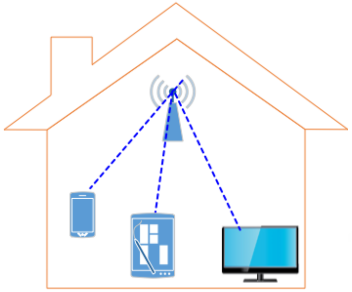
Point-to-Point



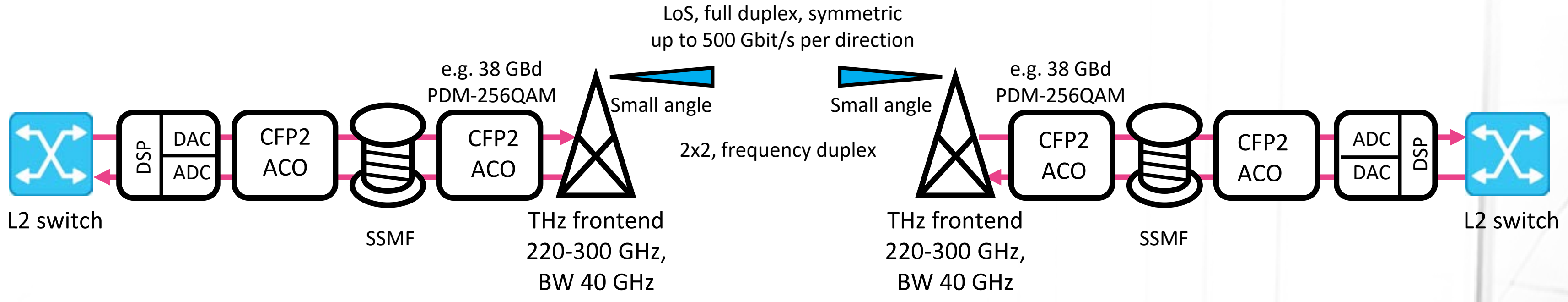
Point-to-Multi-Point



Indoor quasi-omnidirectional



Point-to-Point



- Transparent optical link: Photonic Radio
- Challenge: Optical DSP used for wireless channel impairment mitigation

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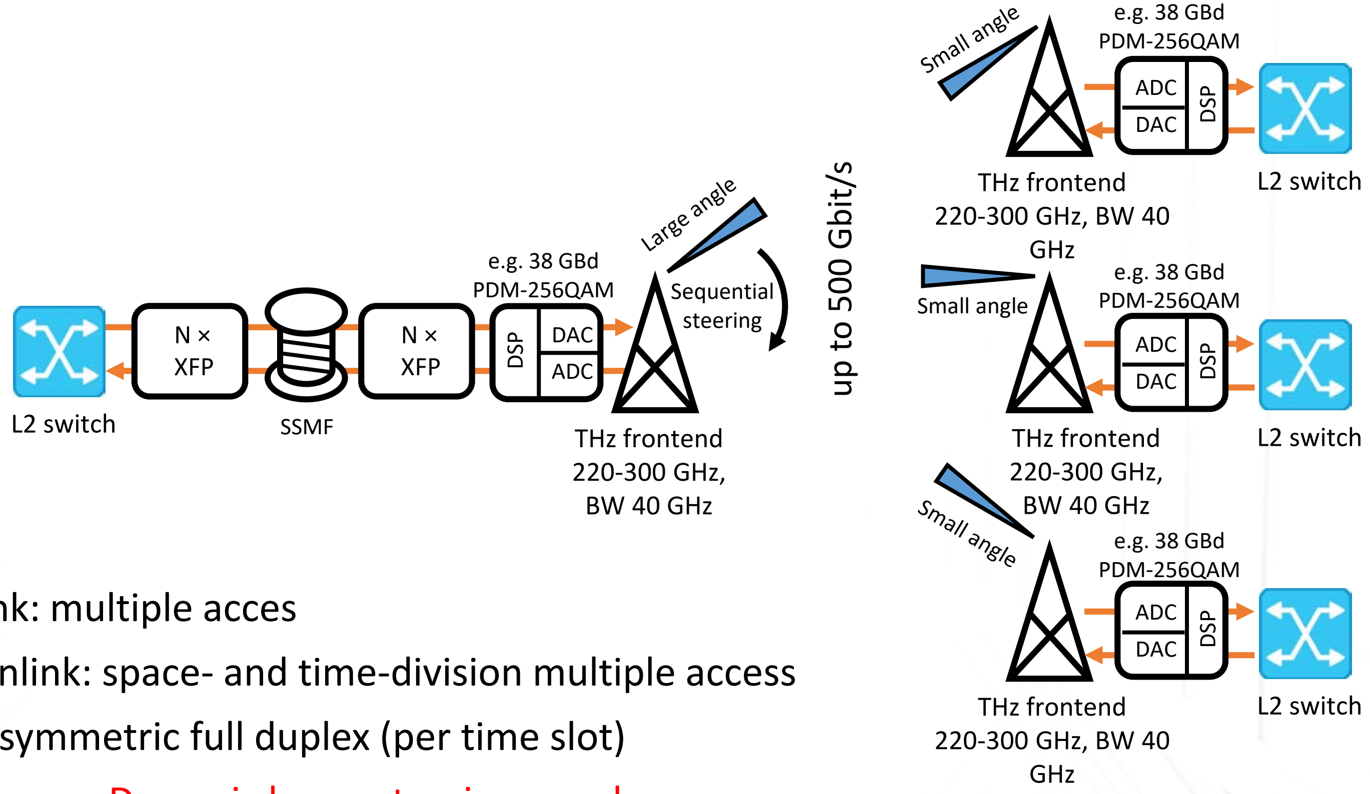
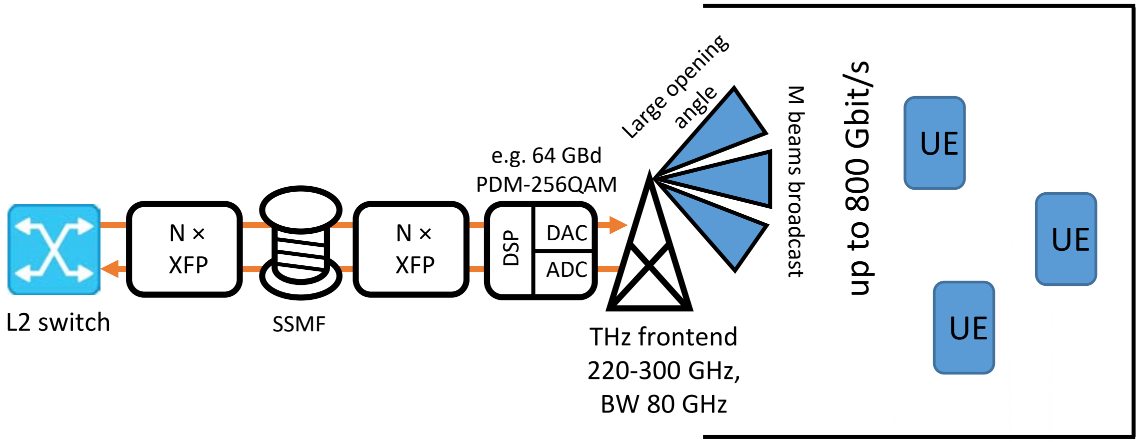
Point-to-Multipoint



- Uplink: multiple acces
- Downlink: space- and time-division multiple access
- LoS, symmetric full duplex (per time slot)
- Challenge: Dynamic beam steering over large angles with pencil beams

Indoor



- Uplink: non-THz technologies
- Downlink:
  Broadcast of multiple beams with identical data
- NLoS, half duplex
- Challenge: Multi-path fading at THz frequencies

TERRANOVA Team

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Thank You !

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