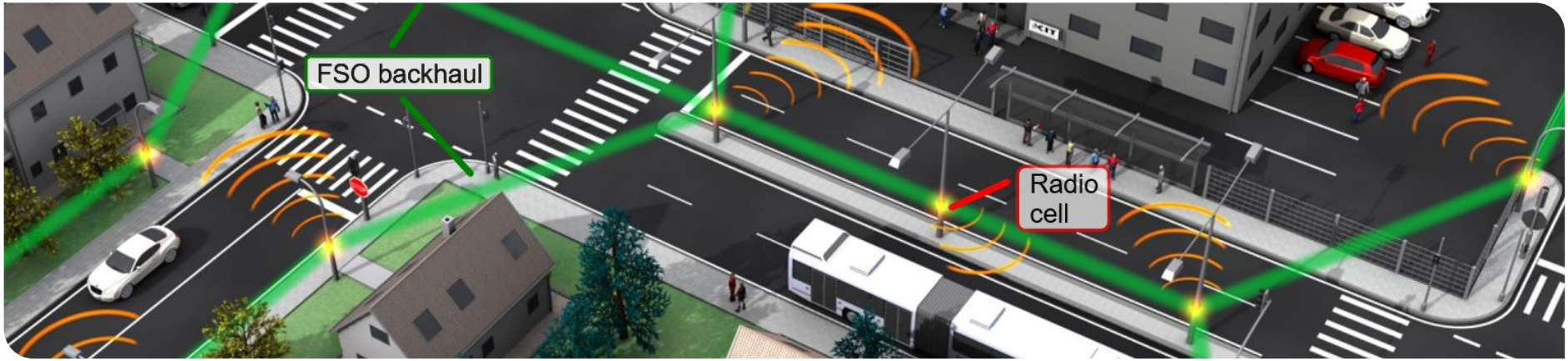
Karlsruhe Institute of Technology

IPQ

EMW Labtour WS 21/22

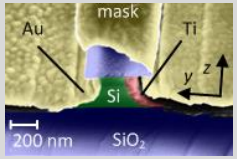


Research Activities at IPQ

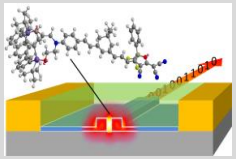
Karlsruhe Institute of Technology

Technologies

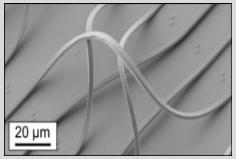
Photonic and Plasmonic Devices
H. Peng



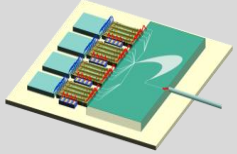
Hybrid Photonic Integrated Circuits
C. Eschenbaum



Additive 3D Nanofabrication
J. Hohmann



Photonic-Electronic Packaging and Mechanics
S. Pfeifer



Algorithms and Digital Signal Processing
S. Randel

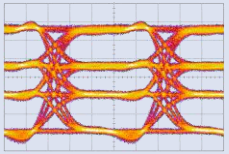
Applications

~ 20 PhD candidates and postdocs
11 technical & administrative staff
~ 10 students (HiWi, MA, BA)

W. Freude

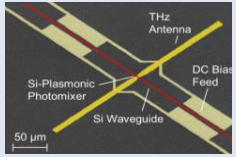
C. Koos

S. Randel



Optical Communications
C. Füllner

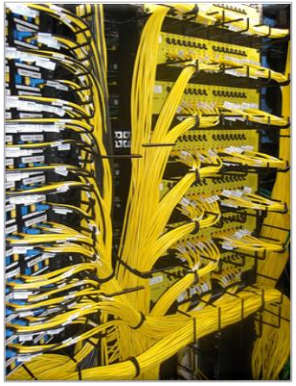
Optical Metrology and Sensing
C. Koos

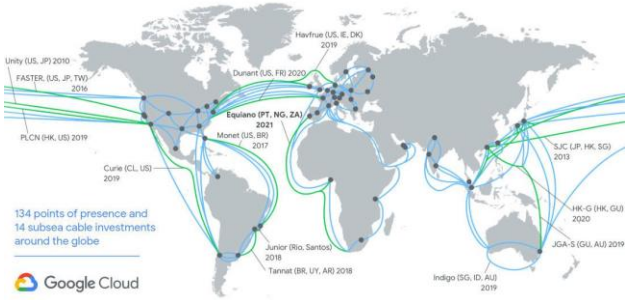


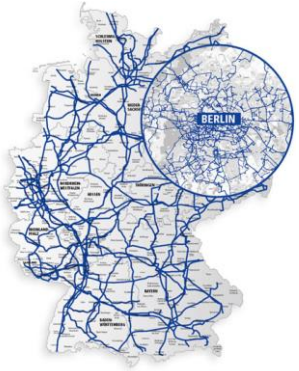
Teratronic Signal Processing
A. Kuzmin

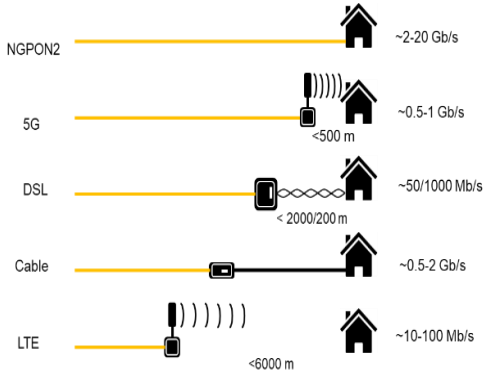
High-Capacity Optical Networks

- Artificial intelligence, social networks, internet of things, assisted driving, smart cities, virtual/augmented reality , cloud computing & storage … are changing our lives
- The global fiber-optic network interconnects distributed datacenters with billions users arcross six continents
- Growing capacity demands are countiuously pushing the limits of photonic and electronic technology



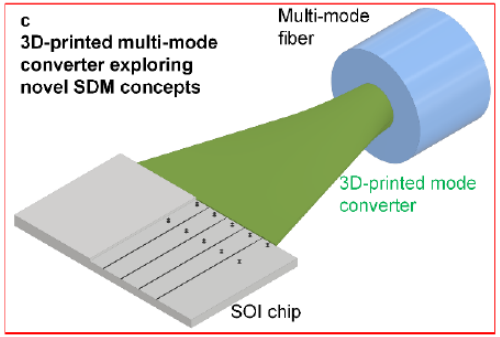


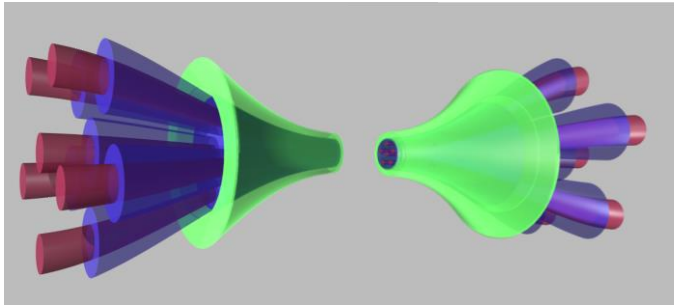


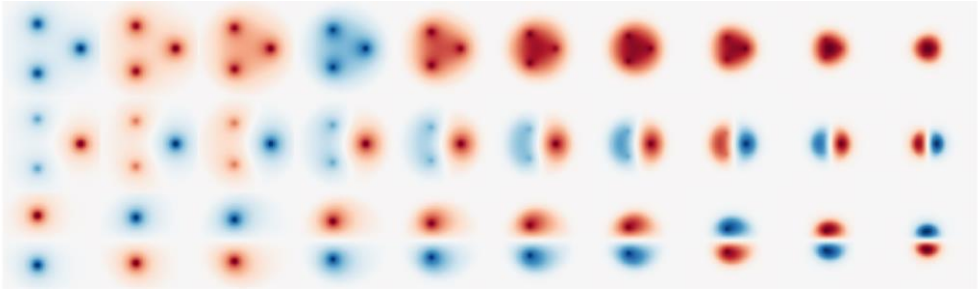


Space-Division Multiplexing in Fiber-Optic Communications

- Traditionally, single-mode fibers are used in long-distance communications
- Recently, space-division multiplexing becomes an attractive approach to increase integration density of electro-optic transceivers
- Thereby, multiple fiber cores or multiple fiber modes are used for parallel transmission

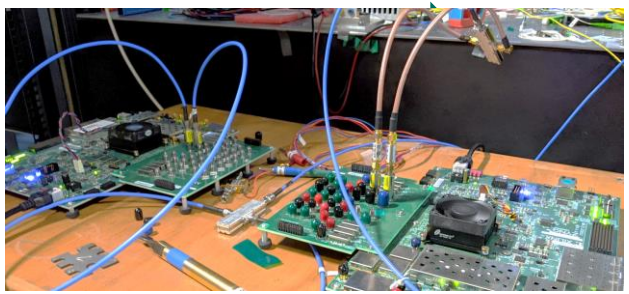




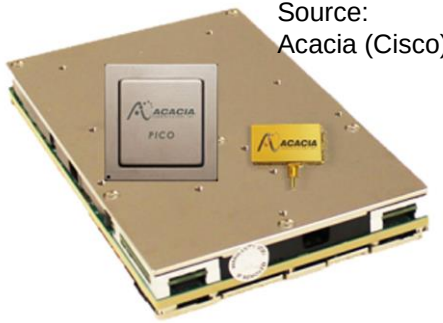


Real-time Digital Signal Processing (DSP)

- General purpose digital processors like CPUs, GPUs, and µPs are not designed to handle high-speed signals used in optical communications.
- Optimized application-specific integrated circuits (ASICs) are designed by system vendors and sold in large volumes.
- In research, field programmable gate arrays (FPGAs) allow to implement and test advanced DSP algorithms in real-time.



DSP Algorithm Validation in the IPQ Laboratory



Source: Acacia (Cisco)

1.2 Tb/s Coherent Optical DSP ASIC

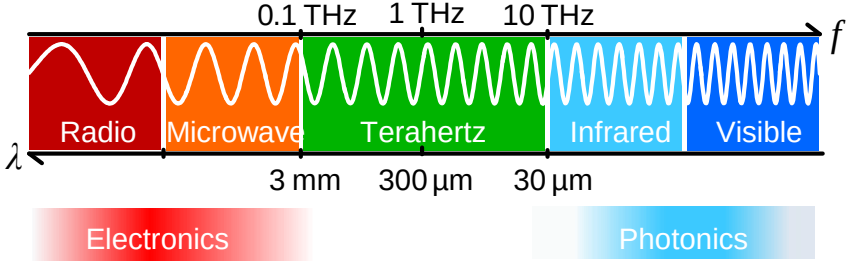
```
MAC_stage1: process(clk_i)
    variable tmp1           : t_tmp1;
    variable cnt            : integer := 0;
    variable delay          : integer := 0;
begin
if rising_edge(clk_i) then
    for m in 0 to NSAMP-1 loop
        cnt := m;

        for n in 0 to NSAMP-1 loop
            tmp1(m,n) := (others => '0');

            for k in 0 to NCOEF/NSAMP-1 loop
                if (reg(cnt)(k+delay) = '1') then
                    tmp1(m,n) := tmp1(m,n) + c_COEF(n,k);
                else
                    tmp1(m,n) := tmp1(m,n);
                end if;
            end loop;

            if (cnt = NSAMP-1) then
                cnt := 0;
                delay := 1;
            else
                cnt := cnt+1;
            end if;

            tmp1_s(m,n) <= tmp1(m,n);
        end loop;

        delay := 0;
     end loop;
end if;
end process;
```

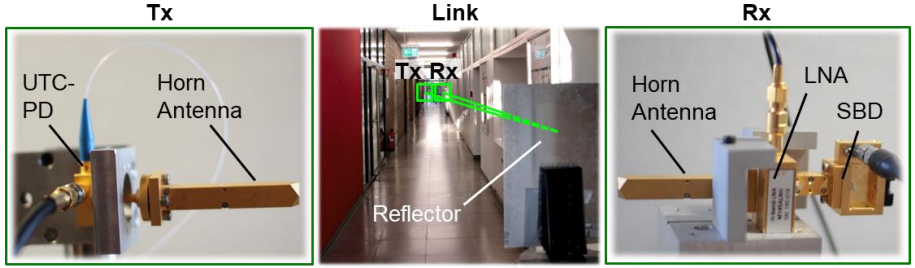
Hardware Description (VHDL)

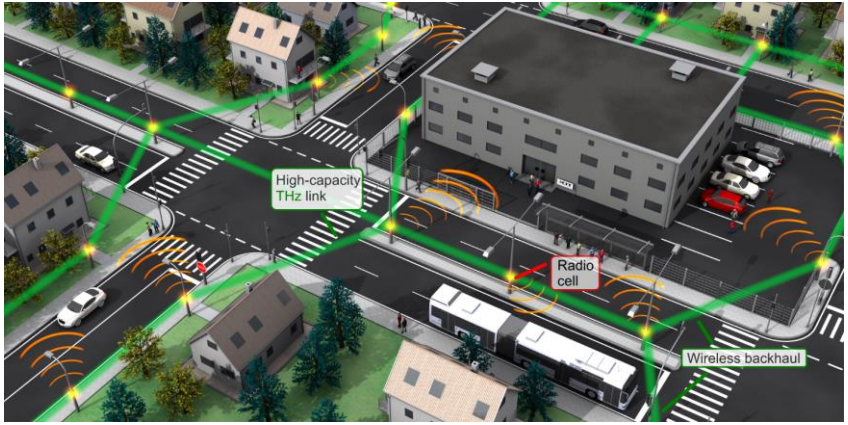
Institute of Photonics and Quantum Electronics
Department of Electrical Engineering and Information Technology

Terahertz Communications

- The THz spectrum fills the gap between electronics and photonics.
- Researchers at IPQ are exploring novel transmitter and receiver architectures in the context of future 6G mobile networks.
- Recently, they achieved a record-high data transmission of 115 Gbit/s over 110 m at a carrier frequency of 0.3 THz [1].







[1] T. Harter, C. Füllner, et al., Nature Photonics, 2020.