

Panel 1: State of mmWave Technology: A View from Industry

- Moderator: Sundeep Rangan (NYU)
- Panelists: Ozge Koymen (Qualcomm), Tommy Svensson (Chalmers U), Ted Rappaport (NYU), Harish Krishnaswamy (Columbia)

Format

The goal of the mmWave RCN is to clarify problems for mmWave research. The focus of this panel is to understand what are the developments in industry, what are the outstanding key research problems and how universities can impact commercial development. Each panelist will give a short intro about their organization, and what they have been working on in mmWave in both the near and short term. We will limit the intros to one minute per participant. If you like, you can have one slide. We would rather focus on the discussions.

Below are a possible set of questions.

General questions

- There has been a tremendous development of mmWave research in the last few years. The first 3GPP standard is complete, vendors have demonstrated complete systems, operators have announced trials and the FCC has opened up spectrum. Would you say that mmWave is now more of engineering challenge than a research challenge?
- What do you see as the role of universities? How can they contribute given the huge investments already made in industry?

Trials, early results

- There have been several major trials at ATT, VZ and others. What have we learned from the trials?
- There was a lot of concern about blockage and coverage in mmWave? Has the coverage been worse or better than thought?
- Have your thoughts on research directions changes since the trials? Are there new problems that were not anticipated?

3GPP standards and Spectrum

- The 3GPP Release 15 standard is complete. Would you describe the standard as mostly incremental changes relative to LTE? Is it just a change in numerology for the higher bandwidth + directional control signaling.
- How did research influence the design of the standard?
- What is the state of spectrum allocations in the US and abroad? Where do you see the initial deployments?
- The standard is very flexible, esp. with regard to carrier bandwidth and multi-carrier bonding. What is the likely configurations to be used?

Circuits:

- While many of the trials have demonstrated functional 3GPP systems, the power consumption and area of the devices still appears to be very high. What circuit technologies are you looking at to address this?
- Power amplifier efficiency?
- Fully digital architectures?
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Networking layer

- A major component of 5G NR is NFV and SDN. How do you see the core network evolving in 5G?
- What will be the driving use cases for NFV / SDN? Will there be third party services deployed in the core?
- Are there fundamental research challenges associated with NFV / SDN?
- A major driver for 5G is ultra-low latency. What latencies do you expect are attainable? What are the research challenges in terms of:
 - Processing power (UE and gNB)
 - Core network architecture
 - MAC layer
 - Congestion control
- There has been some discussion on limitations of TCP. Google has announced a new protocol, BBR. How do you see congestion control evolving?
- There is now a lot of research in adaptive beamforming MAC layer and scheduling problems. Are any of these addressing key issues? What are the key issues, from an industry perspective?

Testbeds

- There are several major testbed initiatives in the US and elsewhere. What is the industry perspective on these testbeds? Do you think we can learn anything fundamental? Or, will they be merely a lot of engineering work?
- Acquiring equipment for mmWave prototyping remains a huge challenge, esp. for smaller university programs. Would industry release any of its components to the broader academic community, esp. phased arrays.

Startups and 6G

- Is it too early to be thinking about 6G? What is industry looking at (if they are looking at all).
- A major issue in mmWave has been the enormous barriers to entry. R&D costs are very high, esp. if one wants to develop custom silicon. What is the role (if any) of startups?
- Would you tell a starting PhD student to study mmWave?