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Toward mm-Wave Frontends for Large Scale Phased Arrays

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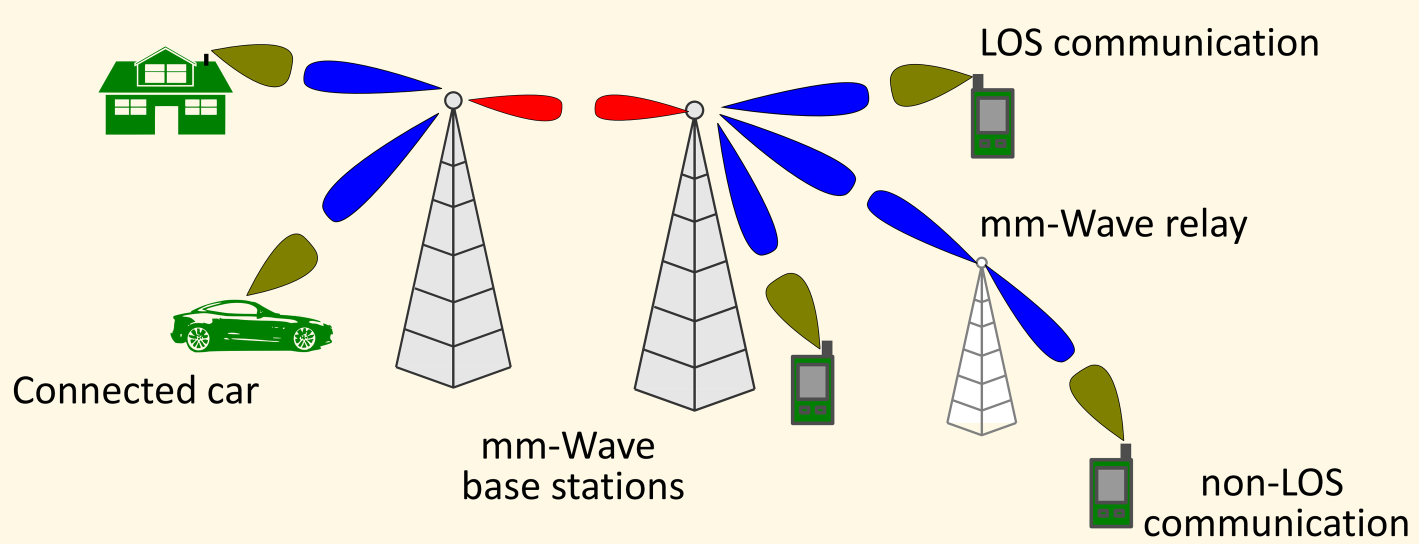
Motivation

<u>Directional beamforming communication:</u>

Large scale integrated phased arrays at mm-Waves can provide high directivity and high bandwidth links:

- Higher EIRP/gain links resulting in high SNR.
- Spatial multiplexing and bandwidth reuse.
- Minimum interference from other users and directions.

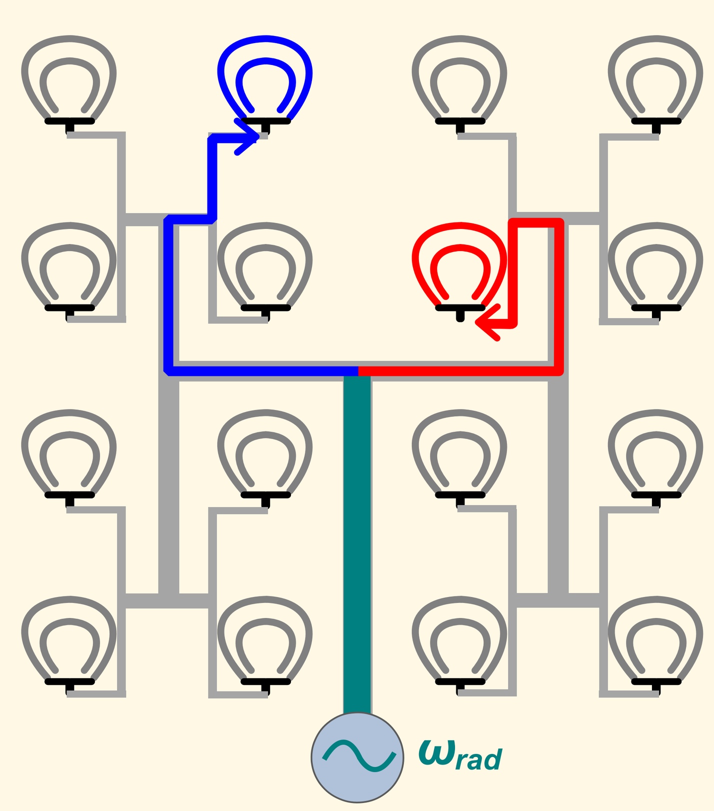
<u>Large scale mm-Wave phased arrays can realize the next generation of wide-band wireless communication systems.</u>



<u>Implementation challenges:</u>

Phased arrays based on the conventional physical structure face major limitations at highly scaled arrays:

- High loss in distribution network
- Increasing physical footprint
- Systematic phase/gain errors
- Extensive required calibration



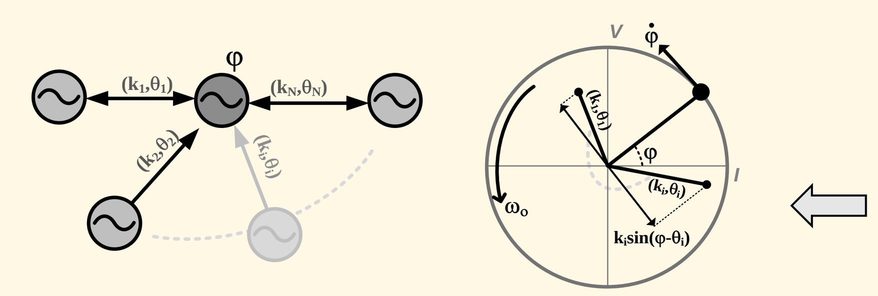
<u>There is need for a scalable phased array architecture and accurate gain/phase control of array elements.</u>

Scalable Phased Arrays

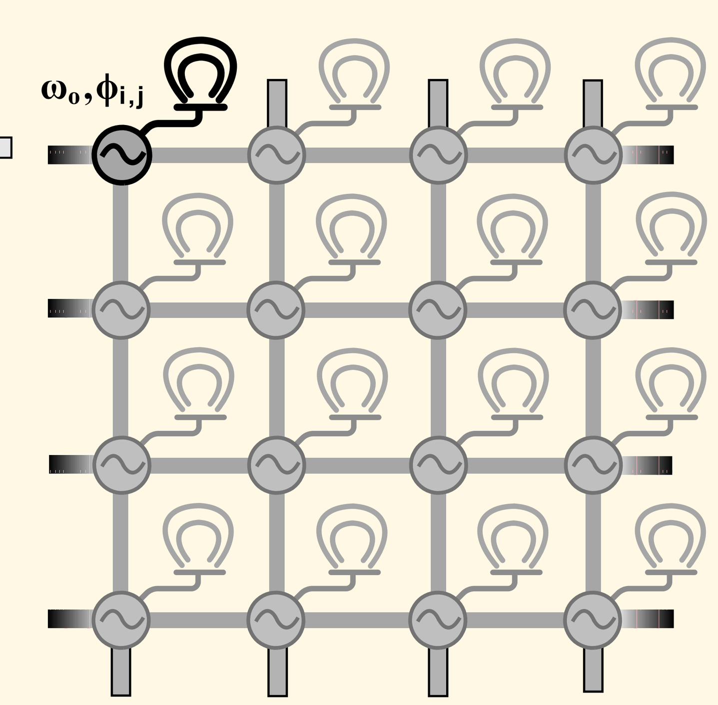
<u>Scalable phased array architecture:</u>

Method based on the theory of nonlinear dynamic systems:

- Each element in the array is an adjustable oscillator.
- Each element is coupled to its nearest neighbor.
- The coupling synchronizes the oscillators.
- Adjusting the coupling controls the direction of the beam.

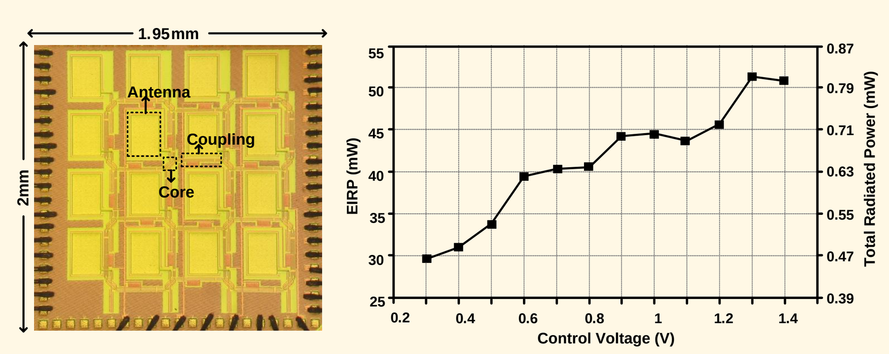


*Tousi et. al. PRL 2012

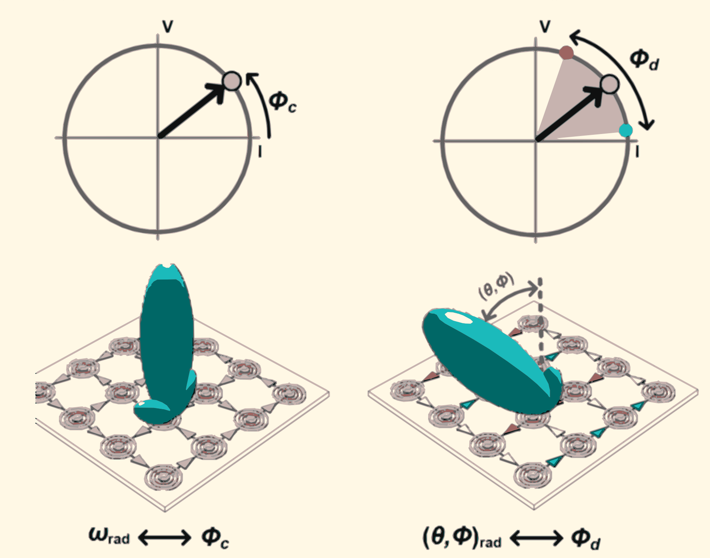


<u>Prototype highlights:</u>

- 340GHz phased array on silicon
- First integrated array > 250GHz
- Beam control > 50 degree
- Record EIRP (>50mW)
- Record phase noise above 200GHz (<92 dBc/Hz @1MHz)

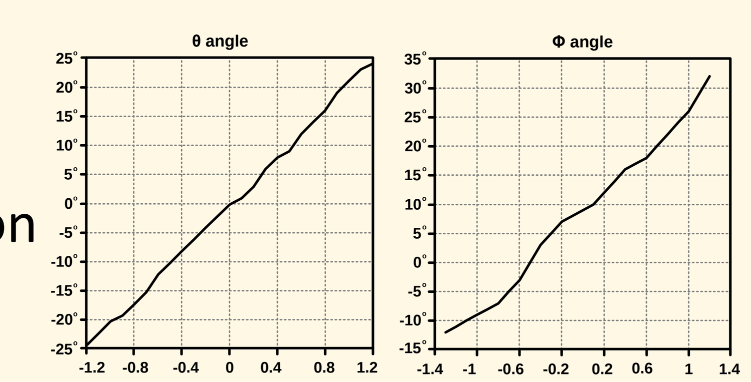


*Tousi et. al. ISSCC 2014



<u>Future work:</u>

- Full transceiver demonstration
- Larger array (>100 elements)
- Signal modulation/demodulation
- Higher efficiency at mm-Wave
- Demonstrate for receive side



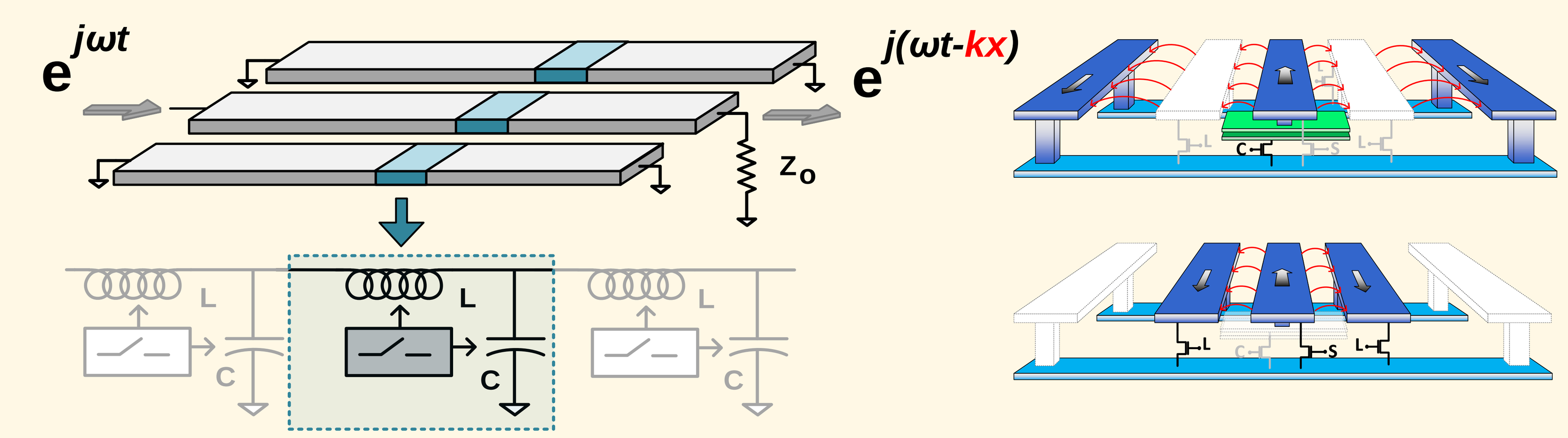
Accurate Phase Control

<u>Distributed phase shifter:</u>

Idea: A transmission line is an ideal phase shifter.

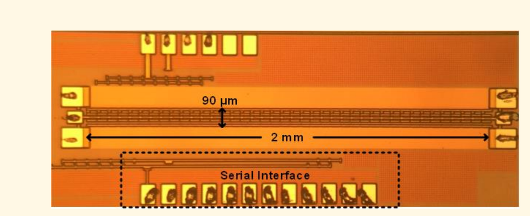
Concept: construct a transmission-line-based phases shifter:

- Controls the propagation velocity of the wave.
- Artificial T-line consists of adjustable unit cells.
- Each unit cell is digitally set to low/high delay modes.



<u>Prototype highlights:</u>

- A 28GHz phase shifter for 5G
- Record phase accuracy (<0.7 degree)
- Record amplitude accuracy (<0.5 dB)



*Tousi et. al. RFIC 2016

<u>Future work:</u>

- Concurrent gain/phase control
- Incorporate into phased arrays
- Higher frequency operation