THE UNIVERSITY OF TEXAS AT AUSTIN

Millimeter Wave Communication with Out of Band Information (OOB)

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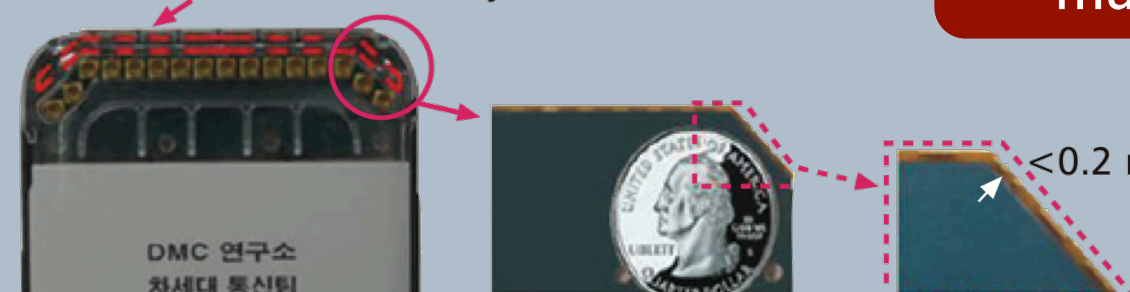
WNCG

MmWave large arrays

Arrays can focus the transmit power

Arrays are a rate multiplier

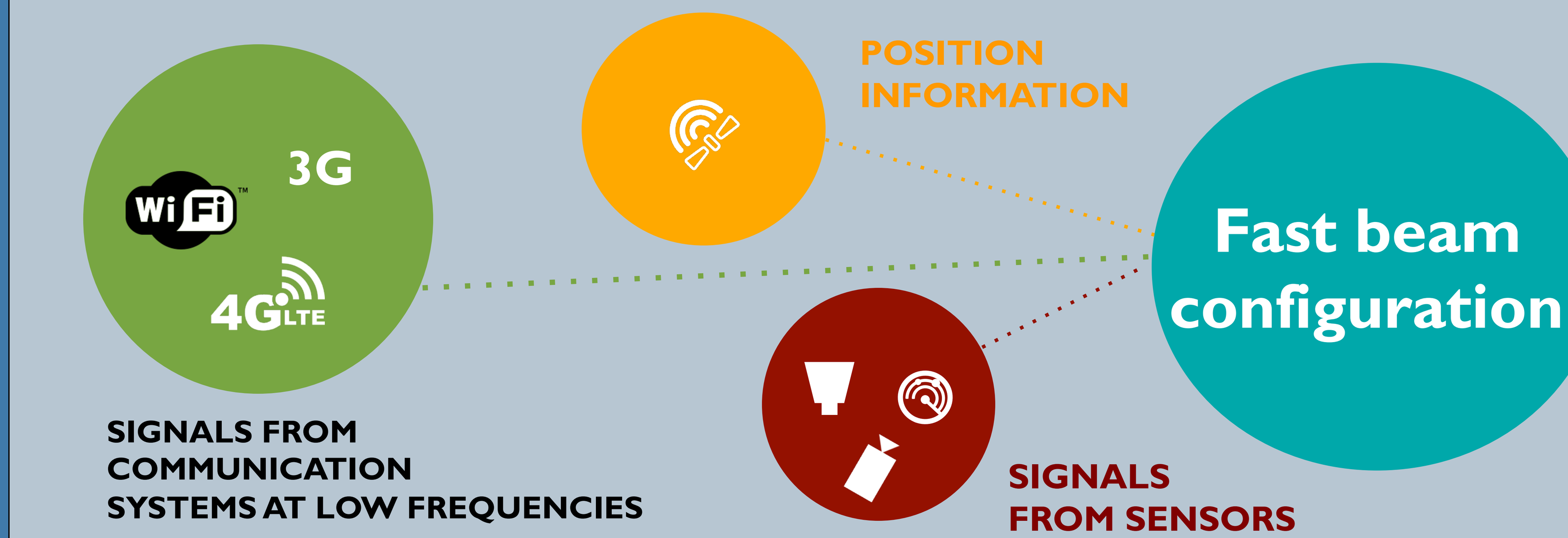
Configuring the arrays from Implicit or explicit channel estimation leads to high overhead



Arrays are small @mmWave

Arrays enable better spectrum sharing

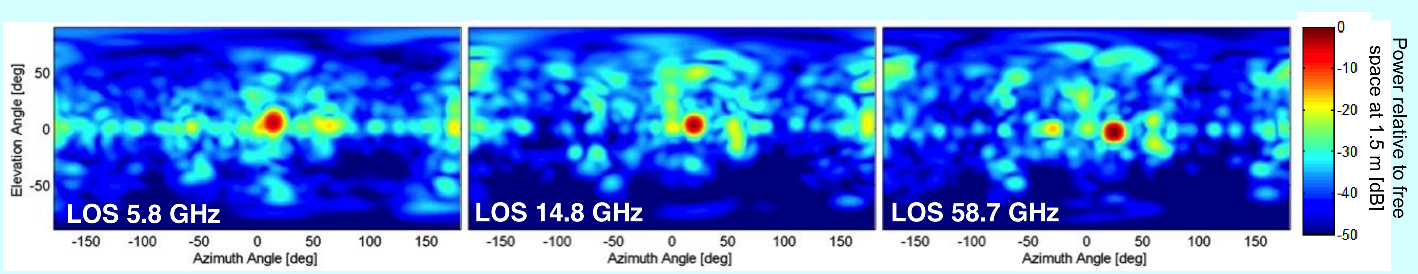
The potential of using OOB info



Channel info extracted without taxing the communication resources!

Going out of band

How different are propagation characteristics between different bands?



From [2]

Spatial characteristics across frequencies on the order of few MHz are similar

Surprisingly some channel parameters also similar across several GHz!

What if comparing sub-6GHz and mmWave bands?

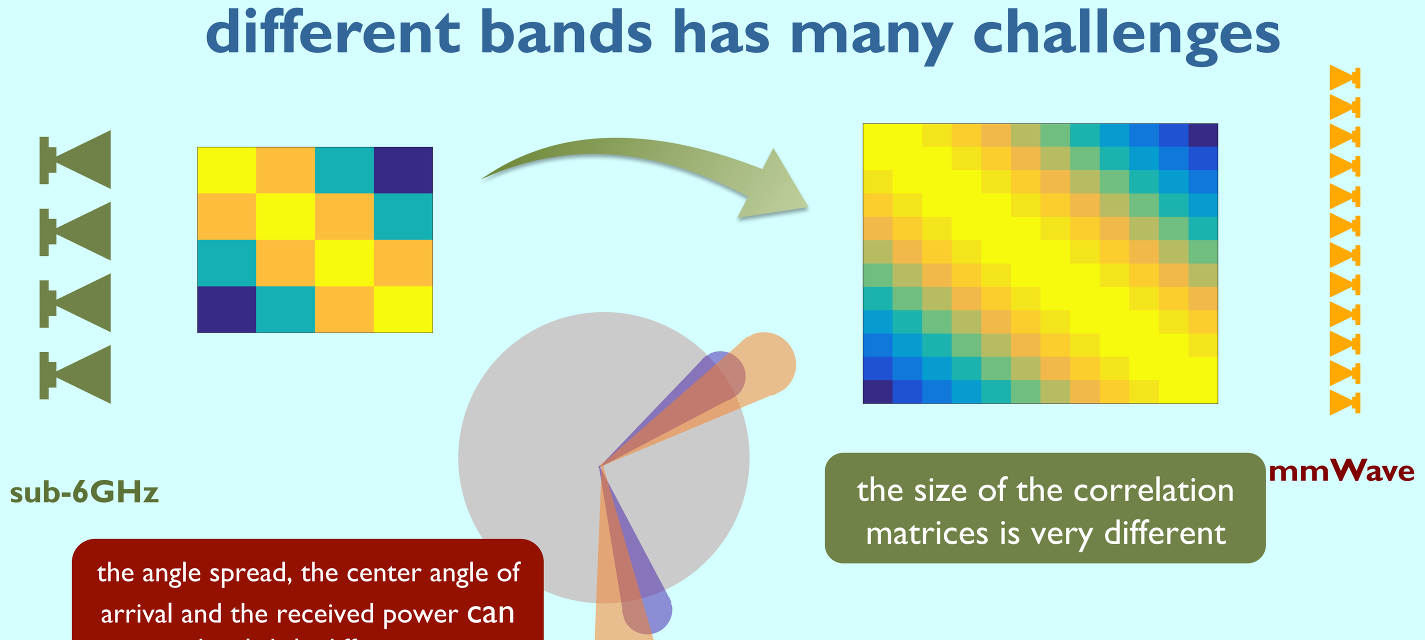
Well established in the 90s [1]

Measurements from legacy WiFi have been used to configure 60 GHz WiFi [3]

We have estimated DL correlation of mmWave systems using sub-6 GHz correlation [4]

[1] T. Asté, P. Forster, L. Féty, and S. Mayrargue, "Downlink beamforming avoiding DOA estimation for cellular mobile communications," in Proc. ICASSP), 1998
[2] M. Peter et al., "Measurement campaigns and initial channel models for preferred suitable frequency ranges," Millimetre-Wave Based Mobile Radio Access Network for Fifth Generation Integrated Communications, Tech. Rep., 2016.
[3] T. Nitsche, A. B. Flores, E. W. Knightly, and J. Widmer, "Steering with eyes closed: mm-wave beam steering without in-band measurement," in Proc. IEEE Int. Conf. Comput. Commun. (INFOCOM), 2015, pp. 2416–2424.
[4] A. Ali, N. González-Prelcic and R. W. Heath Jr., " Estimating Millimeter Wave Channels Using Out-of-Band Measurements," ITA 2016

Translating channel information between vastly different bands has many challenges



Exploiting OOB commun. signals

Covariance translation from sub-6 GHz to mmWave

Construct an estimate of the mmWave spatial correlation matrix

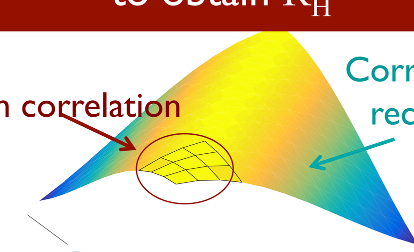
$$\hat{\mathbf{R}}_{\mathrm{H}} = f(\mathbf{R}_{\mathrm{L}})$$

mmWave spatial correlation matrix

Sub 6 GHz spatial correlation matrix

Non-Parametric

Exploit correlation structure. Use interpolation/extrapolation to obtain $\mathbf{R}_{\mathrm{H}}$



Parametric

Theoretical expressions of correlation

$$[\mathbf{R}]_{i,j} = e^{j2\pi\Delta(i-j)\sin(\bar{\theta})}\Phi\left(2\pi\Delta(i-j)\sin(\bar{\theta})\sigma_\theta\right)$$

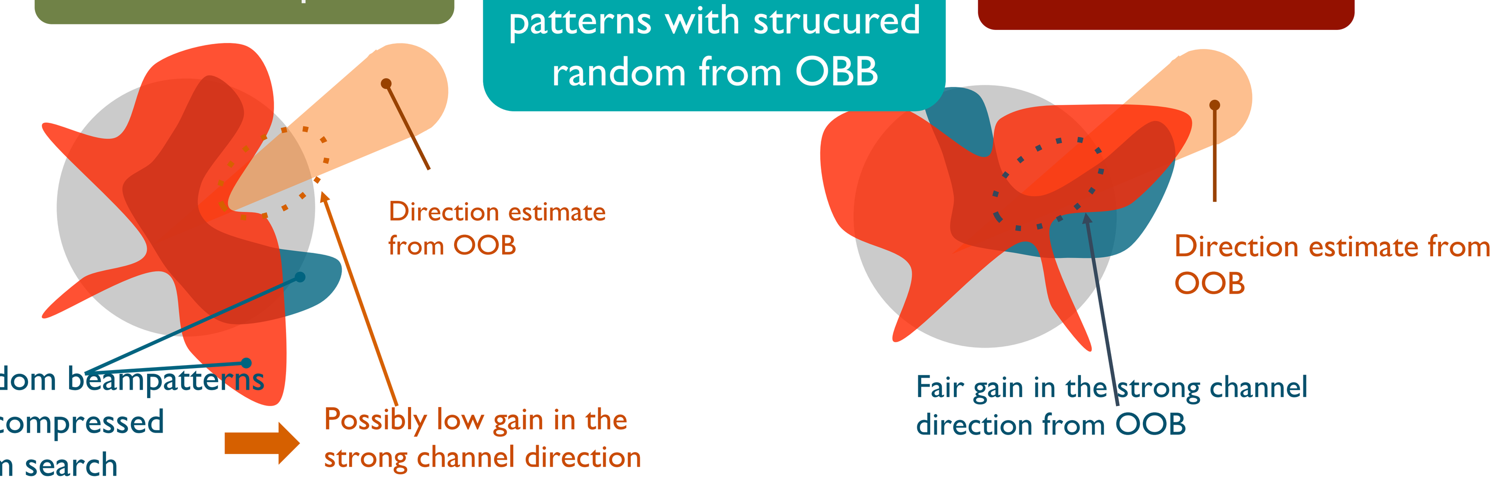
Estimates of angles and angle spreads e.g. using subspace algorithms

Compressed beam search with OOB info

Random beam patterns

Replace random beam patterns with strucured random from OBB

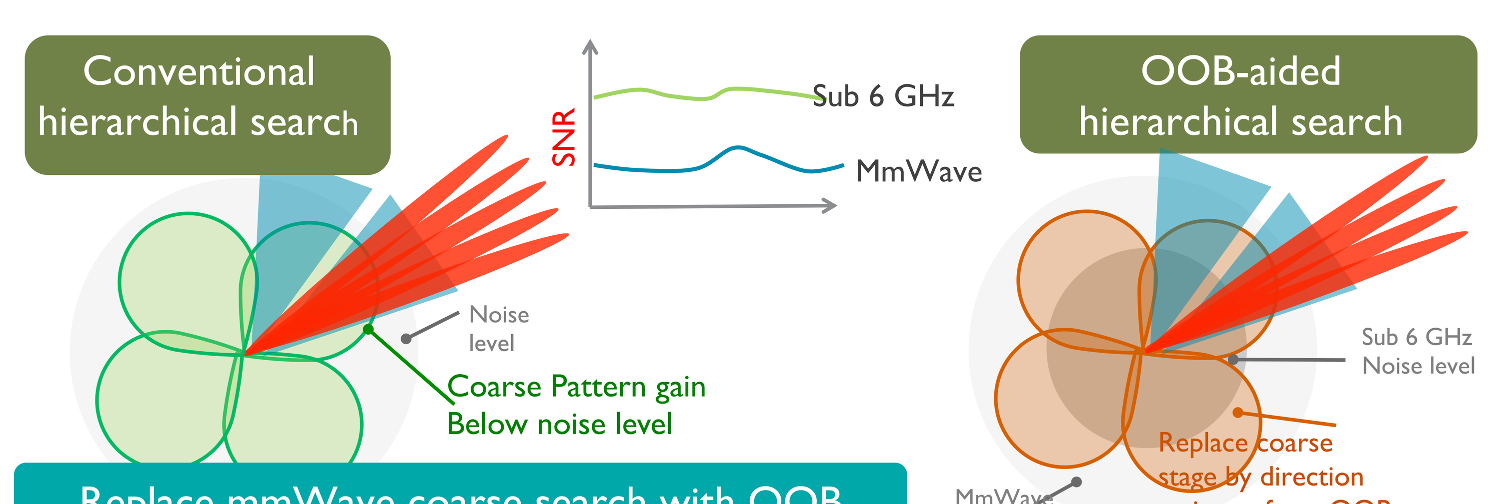
Structured random



Hierarchical beam search with OOB info

Conventional hierarchical search

OOB-aided hierarchical search



Replace mmWave coarse search with OOB

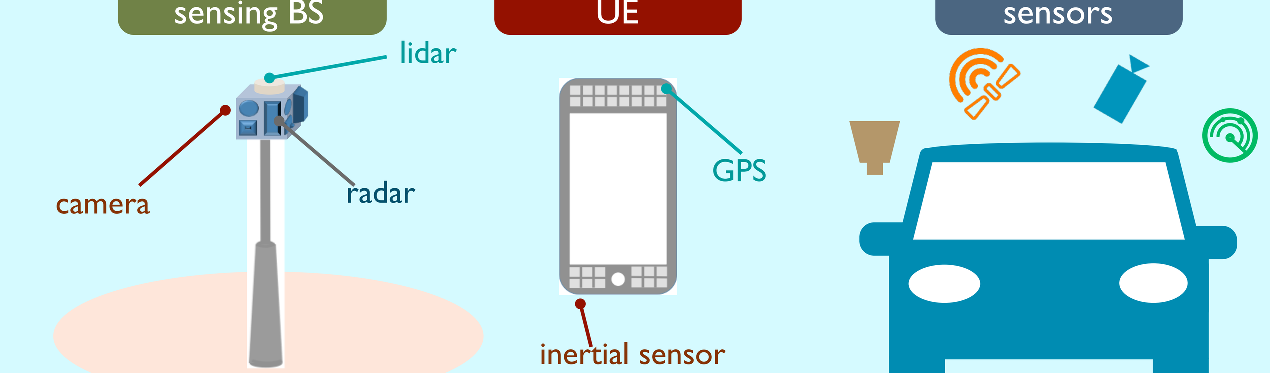
Exploiting sensor information

Sensor aided mmWave

mmWave sensing BS

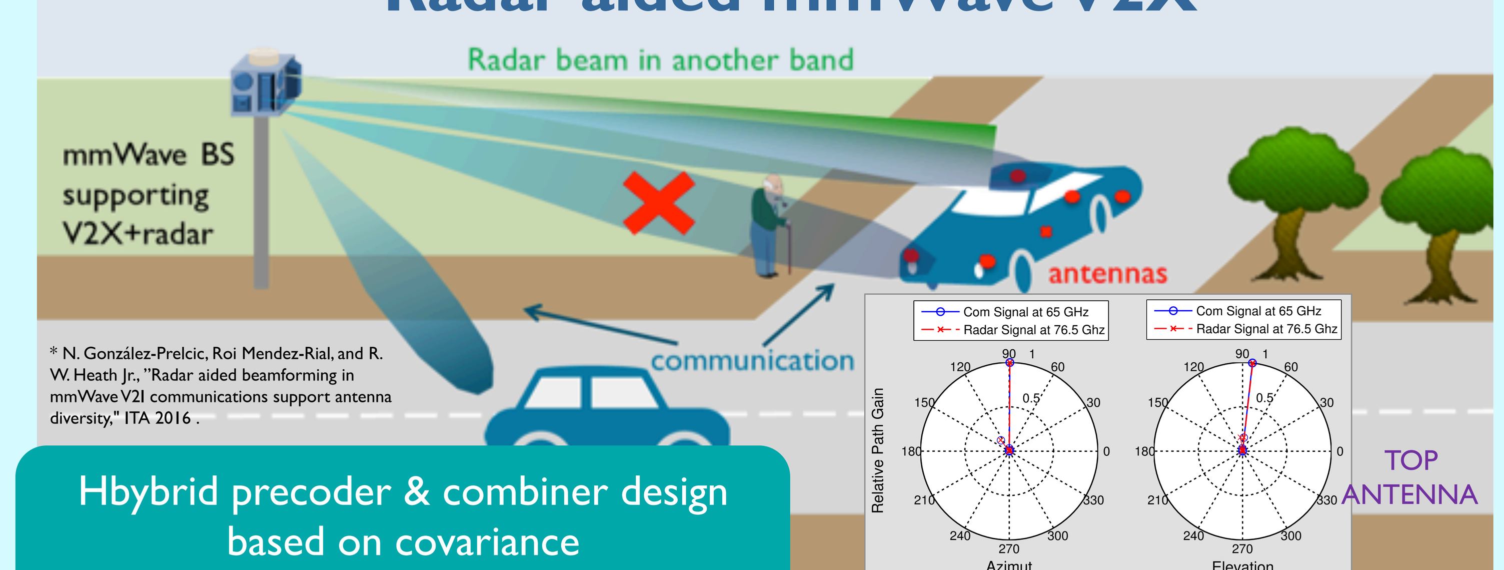
sensors at the UE

automotive sensors



Sensors everywhere…
Why not to exploit sensing info to aid mmWave communication?

Radar aided mmWave V2X

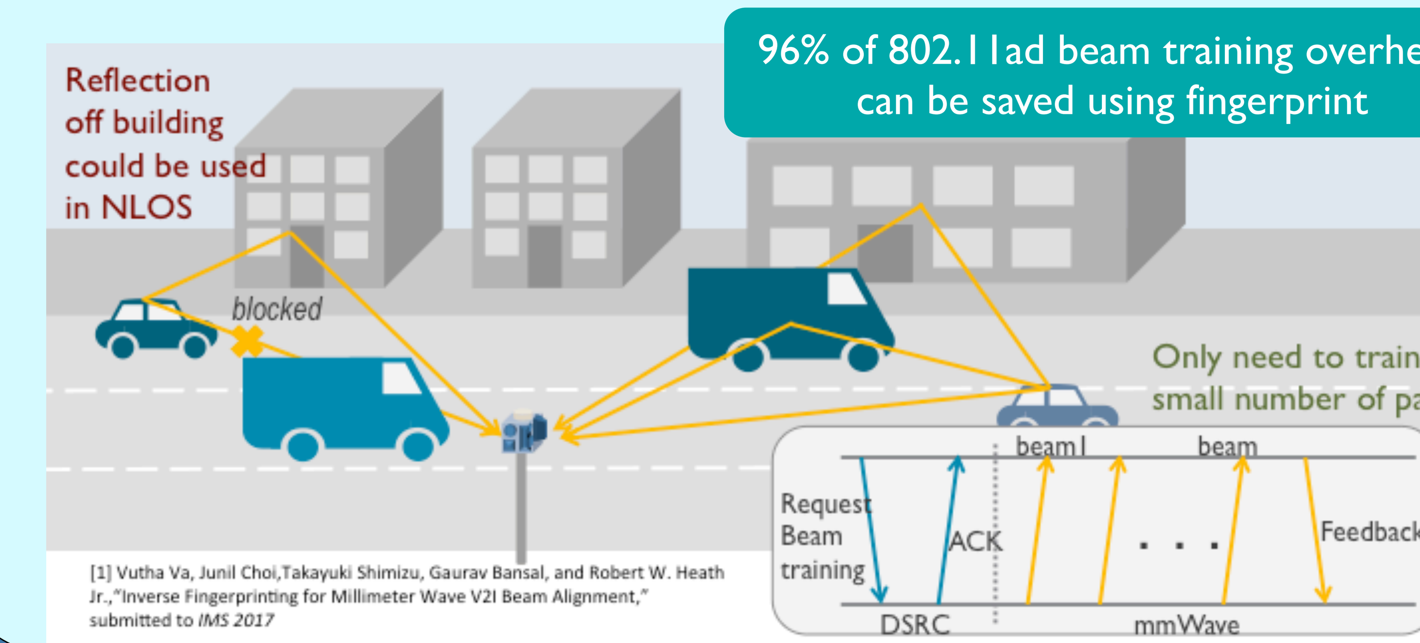


* N. González-Prelcic, Roi Mendez-Rial, and R. W. Heath Jr., "Radar aided beamforming in mmWave V2I communications support antenna diversity," ITA 2016

Hbybrid precoder & combiner design based on covariance information of the radar signal

Position aided mmWave V2X

96% of 802.11ad beam training overhead can be saved using fingerprint



[1] Vutha Va, Junil Choi, Takayuki Shimizu, Gaurav Bansal, and Robert W. Heath Jr., "Inverse Fingerprinting for Millimeter Wave V2I Beam Alignment," submitted to IMS 2017