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mm Band Multi-Antenna Systems & Statistical Learning ?

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5G Summit IMS 2017
Honolulu

Service Vision and Performance

Massive Connectivity

Enhanced Broadband

Tele-Control, V2X

Low Power

Low Latency

High Reliability

High Speed

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mm-Band in 5G RAN

- Proposed US Bands - 28, 37, 39, 57 - 71 GHz
- Propagation mode
  - LOS, near LOS, strong shadowing (Foliage and Rain loss, 60 Ghz small absorption loss)
- Deployment
  - Small cells ~ 150m
- Need large arrays
  - Antenna elements get smaller -> need to rebuild aperture to get reasonable ranges – either use reflectors / lenses or multiple antennas and beamforming

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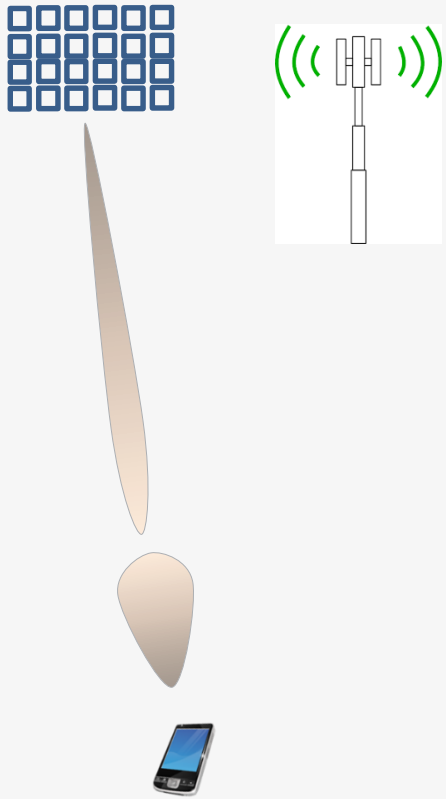
Large MIMO

- Antennas
  - BS >> 32
  - UE 2 - 8
- Narrow Base Station Beam widths
  - 6 to 2 deg
- Channel BW 100 - 1500 MHz
- Multiple Access - Beamforming essential
  - MU-MIMO
  - SU-MIMO + TDMA / FDMA



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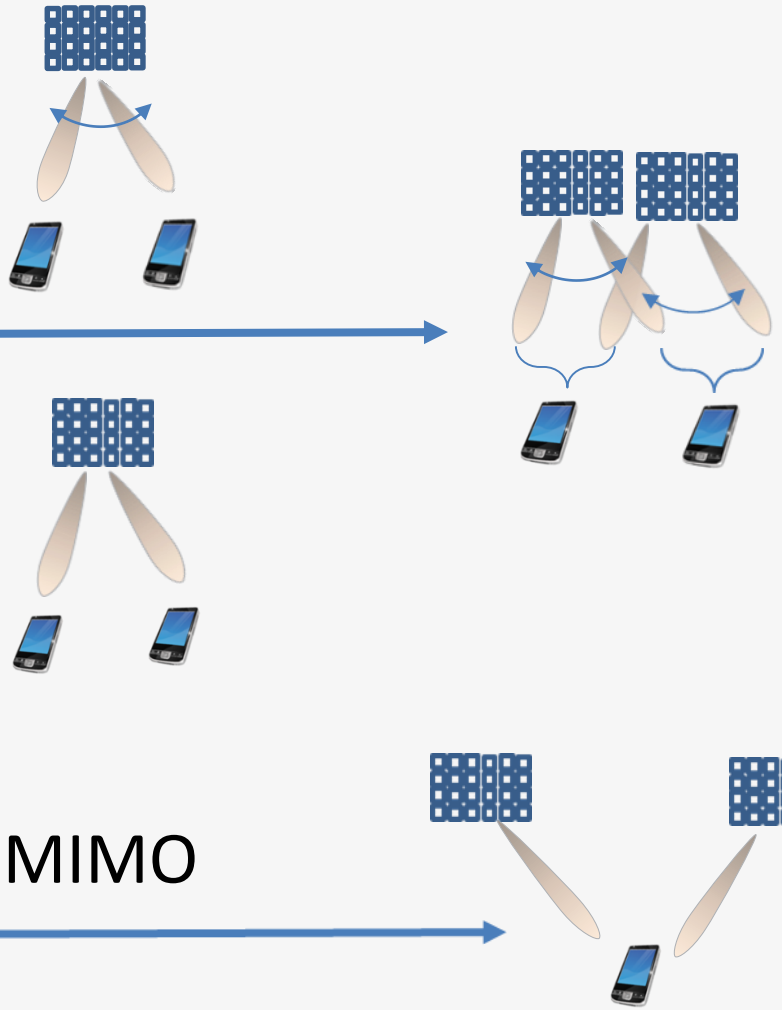
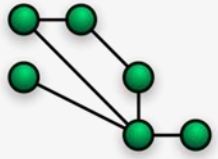
MIMO Modes

- Single Stream (+TDMA)
- Single User MIMO (+TDMA)
- Multi User MIMO
- Distributed Multi User MIMO



Knowledge and Predictability

Backhaul	Baseband	RF + Antennas		Channel	Users	Applications
						
Med	High	High	Med	Poor	Poor	Poor

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Performance Optimization

- Poor knowledge and predictability is a challenge
  - Handover
  - Channel Knowledge and Predication
  - Scheduling
  - Interference
  - More ….

Opportunities for using statistical learning?

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Channel State Information

- MU-MIMO needs good Transmit Channel Information (not so for simple beamforming)
  - FDD (or Closed loop TDD) – Simple Pilot based techniques is overhead expensive
  - In TDD – Tx- Rx calibration is hardware expensive
- Higher channel variability in vehicular environments

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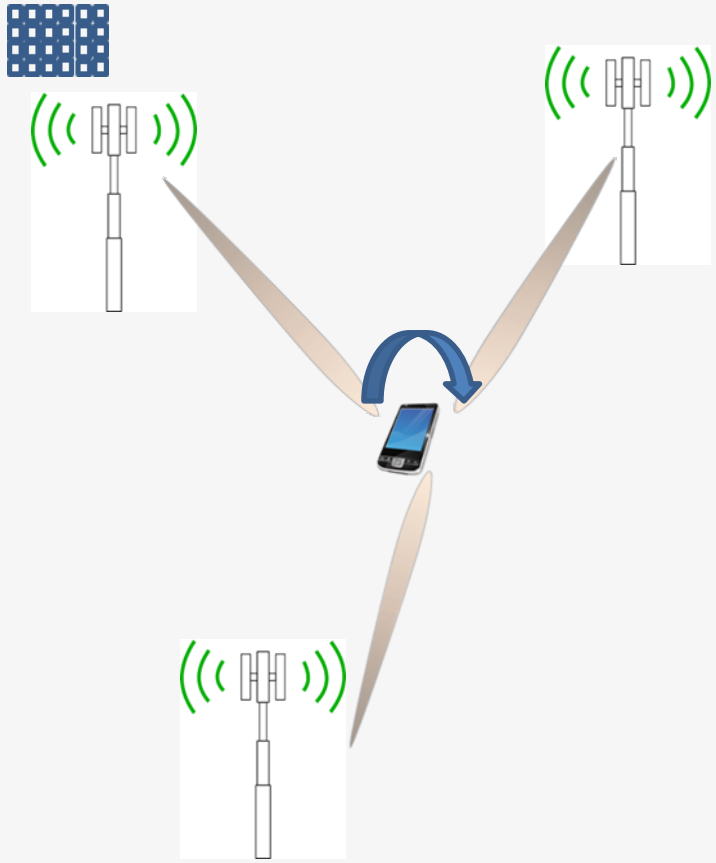
Handover

- Strong shadowing means multiple base stations need to support a terminal with rapid handovers to select the best serving station
- Managing handover (& neighbor list) is complicated



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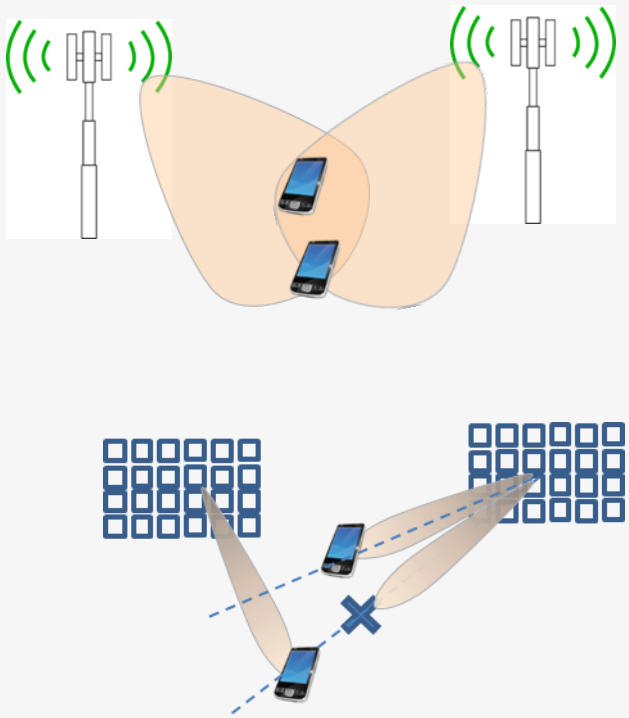
Interference

- Interference is much more dynamic than 4G due to narrow beams – depends on user position, base station beam pointing schedule (NAIC)



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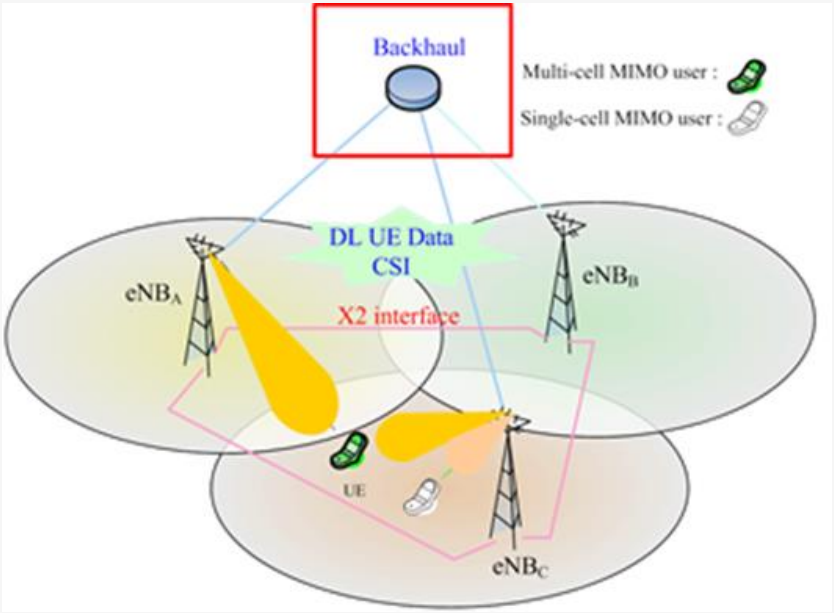
Scheduling

- Scheduling gets more complicated because of tight inter-BS coupling
- Backhaul (S1) bandwidth management also comes into play



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Statistical Learning

- CART, SVMs, DNN, CNN, RNN, RL,….

- Can be useful in applications where there is too little state knowledge or predictability for convex/nonconvex programming, instead works by learning patterns and relationships to extract self programming
- But very fragile… still in Infancy

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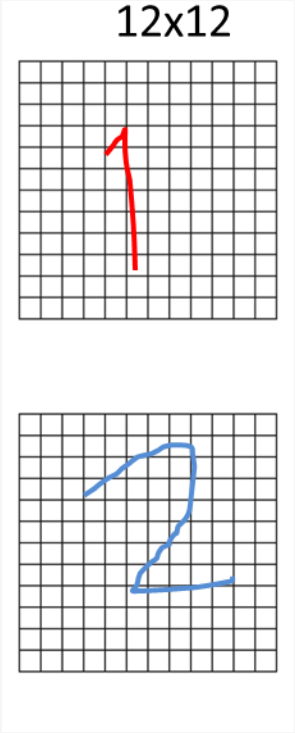
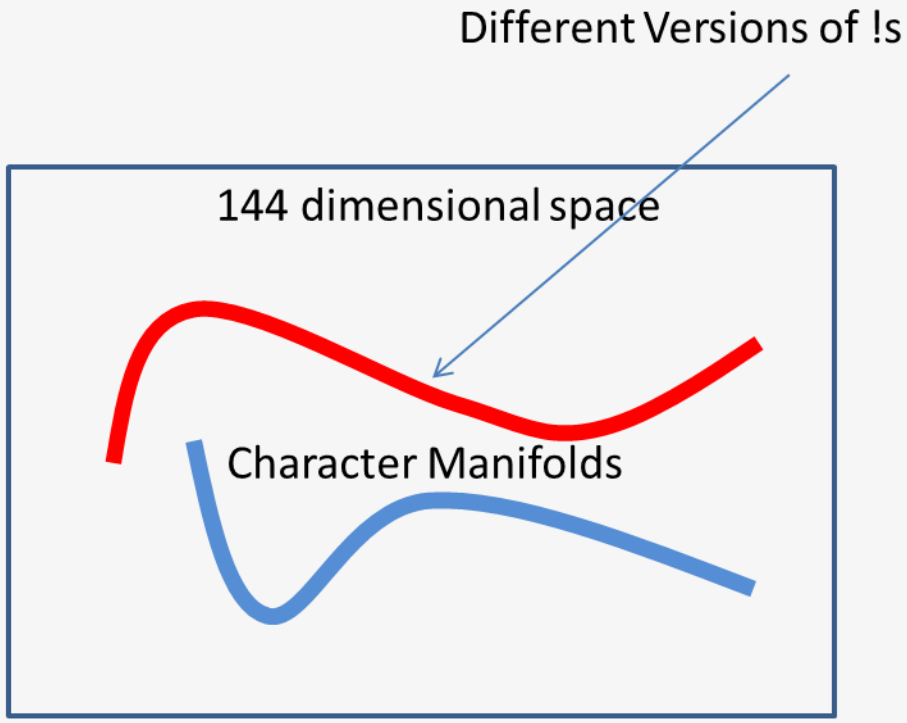
Handwriting Recognition





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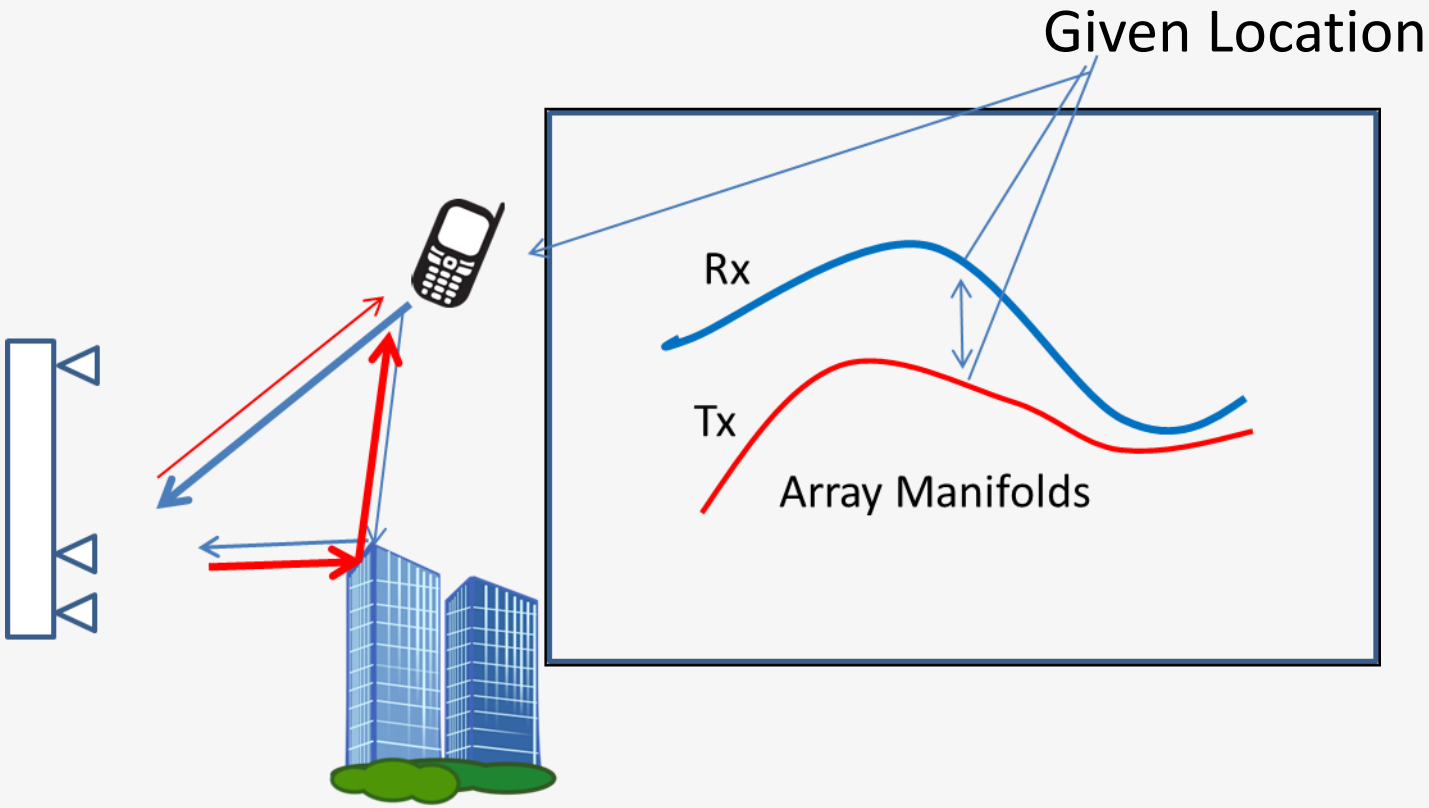
Channel Estimation



Learning the correspondence mapping between Tx and Rx manifolds can help Channel Estimation

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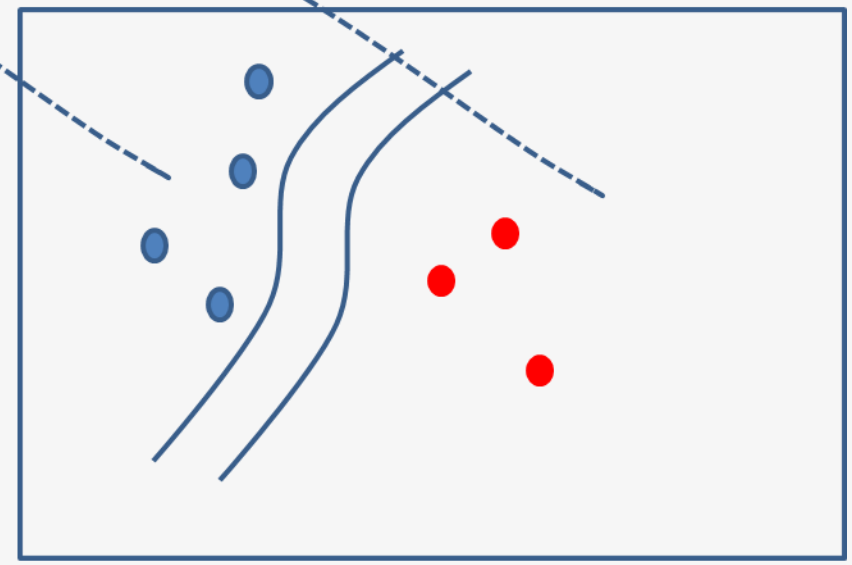
Credit Risk

Joe	Dick
Owns a home	Rents a home
Likes ice cream	Hates ice cream
Single	Married
Employed	Unemployed



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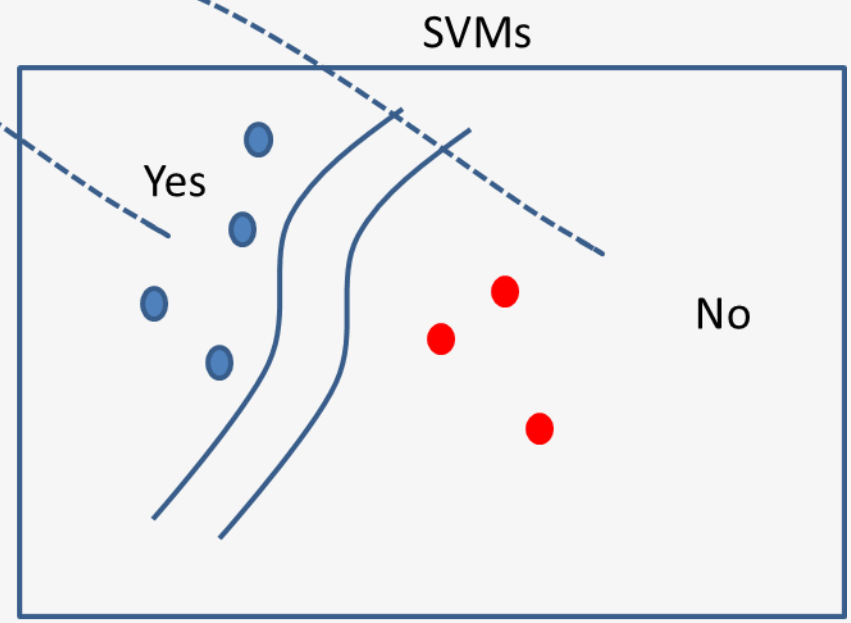
User Likely to Download Movie ?

Joe
In a cafe
Likes ice cream
Good credit score
Paid his phone bills

Dick
Running
Hates ice cream
Bad credit score
Not Paid his phone bills



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Summary

New frontier but many open issues!

Rasa Networks …