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Predictor Antennas in Action

The road to reliable vehicular communication

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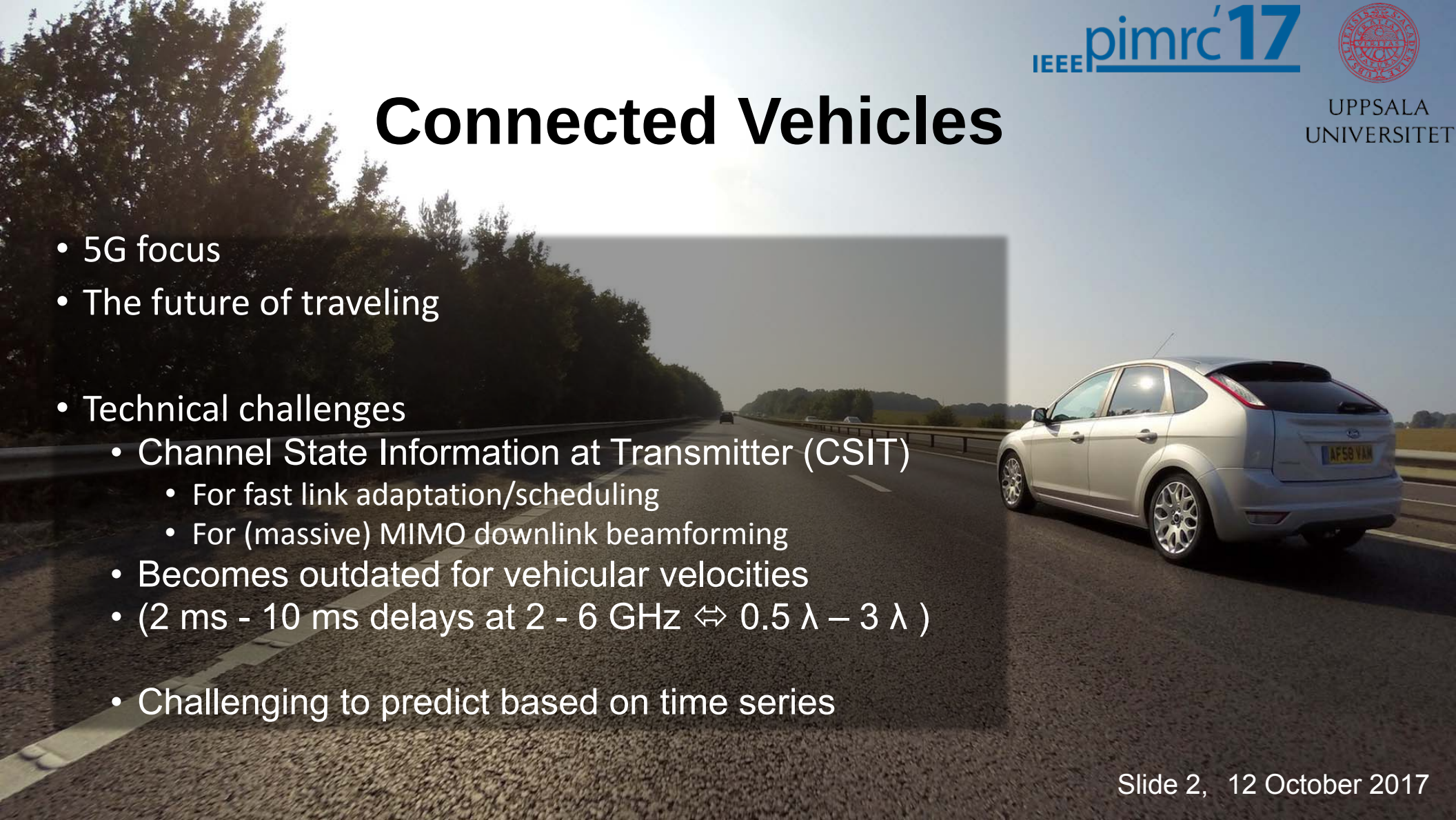
Connected Vehicles



- 5G focus
- The future of traveling

- Technical challenges
  - Channel State Information at Transmitter (CSIT)
    - For fast link adaptation/scheduling
    - For (massive) MIMO downlink beamforming
  - Becomes outdated for vehicular velocities
  - (2 ms - 10 ms delays at 2 - 6 GHz $\Leftrightarrow$ 0.5 λ – 3 λ)

  - Challenging to predict based on time series

Predictor Antenna

- Encounter same position twice
- Predicts the channel at the second time
- Horizon limited by antenna distance
- $h_{main}(pos) = a h_{pred}(pos)$, a - coefficient

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Early Results

- Measurement setup
  - Horizontal metal sheet “roof”
  - Monopole antennas
  - Two selected locations, 50km/h
- Results
  - Average NMSE of -14 dB [2]
  - Long prediction horizon attained (3 λ ahead)

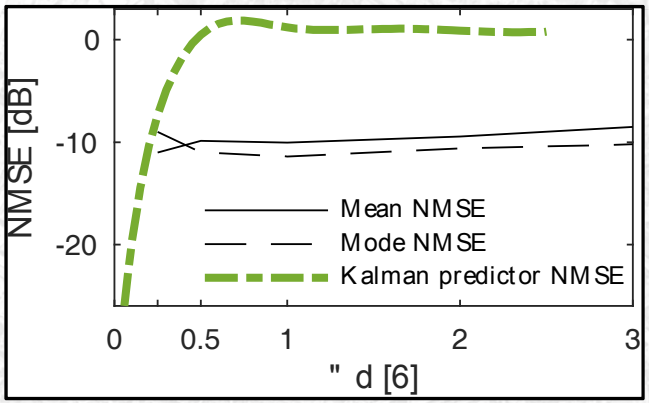
Current measurements

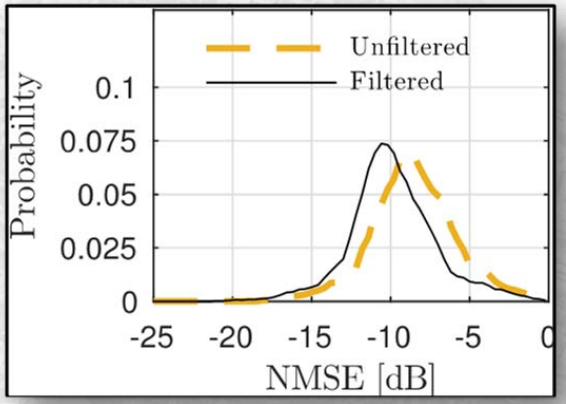
- Theoretical prediction performance

$$\mathrm{NMSE} = 1 - |b|^2 \frac{\gamma_p}{(1+\gamma_p)}$$

  - b - cross-correlation
  - γ_p - predictor antenna SNR
- Realistic average NMSE of -10 dB [6]
- Superior prediction horizon

Antenna distance Δd=12 cm



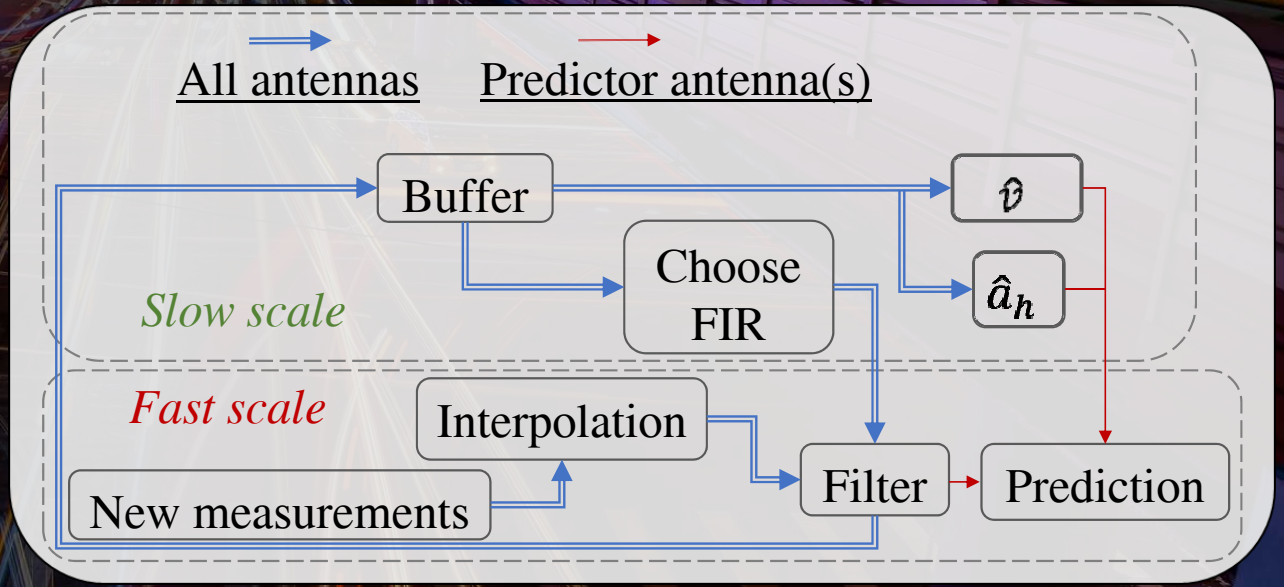


- New measurements:
  - Central Dresden, Germany
  - Similar setup as earlier

Dresden measurements	
Base station sites	*5*
Velocity	*3-50 km/h*
SNR	*5-30 dB*
Burst length	*640 ms*
Number of bursts	*1 445*
Measure OFDM symbols	*650 million*
Carrier frequency	*2.53 GHz*

Algorithm

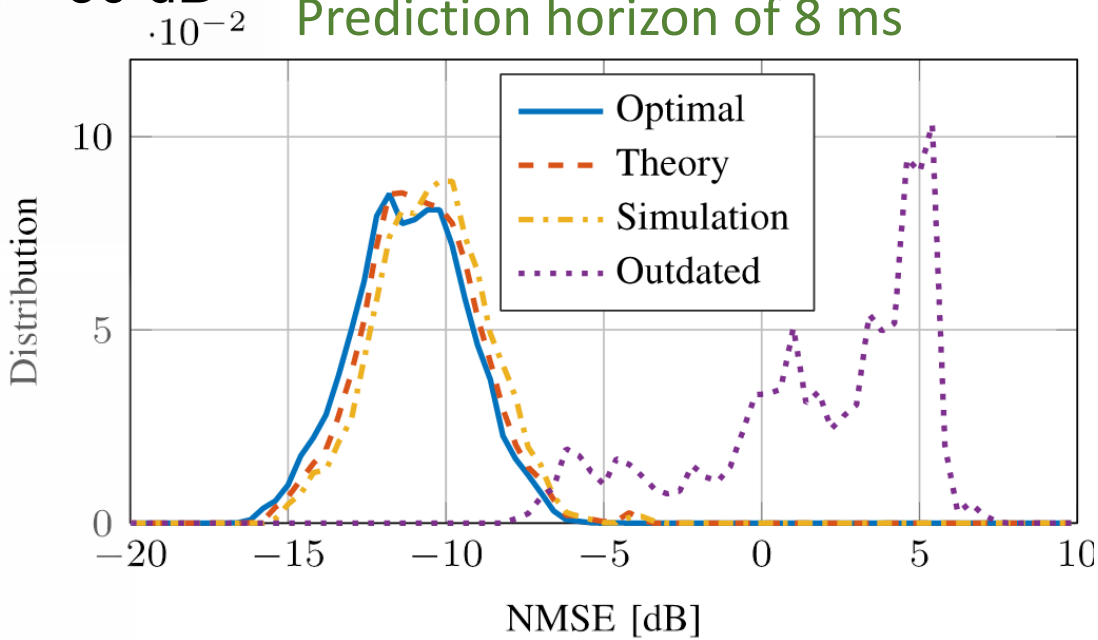
- Designed with implementation in mind
- Slow scale
  - Estimates parameters
  - Runs about every 0.3 s
- Fast scale:
  - Interpolation
  - Filter measurements
  - Predict channel
  - Runs every time-symbol slot



Results

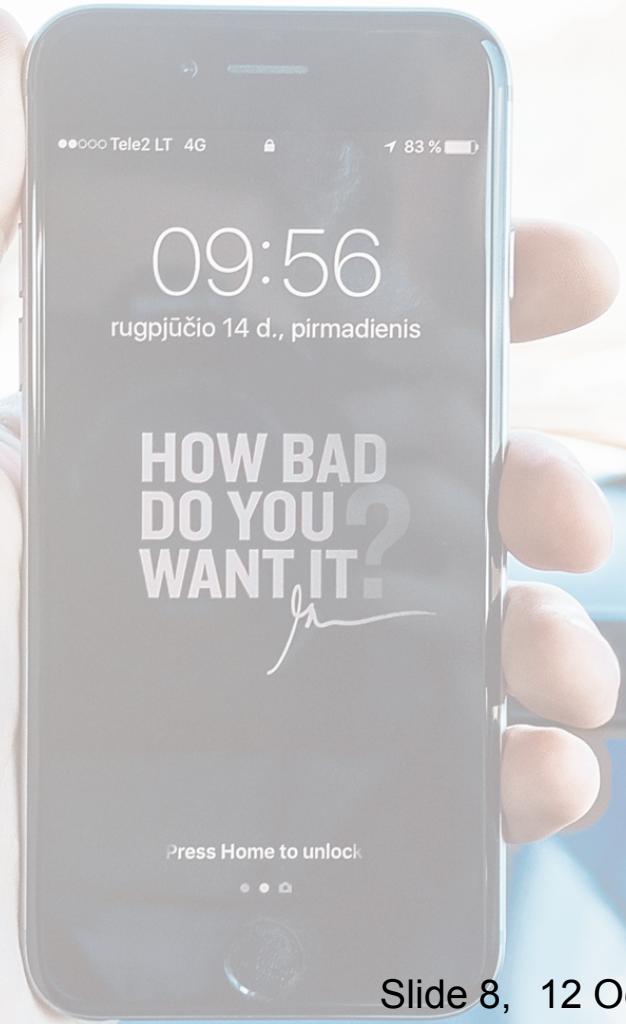
- Prediction evaluation
  - Challenge: True channels unavailable
  - Evaluated on subset with SNR > 30 dB
  - 220 measurement bursts
  - Algorithm vs theory
  - Prediction vs outdating
- Interpretation
  - Simulation is close to theory
  - Outdated channels would be useless
  - Antenna distance limits the prediction horizon

Prediction horizon of 8 ms



Conclusions

- Enabling CSIT for for moving vehicles
  - Current method achieves prediction NMSE of around -10 dB
  - Adequate for downlink beamforming
- Impact on 5G vehicular downlinks
  - Cost efficiency
  - Capacity
  - Link reliability



Thank you!

References

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