NSF Research Coordination Network on Millimeter-Wave Wireless

Marco Mezzavilla, NYU
Tanguy Ropitault, NIST
Michele Polese, U Padova
David Matolak, U South Carolina

Breakout Session

CSP-NET Interface

Communication and Signal Processing & Networking

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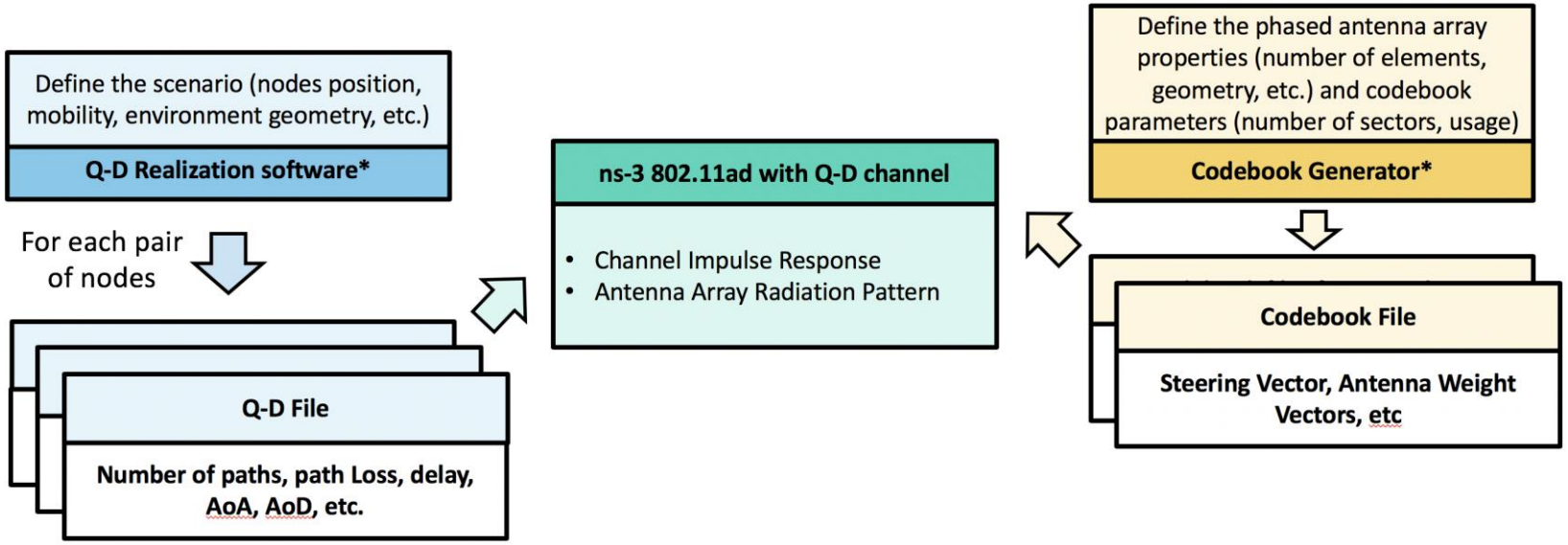
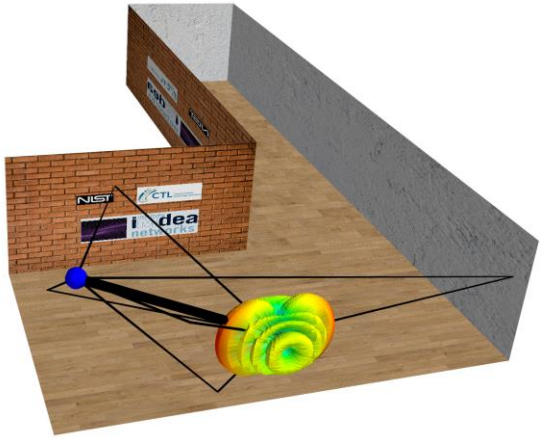
Outline

- Highlights from the 6th CSP/NET breakout session
  - Q-D models for IEEE 11ad/ay
  - Link Abstraction in IEEE 11ay (BER) and 3GPP NR (BLER, LDPC)
  - How can we use testbeds to validate/improve simulations?
- What have we accomplished?
- Moving forward..

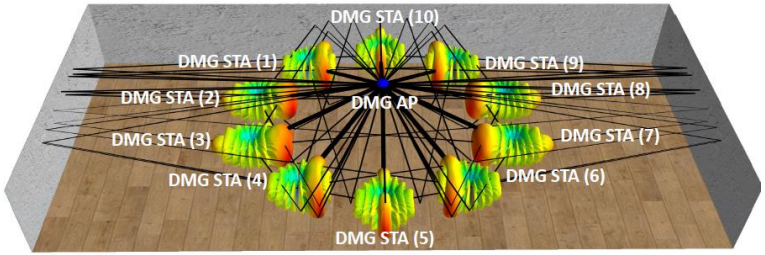
Quasi-Deterministic models for IEEE 11ad/ay



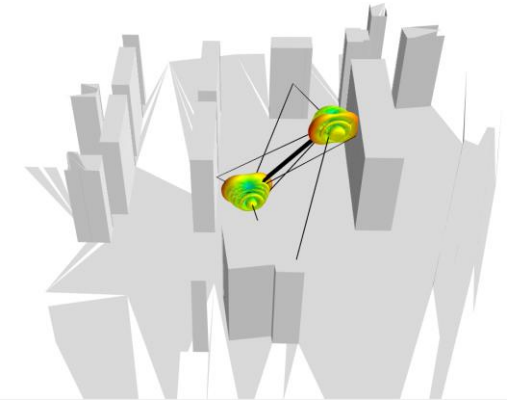
Q-D Visualizer



L-Room Scenario



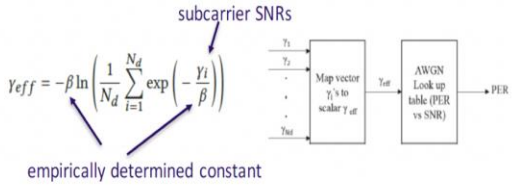
Multi-STAs scenario

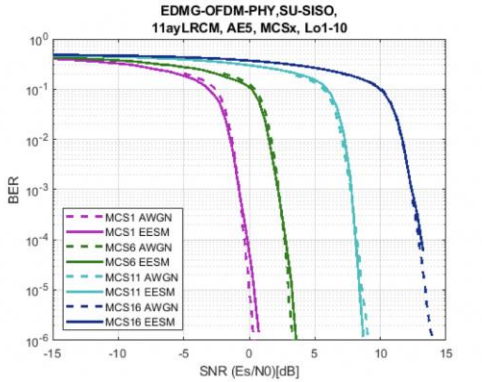


Outdoor Scenario

NIST

Exponential Effective SNR Mapping for 11ay





Link-layer simulation

Q-D fading channel (100 locations) ⇔ AWGN BER/SNR curve

β for each MCS

System-level simulation

Use **β** to compute effective SNR

Use AWGN curve with effective SNR to get BER

- EESM was calibrated using link layer simulation in one environment
- Need to be validated in other environments

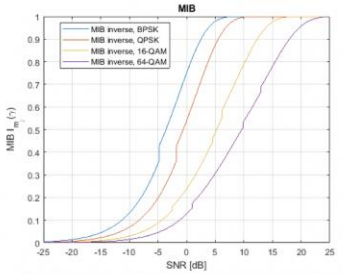
NIST

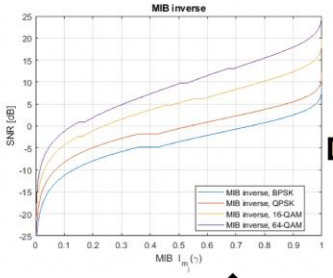
Mutual Information Based SNR Mapping for 11ay

$$M = I\left(SINR_{eff}\right) = \frac{1}{N}\sum_{n=1}^{N} I_m\left(SINR_n\right)$$

$$\Rightarrow SINR_{eff} = I^{-1}(M) = I^{-1}\left(\frac{1}{N}\sum_{n=1}^{N} I_m\left(SINR_n\right)\right)$$

The mapping is already defined for each modulation





Effective SNR

Use AWGN curve

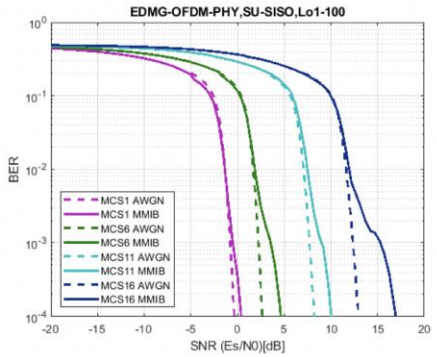
BER

Obtain I_m value

SNR_1 SNR_2 SNR_3 ... SNR_n

Average I_m

System-level simulation

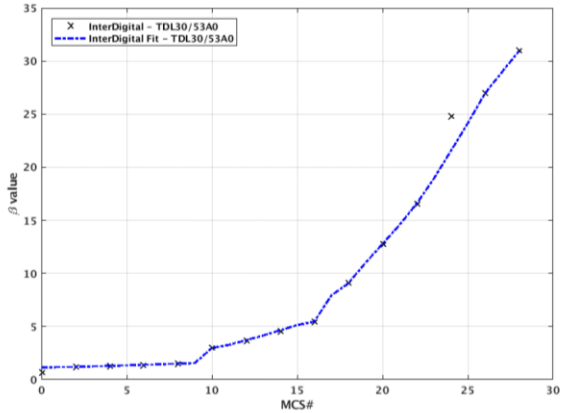


- MMIB is environment independent
- Seems to drift for BER < 10^{-2}

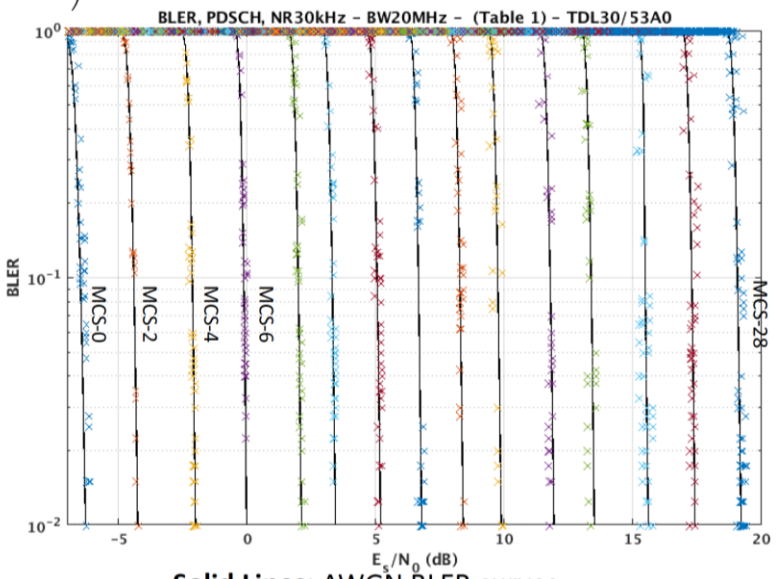
EESM β optimization for NR LDPC Coding

Optimization is carried out for: $SINR_{eff} = -\beta * ln\left(\frac{1}{N}\sum_{n=1}^{N} exp(-\gamma_n/\beta)\right)$

- TDL channel
- Type A (NLOS)
- Delay spread 30-53 ns



β value table for Table 2



Solid Lines: AWGN BLER curves

x Marker: Simulation BLER vs. SNR_{eff}

INTERDIGITAL

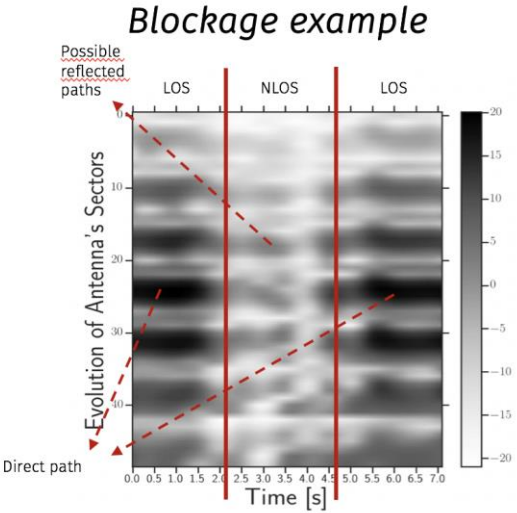
β Look-Up Table

Modulation	Code Rate	Beta (β)
QPSK	120/1024	0.7
	308/1024	1.29
	602/1024	1.5
16-QAM	340/1024	2.98
	553/1024	4.64
64-QAM	466/1024	9.08
	666/1024	16.56
	873/1024	26.94
256-QAM	682.5/1024	52.78
	841/1024	91.8
	948/1024	120

INTERDIGITAL

How can we use testbeds to validate/improve simulations?

- Experimental validation



- Complete channel traces + ns-3 TCP/IP stack

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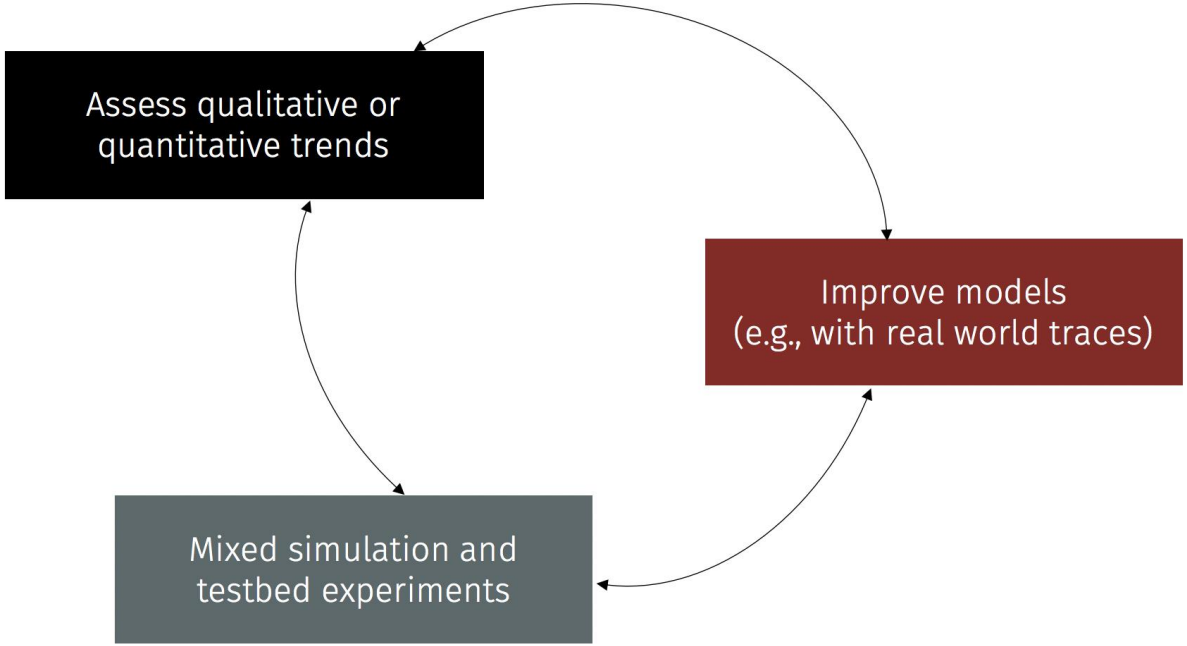
How can we use testbeds to validate/improve simulations?



How can we use testbeds to validate/improve simulations?

Beam Management
- Rotation
- Time scales
- Antenna patterns

Mobility
- Handovers rate
- Mobility management
- Cross-layer interactions

Applications (AR/VR)
- Adaptive streaming on mmWaves
- VR quality with highly variable channels

What have we accomplished?

- Implementation of different lower layers simulation accuracy levels
  - Very detailed (Q-D models)
  - Hybrid (topology-driven + channel models)
  - Simplified channels (Nakagami)
- Link layer abstraction
  - 802.11ay EESN+MMIB
  - NR EESN LDPC
- MIMO models 11ay+NR
- 3GPP features
  - IAB, Synchronization, CSI-RS, ..
- TCP protocols over mmWave + experimental assessment
- Applications
  - Public safety, vehicular, aerial, edge robotics

Moving forward

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