Towards Deep Learning Augmented Robust D-Band Millimeter-Wave Picocell Deployment

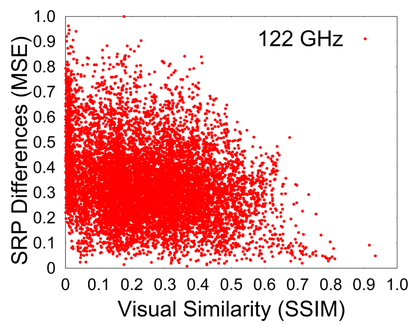
South Carolina

Hem Regmi
Sanjib Sur

D-Band Deployment & Challenges

NextG wireless networks are difficult to design and deploy

- **Millimeter-wave** at **D-Band** (110 GHz to 170 GHz) offers **wider bandwidth** and can increase the **capacity** of existing networks.
- Large number of **picocells** are needed to support high **throughput** demand of clients.
- Deploying **picocells** that are **operating** at **D-band frequency** has **three** major challenges.



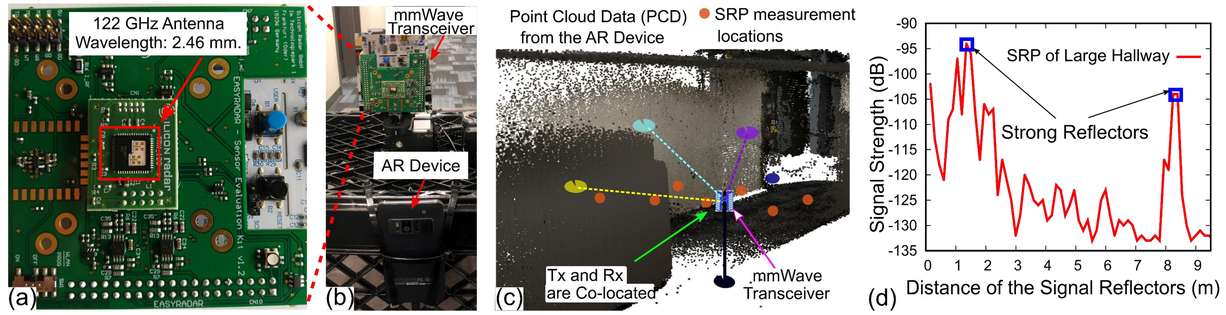
Challenges with picocell deployment at D-band

- **Ray-tracing** simulation based **picocell deployment** are **inaccurate** due to lack of **Non-Line-of-Sight (NLOS)** path models at **high frequency.**
- **Accurate** and thorough manual **site surveys** might help for **picocell deployment**, but they are **time-consuming** and **costly.**
- Even **minor** changes in the **environment** highly impact the **effectiveness** of deployment and may **require** to **update deployment locations.**

Our Approach

Can we deploy picocells at D-band more effectively?

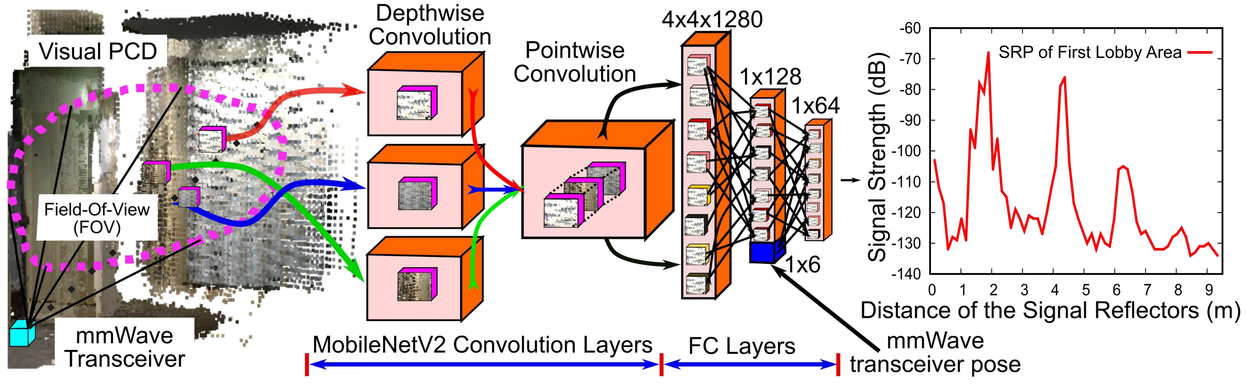
- **Empirical analysis** across **diverse environments** show that **visually similar** objects **produce** similar **millimeter-wave** Signal Reflection Profiles (**SRPs**).
- Similarity between **visual images** and **SRPs** show the **non-linear** relationship, making it **difficult to model** their relationship (**scatter plot** of **Block 1**).
- Deep **learning-based** models can **accurately learn** the mapping between **non-linear data** with **limited number** of environmental **observations.**
- A co-located **mmWave and AR devices** can quickly collect **visual images and SRPs** at random locations **to train** deep learning model and **predict** more **SRPs**.



System Design

Deep Convolutional Neural Network (DCNN) accurately predict SRPs

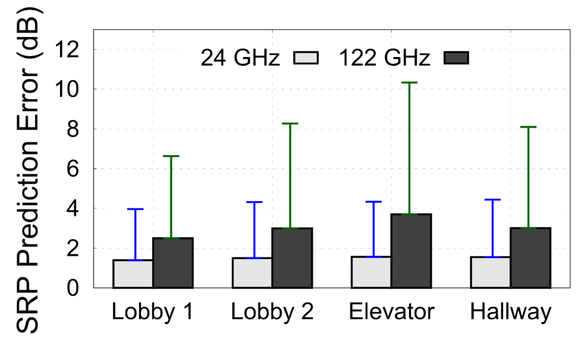
- Preprocess visual **Point Cloud Data** (PCD) to obtain **Inverse Depth Image** for **MobileNetV2** network.
- **Depthwise and Pointwise convolution** layers of **MobileNetV2** extracts high-level **abstract features** from **Inverse Depth Image.**
- **Fully connected layers** use abstract features and **mmWave transceiver pose** to accurately **predict SRPs** at the output layer.



Preliminary Results & Future Goals

DCNN model accurately predicts SRPs across diverse environments

- **Deep learning** model **doesn't require** extensive **manual site surveys** by accurately predicting SRPs at **unobserved** locations.
- **Model** predicts SRP at **D-band** with an average **3.5 dB** median error.



Ongoing Work

- Include **semantic** awareness in the model to **improve** SRP prediction.
- Find **best picocell locations** at **122 GHz** for **diverse environments**.

Future Goals

- Perform ***"what-if"*** analysis of **picocell deployment**.
- Explore 122 GHz and 24 GHz **joint picocell deployment** and simulate **reconfigurable intelligent surfaces** to maximize coverage.