German International University - GIU Berlin
Faculty of Information Engineering & Technology
Course: Mobile Communication Networks [ NETW B 603]
Wireless Communication [ NETW B 601]
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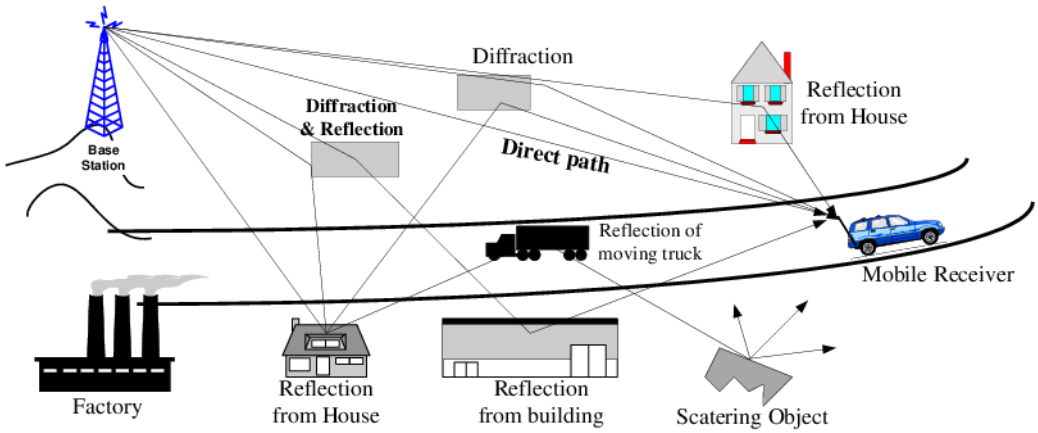
# "Ray-Tracing-Based Wireless Channel Modeling Using NVIDIA Sionna"

## Project Purpose and Rationale:-

Modern wireless systems especially at higher frequencies such as 6 GHz, 28 GHz, and 60 GHz are highly sensitive to environmental geometry and material properties. Deterministic **ray-tracing (RT)** models offer an accurate way to study propagation effects such as:

- Reflection
- Diffraction
- Transmission
- Multipath formation

This project provides students with hands-on experience building a realistic RT-based wireless simulation and analyzing channel behavior in controlled 3D environments.




## Project Objectives:-

Students will design and implement a full RT simulation by:

1. Creating a realistic 3D indoor or outdoor wireless environment.
2. Assigning electromagnetic material properties to scene objects.
3. Configuring transmitter (Tx) and multiple receiver (Rx) nodes.
4. Running RT simulations with reflection, transmission, and diffraction.
5. Extracting channel parameters such as path loss, and delay spread.
6. Comparing behavior across different system configurations or frequencies.
7. Producing a formal technical report documenting methodology and results

## Design Specifications:-

### ➢ Simulation Environment

Students must design a 3D scene that includes:

- Minimum **6 physical objects** (e.g., walls, buildings, furniture, cars)
- Minimum **3 materials** (e.g., concrete, glass, metal)
- At least **one diffraction edge**
- At least **two reflective structures**

### ➢ Materials

Students must assign realistic electromagnetic parameters, including:

- Relative permittivity
- Conductivity
- Thickness (if applicable)

### ➢ Radio Nodes

- **1 Transmitter (Tx)** at a fixed location
- **5–20 Receivers (Rx)** positioned along a path or grid
- Frequencies: **3.5 GHz** and **28 GHz** (or other instructor-specified values)
- Omni or directional antennas

### ➢ Ray-Tracing Configuration

- Maximum reflection depth ≥ 3
- **Diffraction enabled**
- Transmission losses through glass or thin materials are modelled

## Design Workflow: -

### Step 1: Environment Construction

- Build a scene using Sionna primitives or external 3D objects
- Define materials for each object
- Validate geometry and object placement

### Step 2: Node Placement

- Set Tx height and location
- Define Rx positions along a straight path, corridor, or grid

### Step 3: Ray-Tracing Execution

- Run Sionna RT with final environment
- Visualize ray paths
- Export multipath components

### Step 4: Channel Analysis

Students must compute or extract:

- Path Loss
- CIR and Power Delay Profile (PDP)
- RMS Delay Spread
- Angles of arrival/departure
- Dominant reflective or diffractive objects

### Step 5: Comparison Study

- Reflection-only vs reflection+diffraction
- Frequency comparison (e.g., 3.5 vs 28 GHz)
- Material variation (replace concrete with drywall/glass)
- Geometry variation (add/remove wall or object)

## Expected Outputs:-

### ➢ Required Figures

- 3D scene visualization
- Ray-path diagrams
- Path loss vs distance plot
- PDP graphs
- Delay spread table

### ➢ Required Code Deliverables

- Scene construction script
- RT simulation script
- Channel processing and visualization scripts

### ➢ Required Report Sections

- Introduction
- Environment Design
- Simulation Methodology
- Results ( PL, multipath analysis)
- Comparison Study
- Conclusion

## Team Structure: -

Students must work in **teams of up to 3 members**. Individual submissions are allowed, but collaboration in small teams is recommended for workload distribution and deeper exploration.

## Important Date: -

**Final Submission: December 11**

Late submission penalty: **−10% per day**

Good Luck ☺