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Electromagnetic Simulation Software

IMS2018 MicroApps

Simulating Throughput as a Device Design Metric

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Evaluating Device Performance

Determining a good design requires knowing that it will work well in its intended environment.

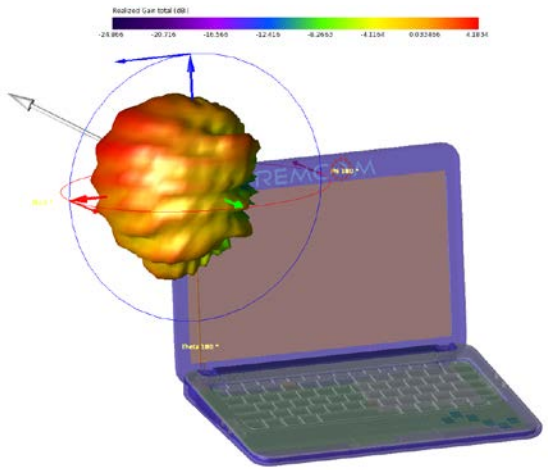
This is a difficult task because of the many factors involved in the device's performance including:

- Antenna design and location
- Effects of the multipath propagation between antennas
- Modeling the transfer of data between antennas

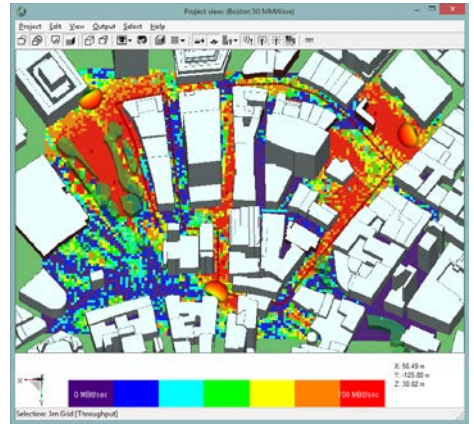
As the number of antenna elements on devices is increasing to meet user demands for higher throughputs, the complexity of the devices is compounding.

Testing in various environments is expensive and cannot cover enough variations characterized device performance.

Device simulation needs to incorporate the antenna design, propagation, and communication modeling together to provide designers with a clear picture of device performance.



Far field gain pattern of an inverted FL antenna in a laptop simulated



Propagation modeling between base stations and devices in an urban area

Components of Throughput Simulation

Requires a coupling between results from Full-wave antenna design, 3D propagation modeling, and communication system modeling.

Full-Wave Solver for Antenna Design

- Antenna geometry
- Antenna location on the device
- Antenna performance vs frequency
- Coupling between antennas

3D Propagation Model

- Antenna orientation
- Performance in various scenarios (e.g. indoor, urban)
- Input power vs coverage trade-offs

Communication System Model

- MIMO antenna behavior
- Wireless access method
- Modulation and coding schemes
- Coordination between antennas

Integration enables all aspects of a device, from antenna designs to operational performance, to be assessed, iterated over, and optimized.

Throughput is a single metric that can be used to characterize device performance.

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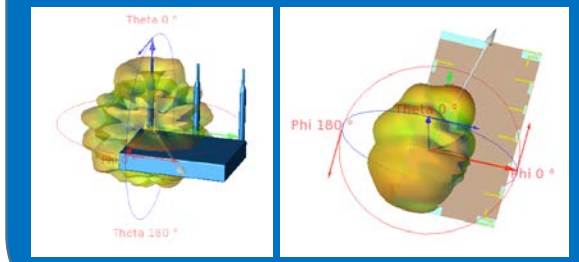
Proposed Design Workflow

XFdtd® MIMO Antenna Element Simulations



3D Antenna Patterns
VSWR

Wireless InSite® Propagation Modeling

Received Power, Complex Impulse Response, Complex H-matrix

Wireless InSite® Communication System Modeling

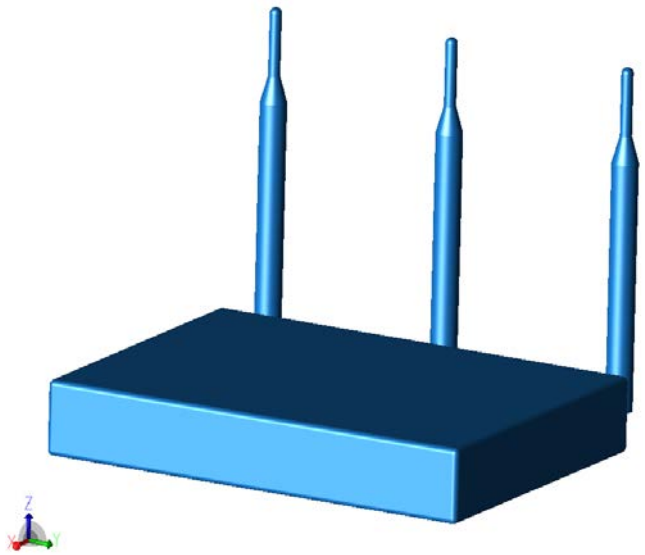
- **MIMO Antenna Behavior**
- Wireless Access Method
- Modulation and Coding Schemes
- Coordination between antennas

Throughput

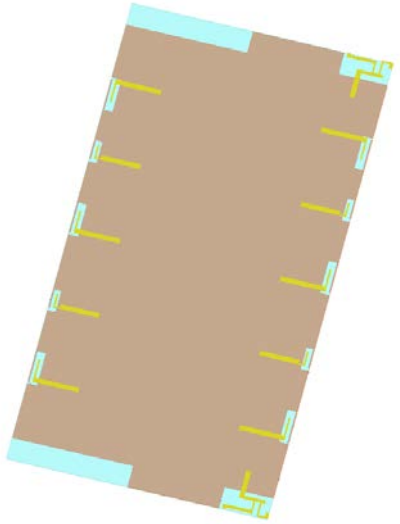
Device Design Example

Evaluate the performance of Wi-Fi antennas on a cell phone at 5.2 GHz in an indoor environment

Design question: Which MIMO receiver diversity technique results in the best performance as characterized by throughput?



Transmitting Device
Router with 3 elements



Receiving Device
Cell phone with 6 elements at 5.2 GHz
4 additional elements at 3.6 GHz (not in use)

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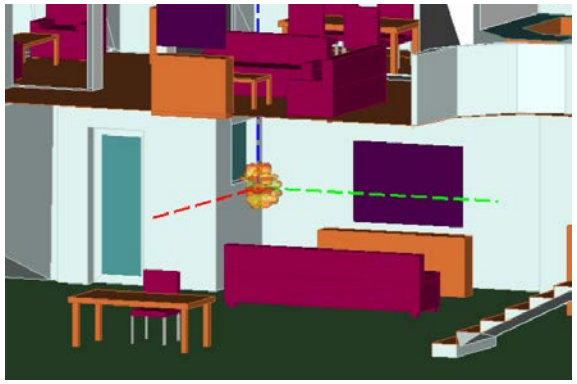
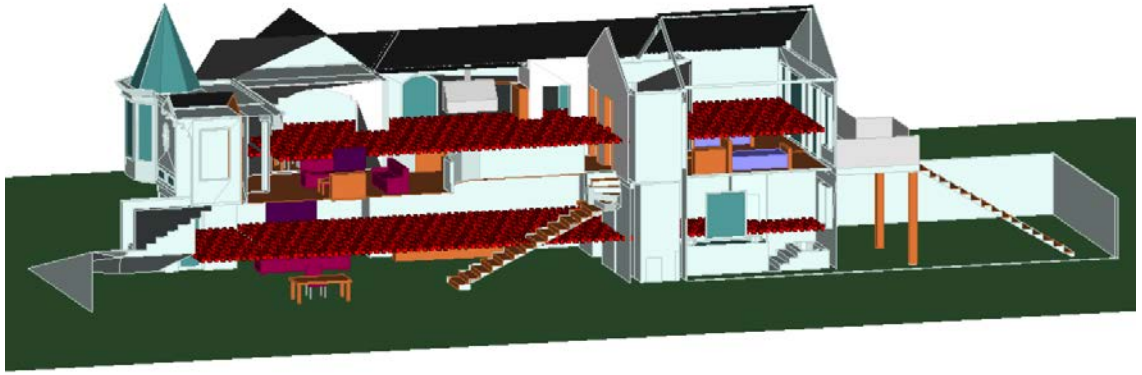
3D Propagation Indoor Scenario



Router located on the lower level



Device evaluation points (XY Grids)
4,289 total locations

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Communication System Description

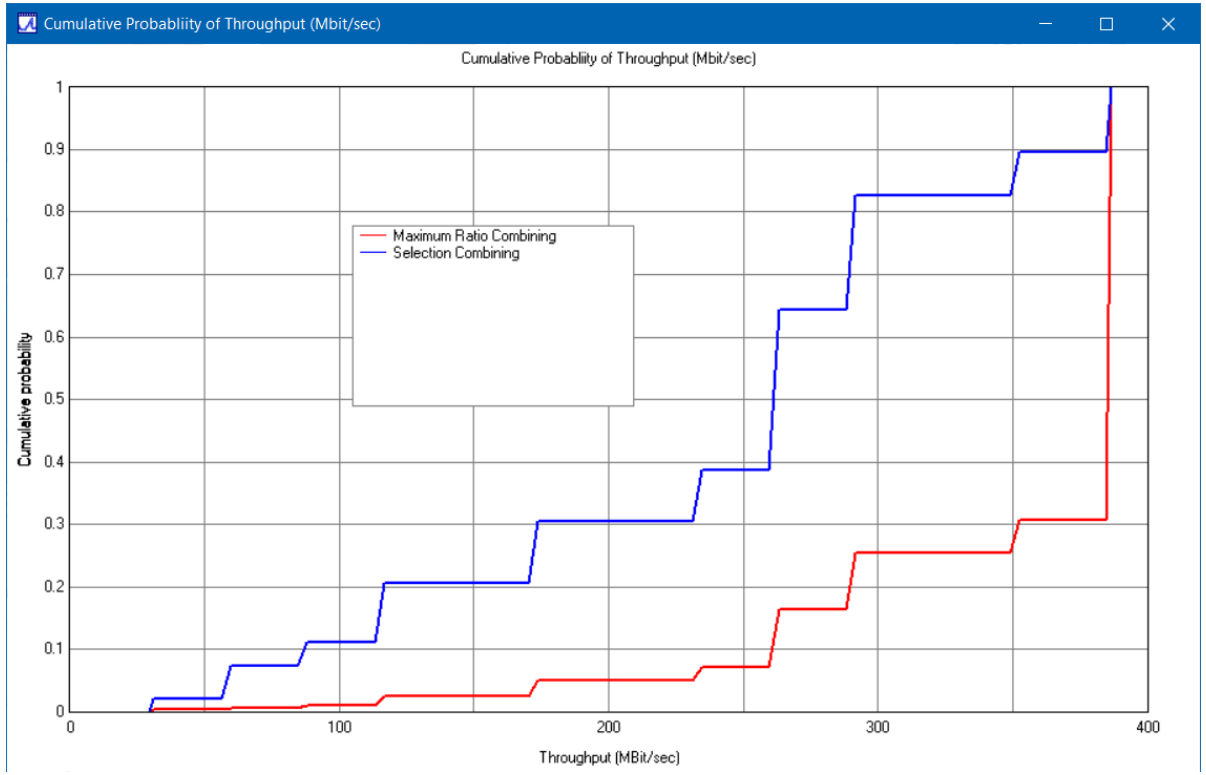
Transmitter's MIMO antenna is using Beamforming using Maximum Ratio Transmission (MRT)

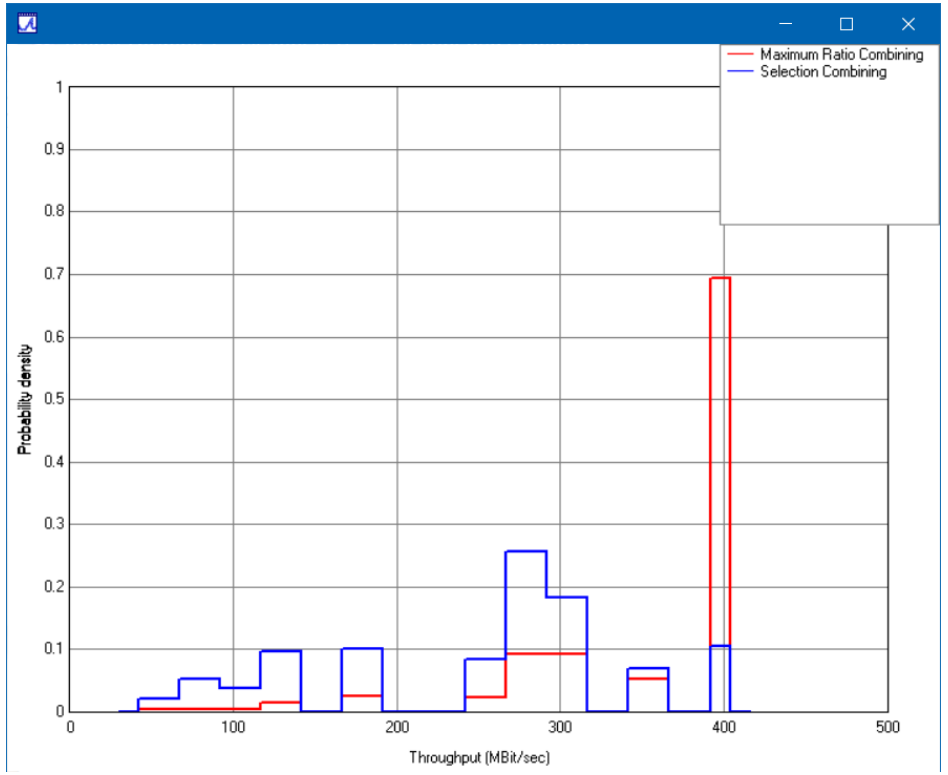
Evaluate throughput for the following 2 options at the receiver locations:

- **Selection Combining:** choose receiver antenna element with strongest SINR
- **Max Ratio Combining (MRC):** weighting vector adjusts magnitude and phase of the cell phone's antenna elements to optimize total SINR

Wireless Access Method: 802.11ac

Cumulative Distribution & Probability Distribution of Throughput over all Receiver Locations





Comparison of the throughput probability distributions show the cell phone provides higher throughputs when Maximum Ratio Combining method is used.

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Summary

- As device complexity increases, designers need new methods for evaluating and comparing designs.
- Integrating antenna design, propagation modeling, and communication system modeling provides a comprehensive characterization of device performance.
- Throughput is a useful metric that can be used to characterize, compare, and optimize device designs – from antenna design to operation performance.

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