WIFI-6 PERFORMANCE ANALYSIS

Annamaneedi Charishma
Hemanth Cheela Ramu
Narendra Gautam Sontu

Contents

High Efficiency Single User (HE SU) Transmission

High Efficiency Single User (HE SU) is a pivotal feature of the latest WiFi 6 (802.11ax) standard, designed to enhance network efficiency and throughput significantly. This configuration enables more robust and efficient handling of data in environments with multiple connected devices, ensuring faster speeds and improved performance. HE SU plays a crucial role in optimizing individual data transmission to a single user or device, leveraging advanced encoding and signal processing techniques to maximize data rates and reliability in crowded or complex network environments.

High Efficiency Single User (HE SU) Transmission

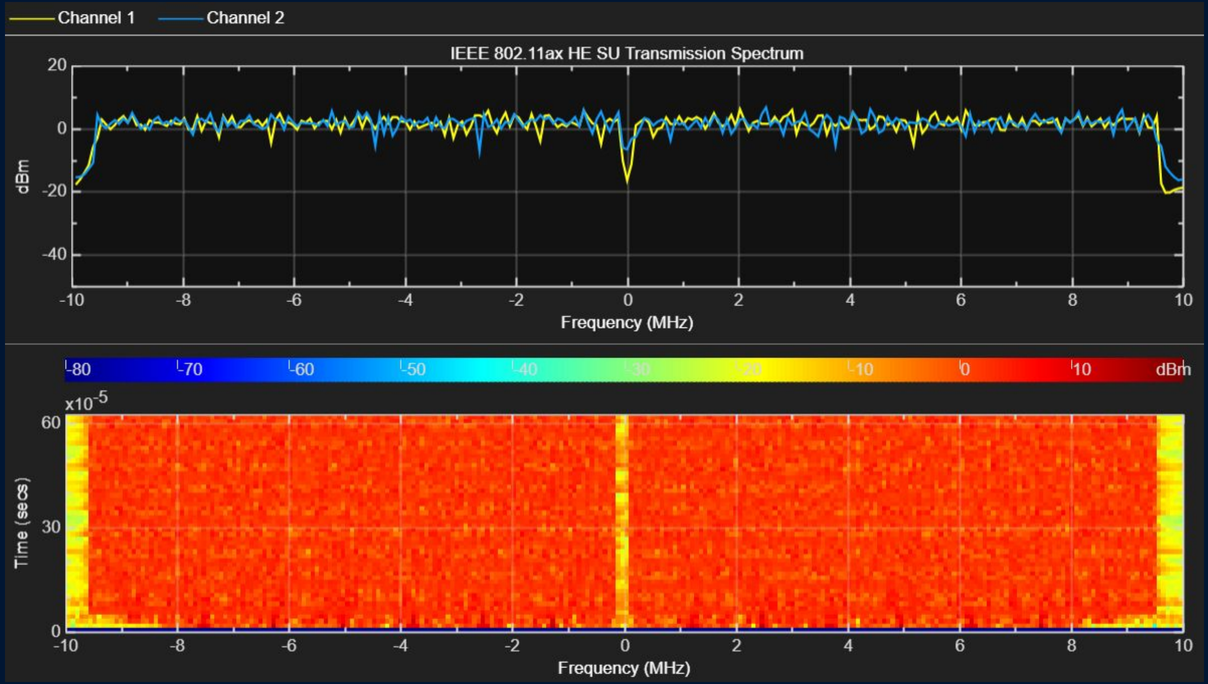
Configuration Highlights:

- **Channel Bandwidth:** 'CBW20' for a balanced speed and coverage.
- **Payload Length:** 1000 bytes, setting the data payload size.
- **MCS:** MCS 0, optimizing reliability and efficiency.
- **Channel Coding:** 'LDPC' for superior error correction.
- **Space-Time Streams:** 2 streams, higher data rates.
- **Transmit Antennas:** 2 antennas

Purpose: Demonstrates WiFi 6's HE SU capabilities in improving wireless communication, especially in environments with high network demand.

High Efficiency Single User (HE SU) Transmission

Streams - 2 , Antenna - 2



High Efficiency Extended Range Single User (HE ExSU)Transmission

The HE Extended Range Single User (HE ExSU) configuration marks a significant advancement in WiFi 6 technology, designed to overcome the traditional limitations of wireless connectivity. By extending the reach of WiFi networks, HE ExSU ensures that high-speed internet is not just confined to proximate spaces but is accessible across larger distances, penetrating through obstacles more effectively. This evolution caters to the growing demand for reliable, high-performance wireless networks in expansive environments such as large homes, offices, and outdoor areas.

High Efficiency Extended Single User (HE ExSU) Transmission

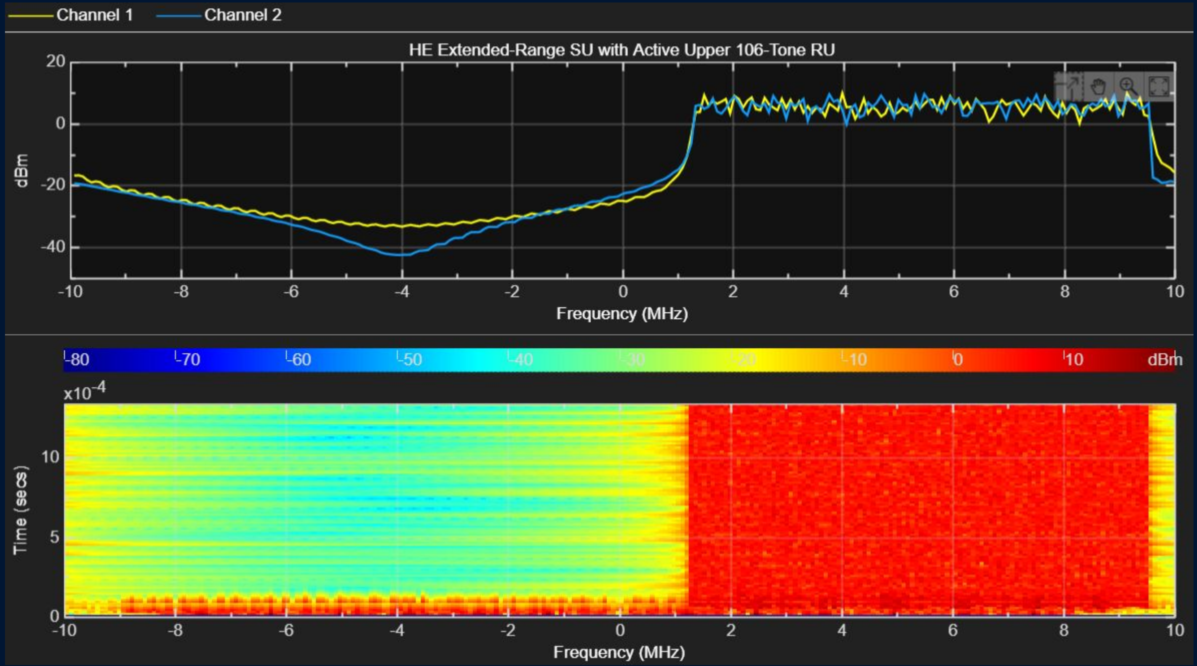
Configuration Highlights:

- **Channel Bandwidth:** 'CBW20' for optimal range and performance.
- **Payload Length:** 1000 bytes for substantial data handling.
- **MCS:** MCS 0 for reliable transmission over extended distances.
- **Channel Coding:** 'LDPC' coding for error correction across longer ranges.
- **Space-Time Streams:** 2 optimized for long-distance transmission
- **Transmit Antennas:** 2 focusing on range extension.
- **Extended Range:** Enabled, to push the boundaries of WiFi coverage.
- **Upper 106-Tone RU:** Utilizes only the upper 106-tone Resource Unit (RU) for clearer signal paths in extended-range scenarios.

Purpose: Highlighting the advancements in WiFi 6 that allow for extended coverage without sacrificing data transmission quality. This extended range capability ensures reliable connectivity even at the edge of a network's reach, making WiFi 6 an ideal solution for large homes, offices, and outdoor spaces.

High Efficiency Single User (HE ExSU) Transmission

Streams - 2 , Antenna - 2

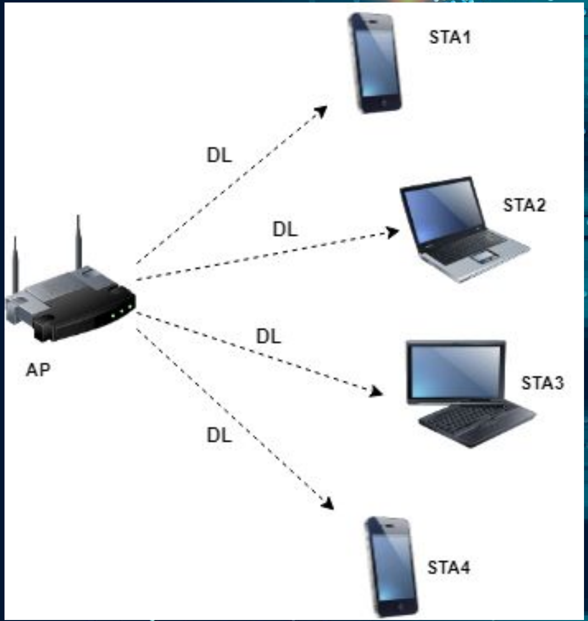


Simulation Setup

Channel Model: A TGax indoor MIMO channel simulates the communication link between the AP and users, incorporating an evolving indoor fading model and AWGN.

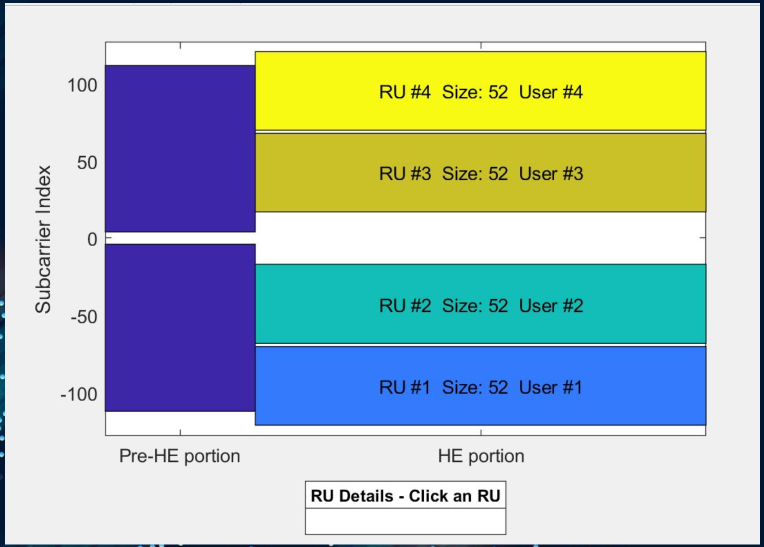
Beamforming Feedback: Before data transmission, a null packet is sent to the user to obtain channel state information for beamforming. Perfect feedback conditions are assumed.

Simulation Parameters: Includes AP transmit power, STA noise floor, path losses, and the number of packets transmitted.. For each path loss simulated, 10 packets are passed through the channel, each packet separated by 20ms.

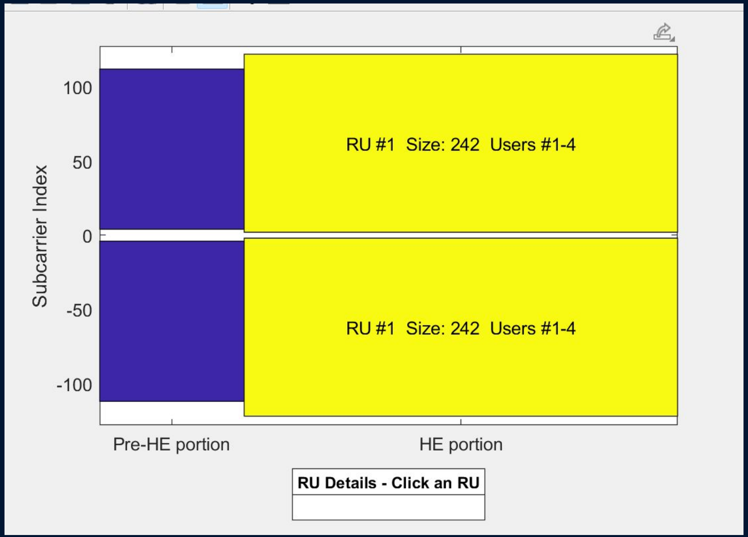


Transmission Configurations

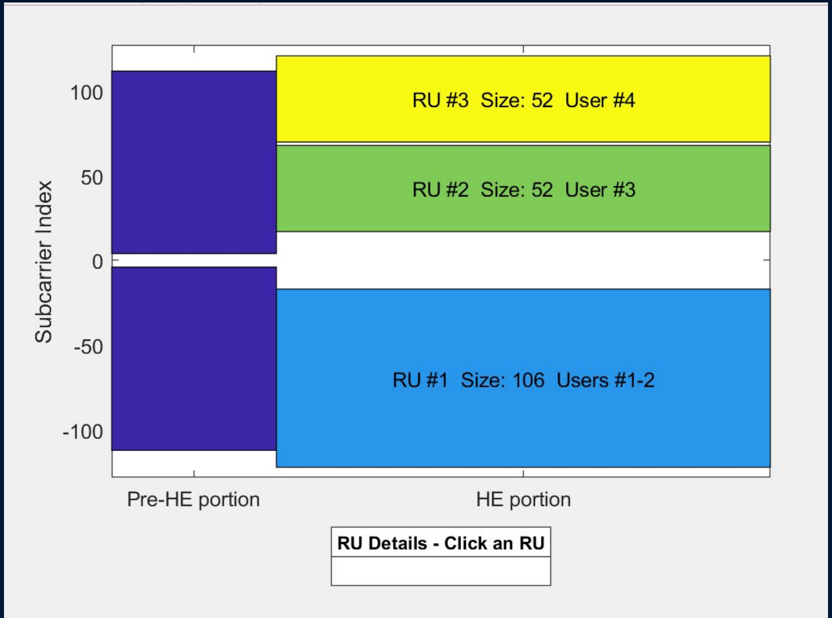
OFDMA Configuration: OFDMA allows multiple users to share the channel by dividing it into smaller frequency units.



MU-MIMO Configuration: MU-MIMO enables the AP to communicate with multiple users at the same time using the spatial domain.



Mixed Configuration: Mixed Mode combines OFDMA and MU-MIMO, leveraging both frequency and spatial multiplexing for efficiency.



OFDMA Configuration:

- The simulation starts with configuring the OFDMA transmission mode.
- Guard Interval - 0.8 ms, APEP length = 1000 Bytes.
- MCS = 4 (Channel coding scheme) and Model - D delay profile is used.
- A steering matrix, calculated using feedback from the STAs (based on Channel State Information or CSI), is applied to each RU. This matrix helps focus the transmitted signal towards the intended receivers, enhancing signal strength and reducing interference, a process known as beamforming.

OFDMA Simulation

The observed decrease in throughput with increasing path loss highlights the challenges of maintaining high network performance in environments with significant signal attenuation, underscoring the need for effective network planning and optimization strategies in deploying Wi-Fi 6 technologies.

Command Window

```
>> wifi
Simulating OFDMA...
 Pathloss 96.0 dB, AP throughput 66.1 Mbps
 Pathloss 99.0 dB, AP throughput 66.1 Mbps
 Pathloss 102.0 dB, AP throughput 49.6 Mbps
 Pathloss 105.0 dB, AP throughput 16.5 Mbps
```

MU-MIMO Configuration:

- The steering matrix is calculated and then applied to the RU to direct the transmission beams towards their respective users, enhancing signal clarity and reception quality. This step is crucial for exploiting the spatial multiplexing capability of MU-MIMO.
- The simulation proceeds to transmit a series of packets to the users, assessing the MU-MIMO configuration's effectiveness in a dynamic indoor environment modeled by the TGax channel with added white Gaussian noise.
- The simulation mirrors real-world processing steps, including packet detection, frequency offset correction, timing synchronization, channel estimation using HE-LTF, signal demodulation and equalization, noise estimation, and finally, decoding to retrieve the original PSDU. The aim is to determine if the transmitted data can be accurately recovered by each user.

MU-MIMO SIMULATION:

- The initial high throughput at lower path losses showcases MU-MIMO's strength in utilizing spatial streams to simultaneously serve multiple users without significant inter-user interference, thereby maximizing the use of available spatial and frequency resources.
- The decline in throughput as path loss increases is due to the exacerbated effects of signal fading and interference, which impair the receiver's ability to distinguish between intended and unintended signals. Beyond a certain point (105 dB in this scenario), the system cannot sustain reliable communication, resulting in zero throughput.

Command Window

```
Simulating MU-MIMO...
 Pathloss 96.0 dB, AP throughput 110.5 Mbps
 Pathloss 99.0 dB, AP throughput 110.5 Mbps
 Pathloss 102.0 dB, AP throughput 63.5 Mbps
 Pathloss 105.0 dB, AP throughput 0.0 Mbps
```

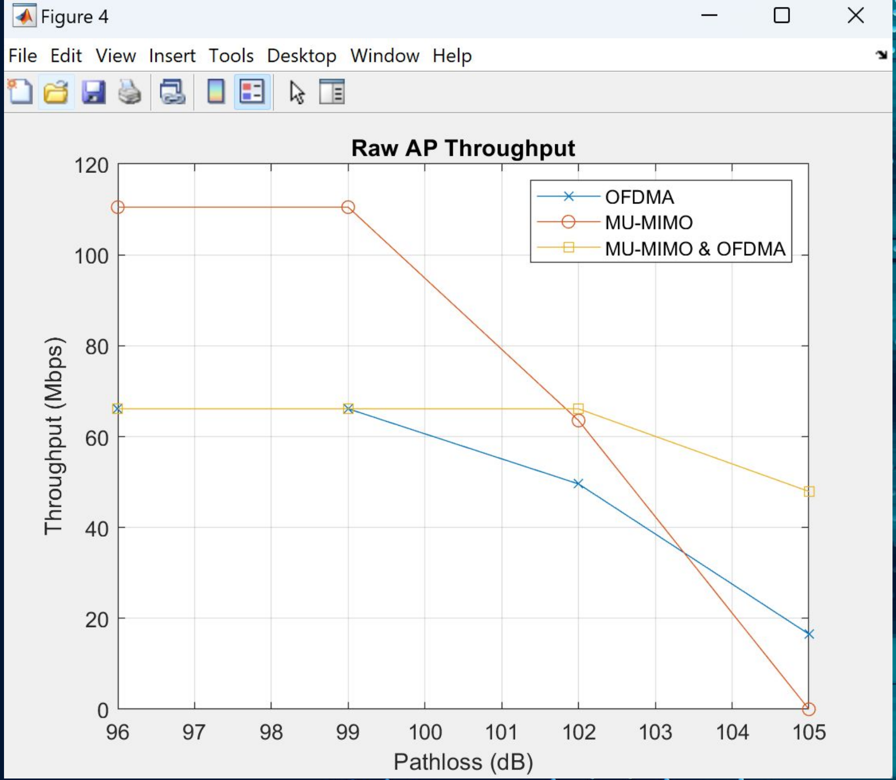
Simulation with Combined MU-MIMO and OFDMA

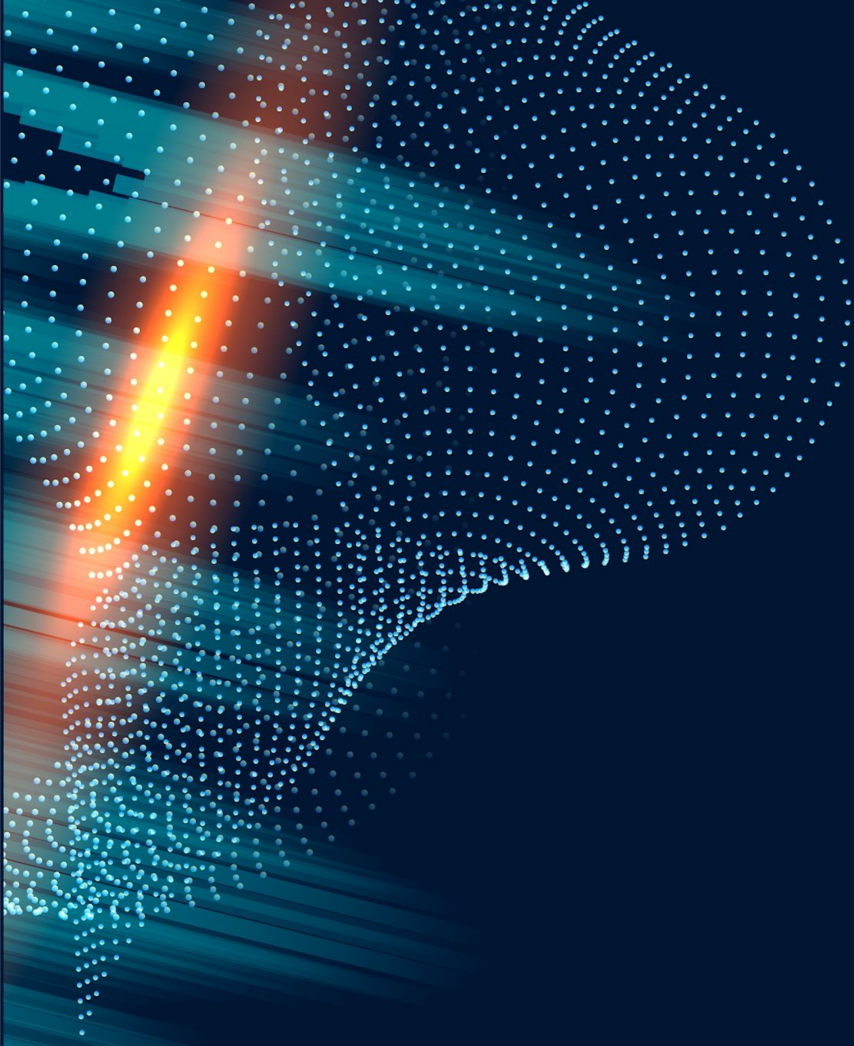
- At path losses of 96 dB, 99 dB, and 102 dB, the network maintains a stable throughput of 66.1 Mbps. This consistent performance across a range of relatively low to moderate path loss values illustrates the efficacy of combining MU-MIMO and OFDMA in maintaining high data rates even as conditions start to degrade.
- At a path loss of 105 dB, throughput decreases to 47.9 Mbps. This reduction reflects the increasing impact of signal attenuation on the network's ability to deliver data successfully to all users.
- This strategy allows the network to adaptively allocate resources based on user demand and channel conditions, optimizing overall performance.

```
Simulating Mixed MU-MIMO and OFDMA...
 Pathloss 96.0 dB, AP throughput 66.1 Mbps
 Pathloss 99.0 dB, AP throughput 66.1 Mbps
 Pathloss 102.0 dB, AP throughput 66.1 Mbps
 Pathloss 105.0 dB, AP throughput 47.9 Mbps
```

Throughput vs pathloss for three different transmission modes

- Low Pathloss (High SNR): MU-MIMO's spatial multiplexing is highly efficient, but as pathloss increases, this efficiency is compromised due to the noise and interference.
- High Pathloss (Low SNR): OFDMA and the combined method prove more effective, due to their ability to adapt to different channel conditions for each user, allowing them to maintain higher throughput.
- Adaptability and Efficiency: The combined approach combines the strengths of both MU-MIMO and OFDMA, suggesting that a dynamic approach to transmission mode selection could optimize network performance across varying conditions.





Thank you