FlexRadio: Fully Flexible Radios and Networks

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Introduction



Large number of *Multi-Antenna, Multi-RF Chain* Devices.



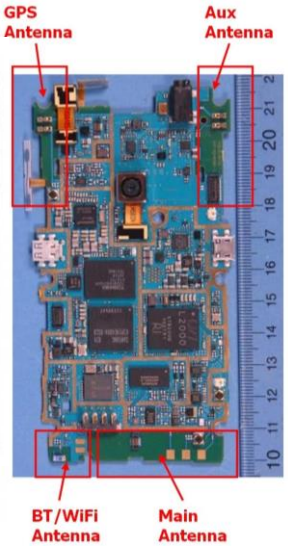
Introduction



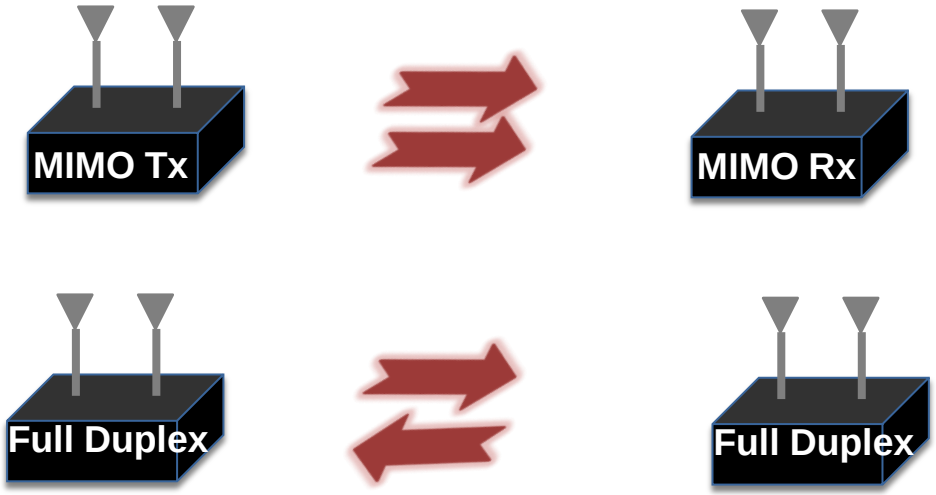


Operate either as *MIMO or Full-Duplex*.





MIMO vs Full-Duplex



Compare the transmission between a pair of radios.

Same number of parallel independent streams

RF Chain

Antenna resource is important, but it's not the only parameter that determines the number of parallel, independent wireless streams



iPhone uses two antennas with one RF chain for the transmission

MIMO vs Full-Duplex



No matter how the radio is built, the number of active RF chains at a node determines the number of independent streams it can support

FlexRadio

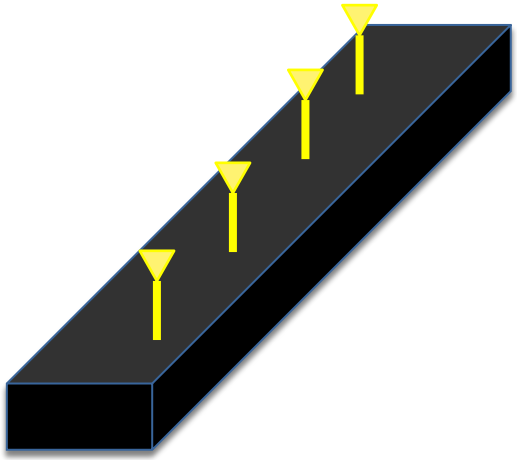
Transmission between nodes needs to be done in a more cooperative manner.

To support cooperation, radio configuration needs to be flexible.

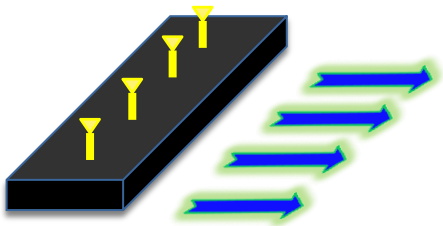
Here comes FlexRadio.

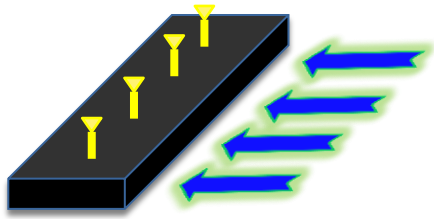
What is FlexRadio?

Consider a 4-antenna, 4 RF-chain node.



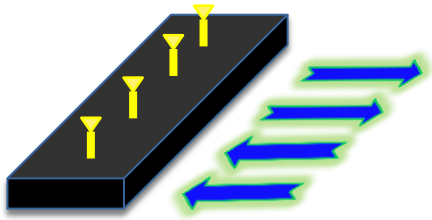
Supported *Configurations*





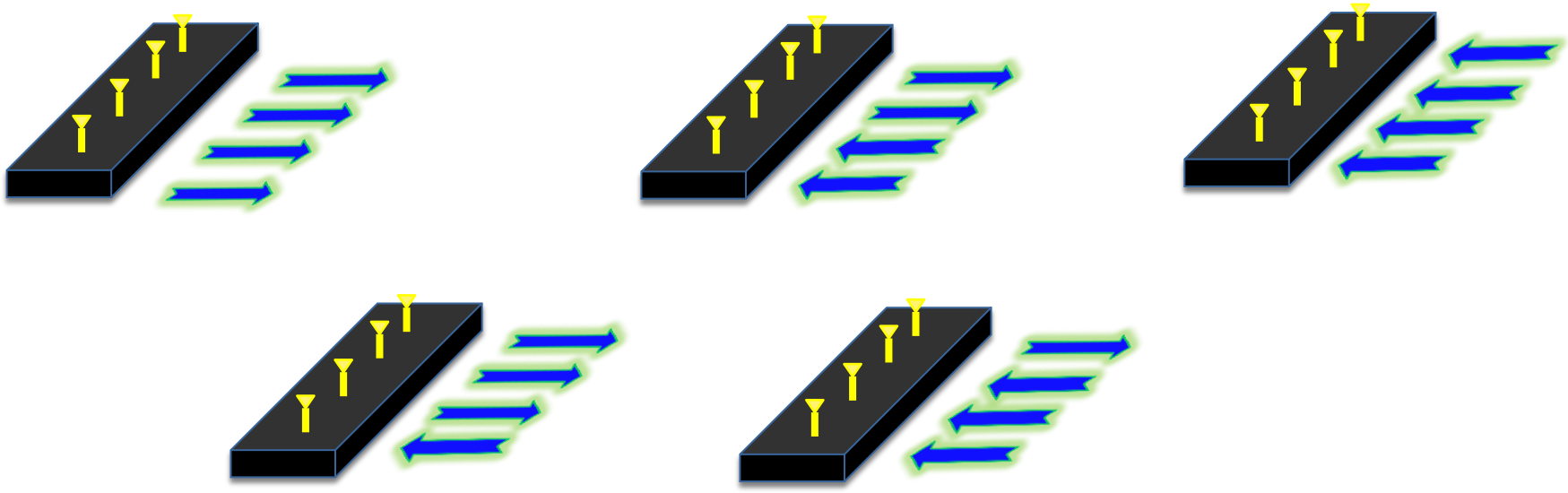
Operating as a MIMO node.

Supported *Configurations*



Operating as a Full-Duplex node.

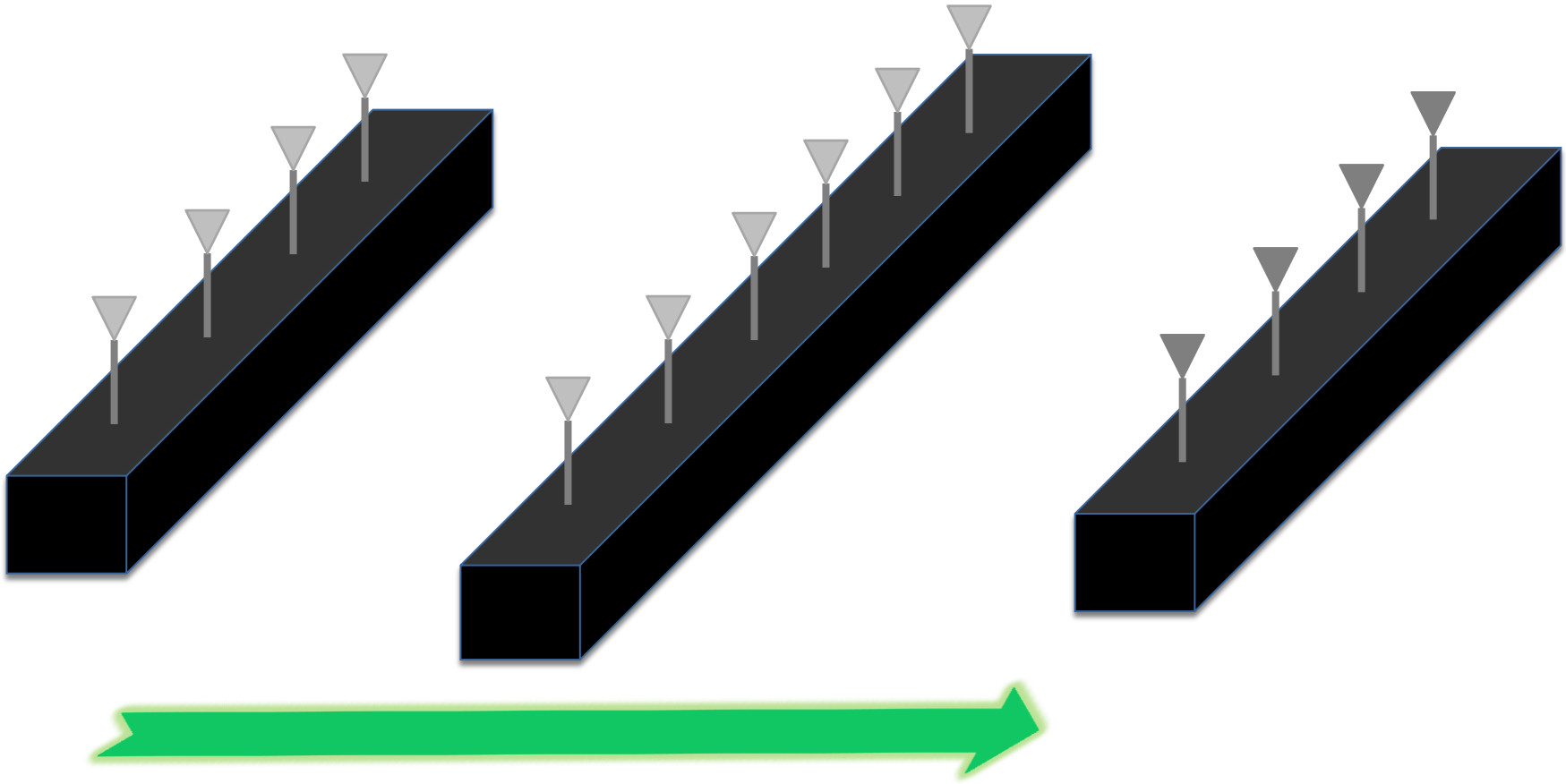
What is FlexRadio?



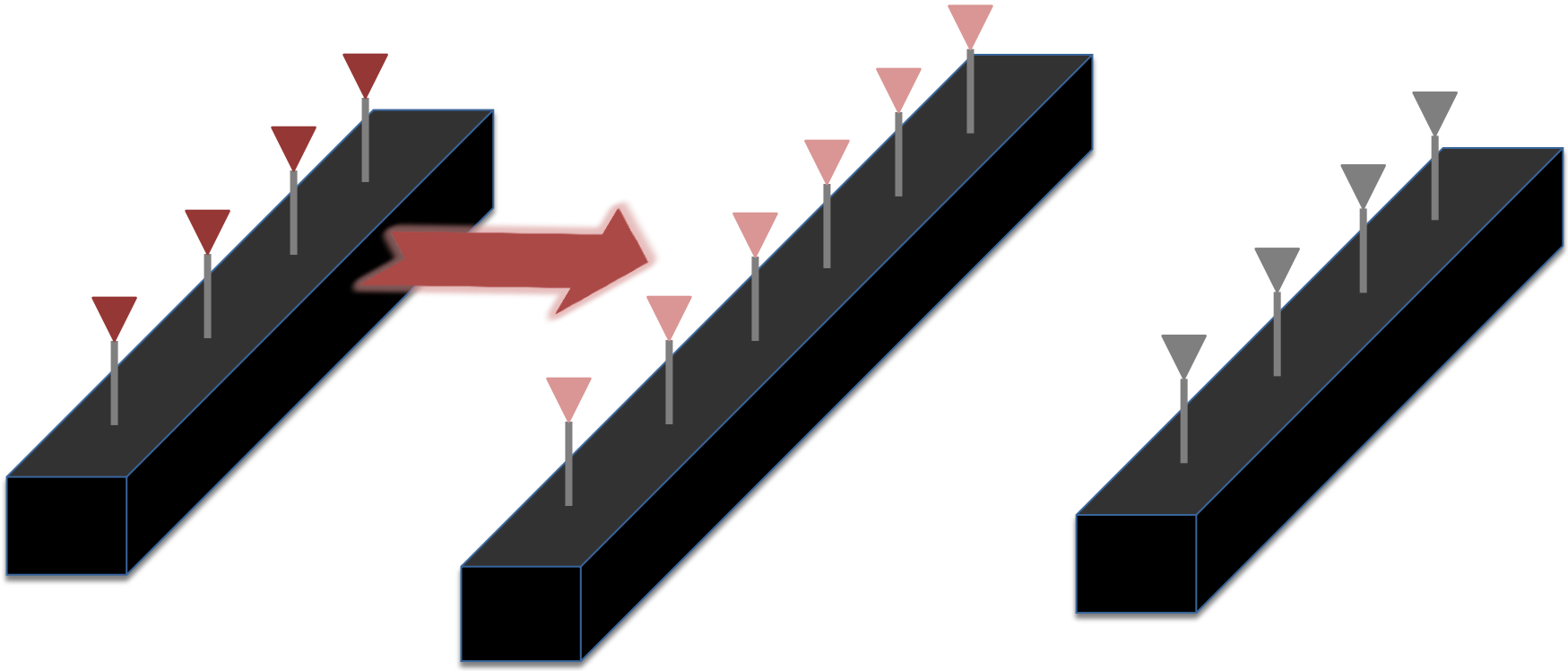
FlexRadio provides the ***flexibility*** to enable the node to maximize its configuration options.

Why FlexRadio?

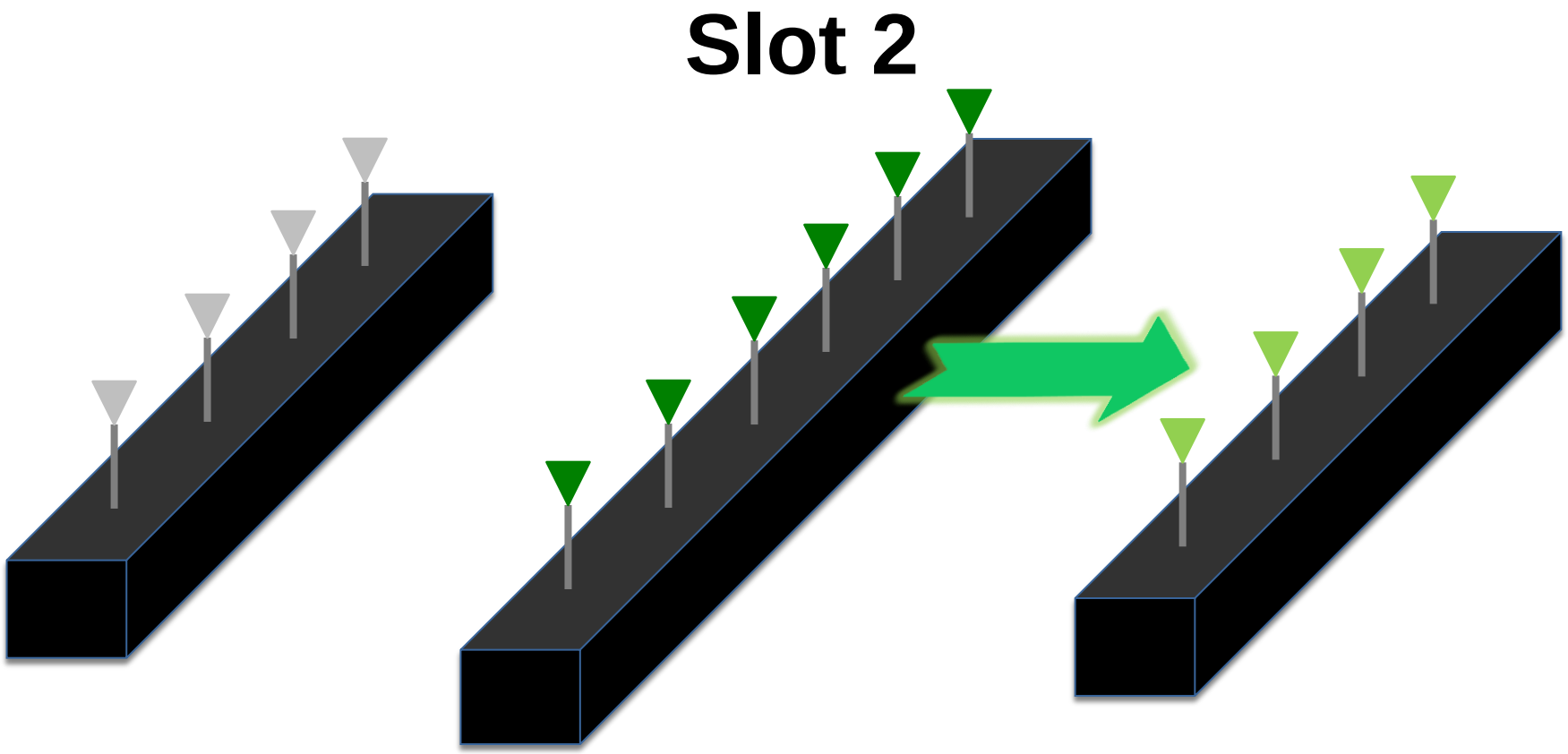
Case 1: Desired Direction



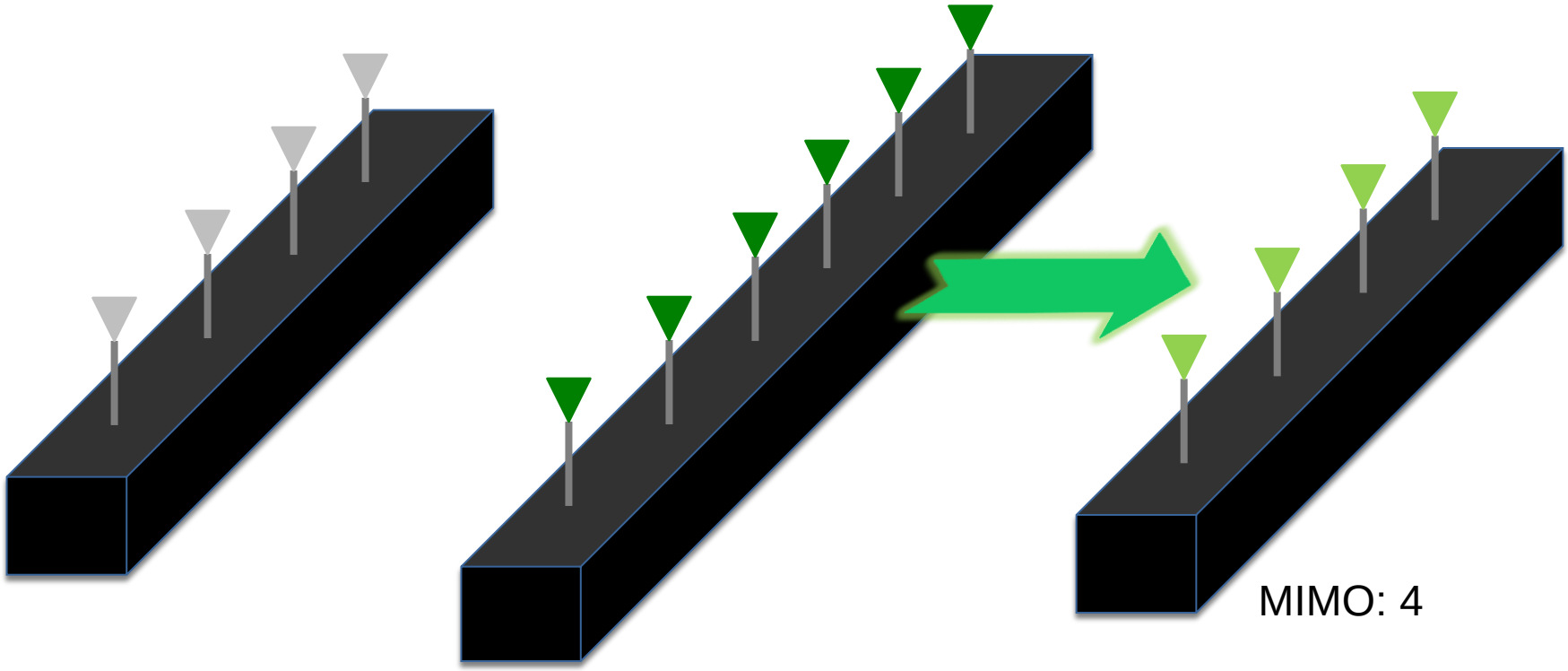
Case 1: MIMO



Case 1: MIMO

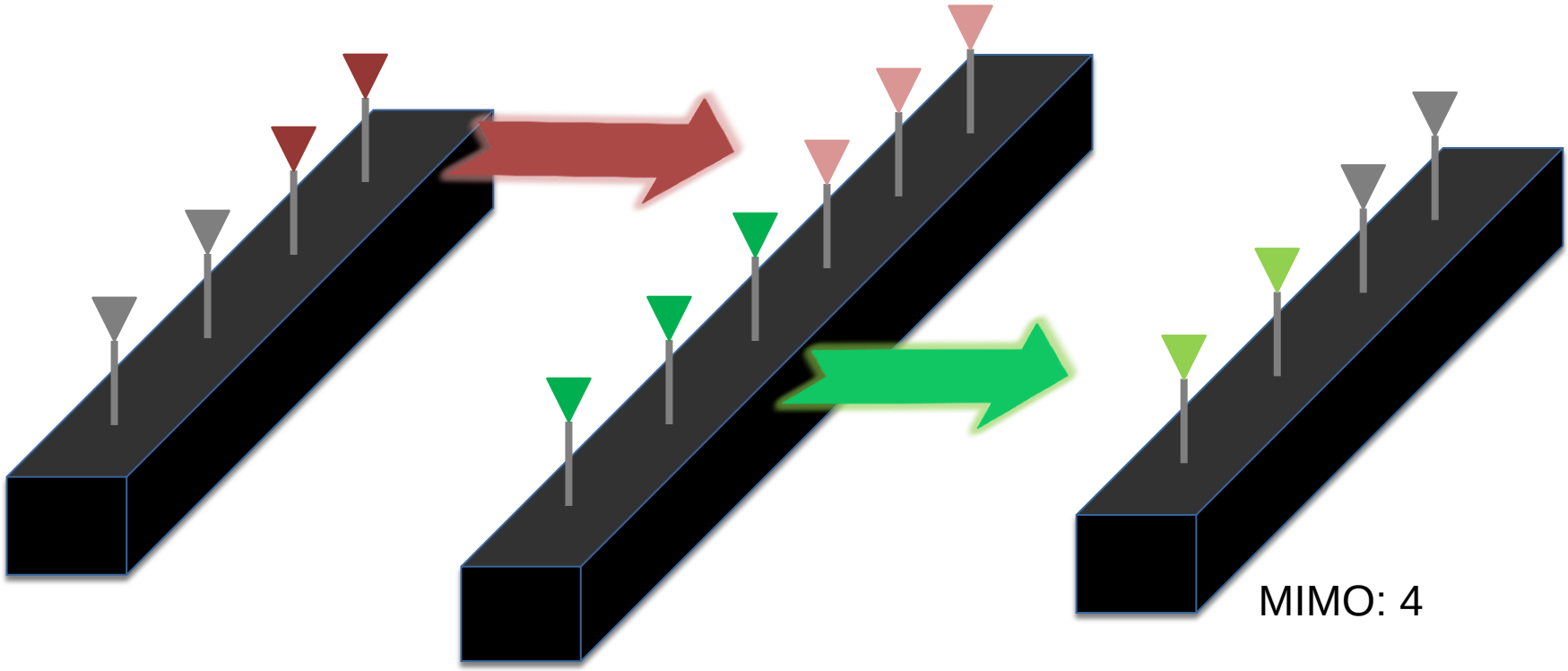


Case 1: MIMO

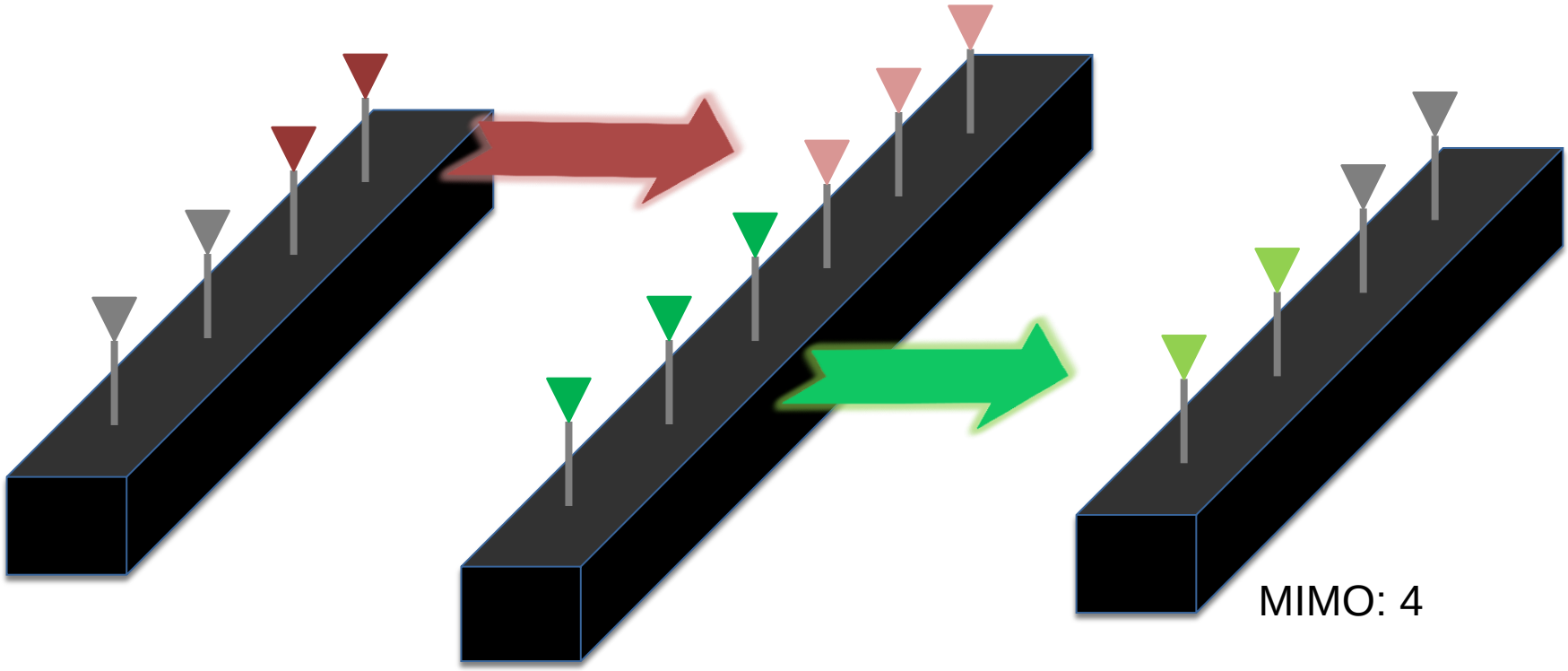


MIMO supports 4 streams

Case 1: Full Duplex

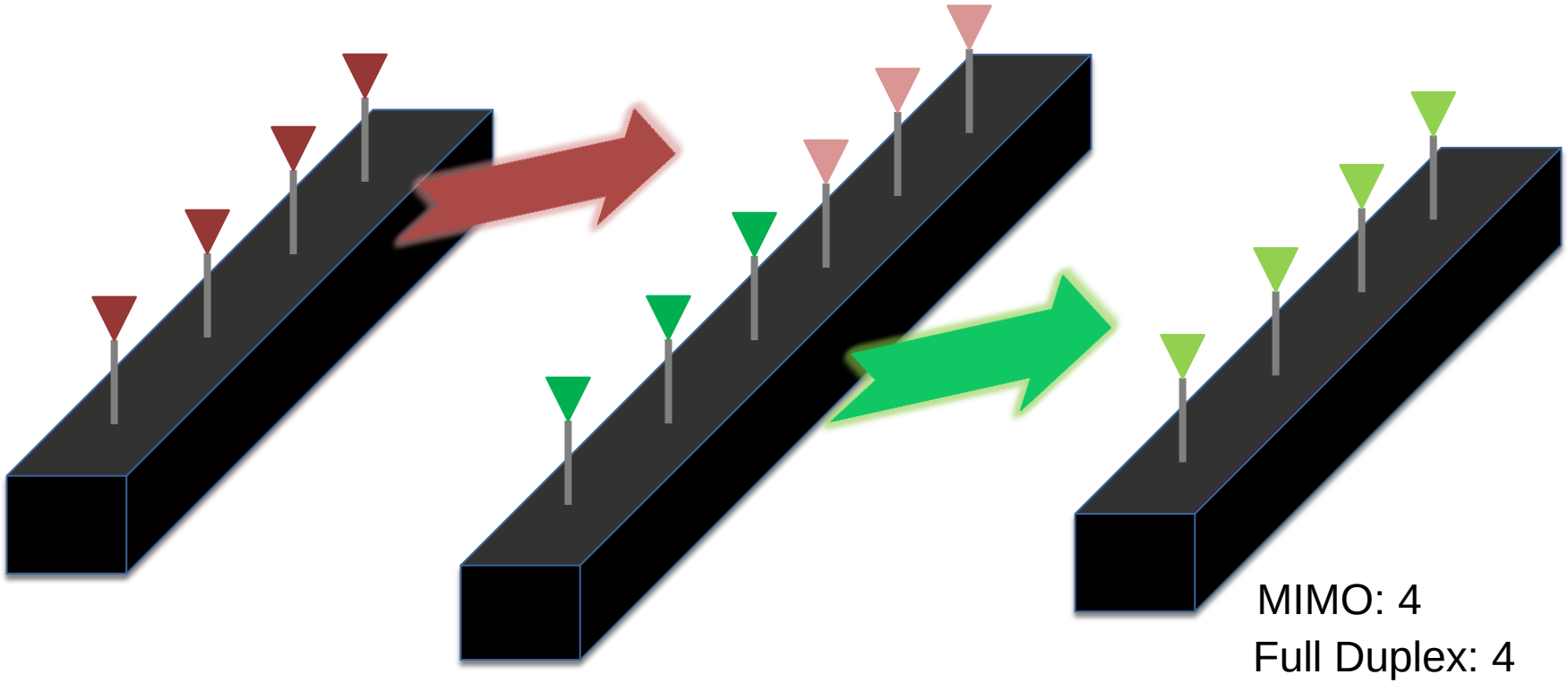


Case 1: Full Duplex



Full Duplex also achieves 2 x 2 = 4

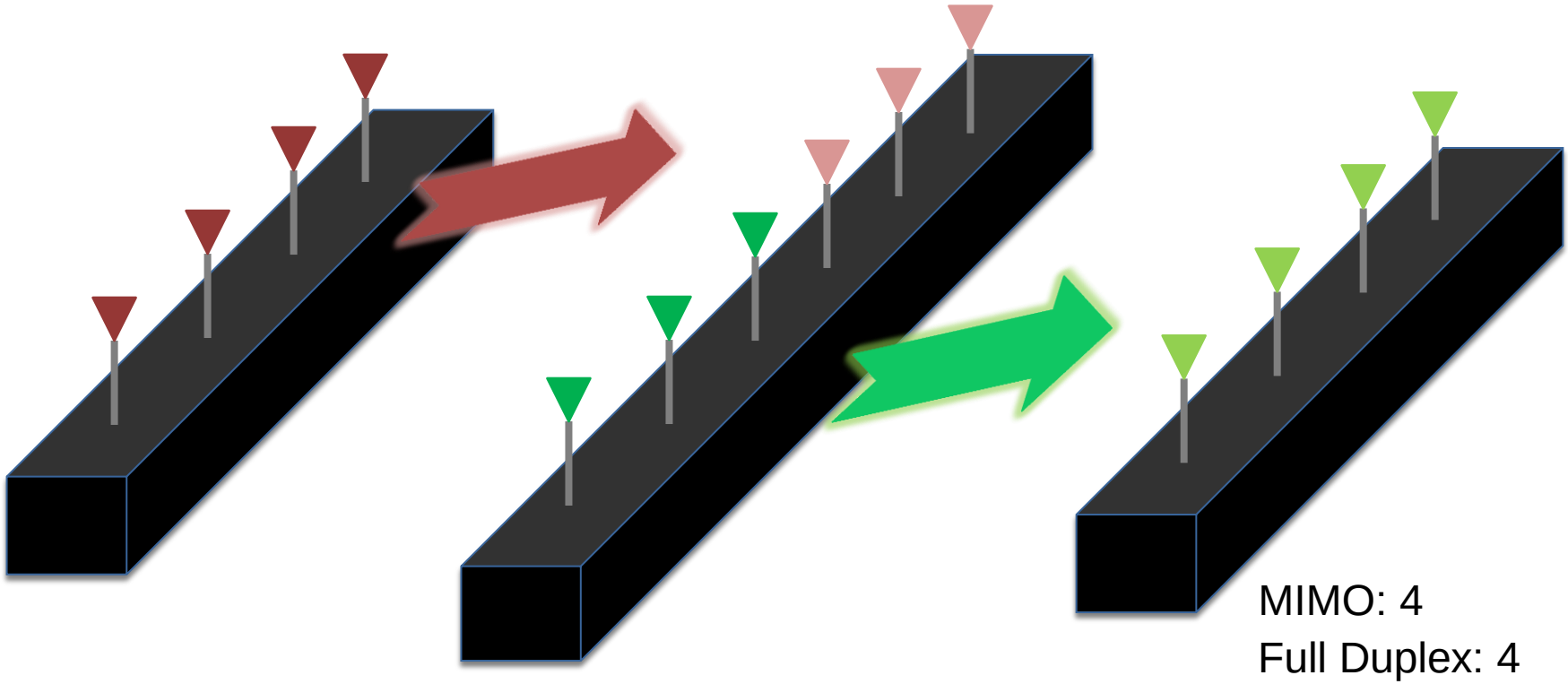
Case 1: FlexRadio



MIMO: 4

Full Duplex: 4

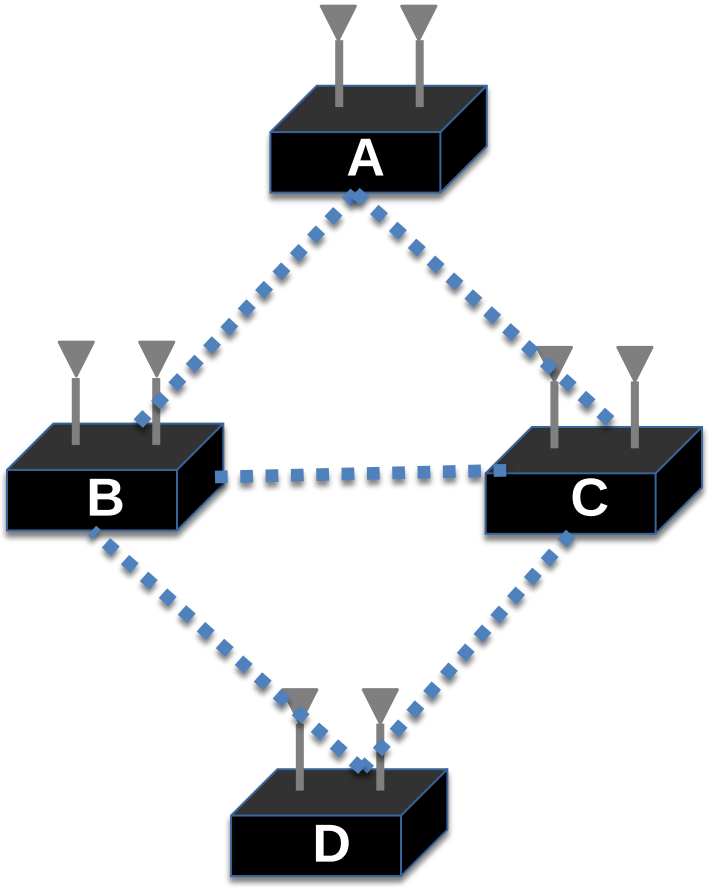
Case 1: FlexRadio



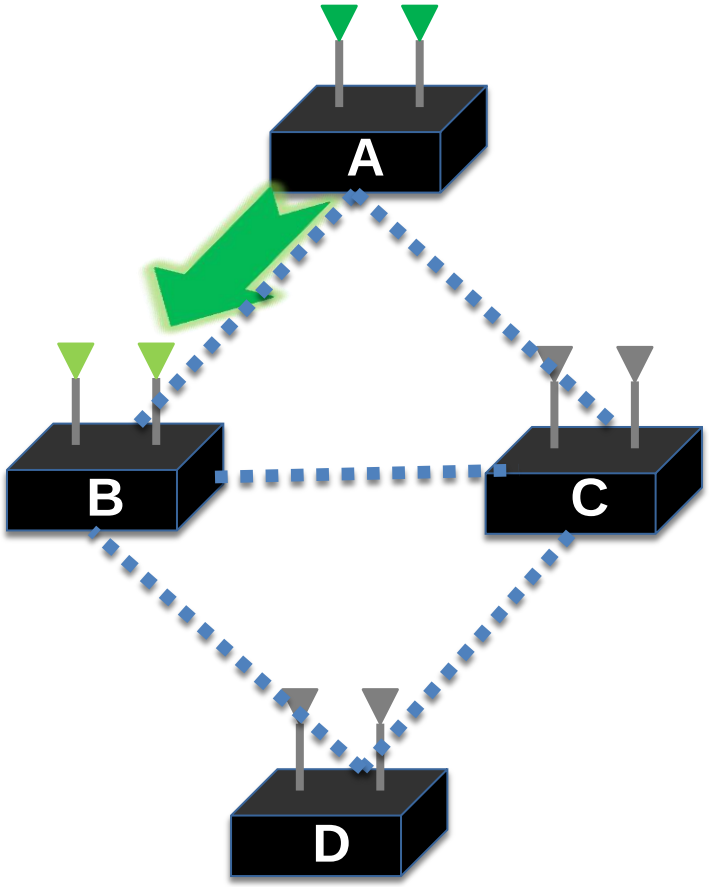
MIMO: 4
Full Duplex: 4
FlexRadio: 6

FlexRadio achieves 3x2 = 6 streams

Case 1: Topology Limit

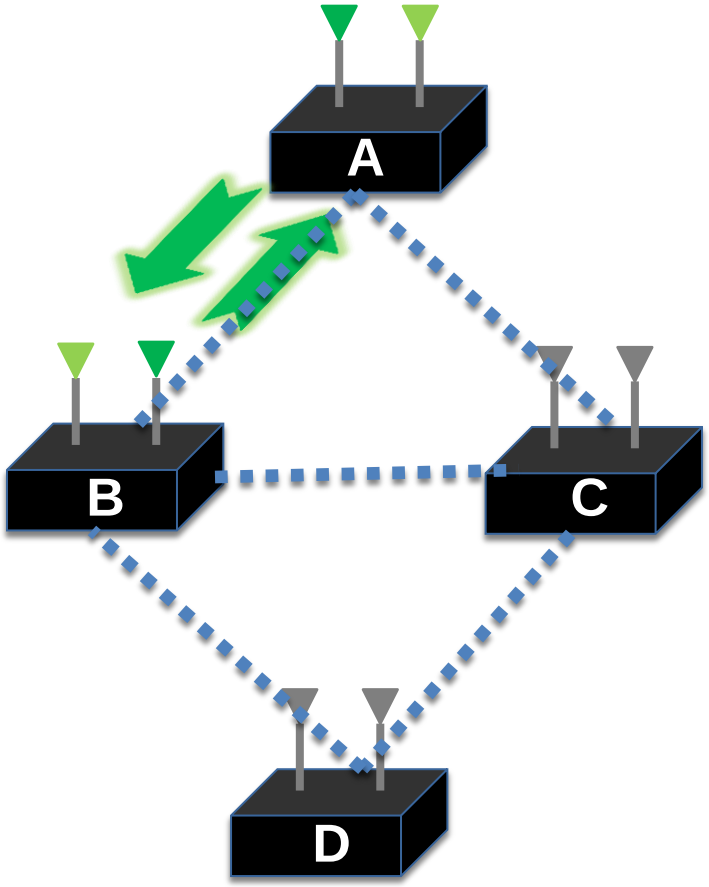


Case 2: MIMO



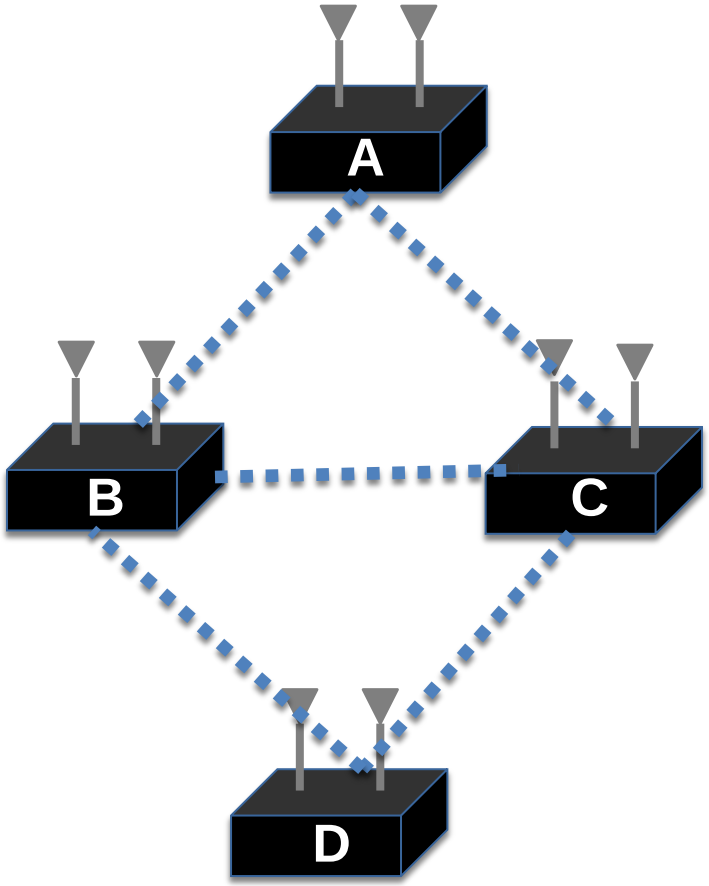
MIMO transmits 2 streams

Case 2: Full Duplex



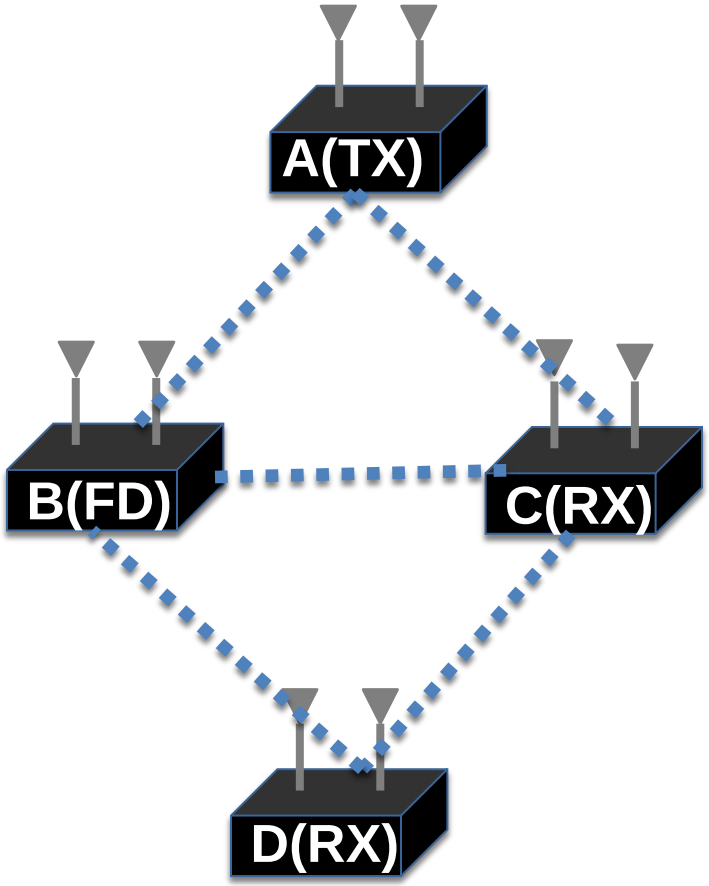
Full Duplex also transmits 2 streams

Case 2: FlexRadio



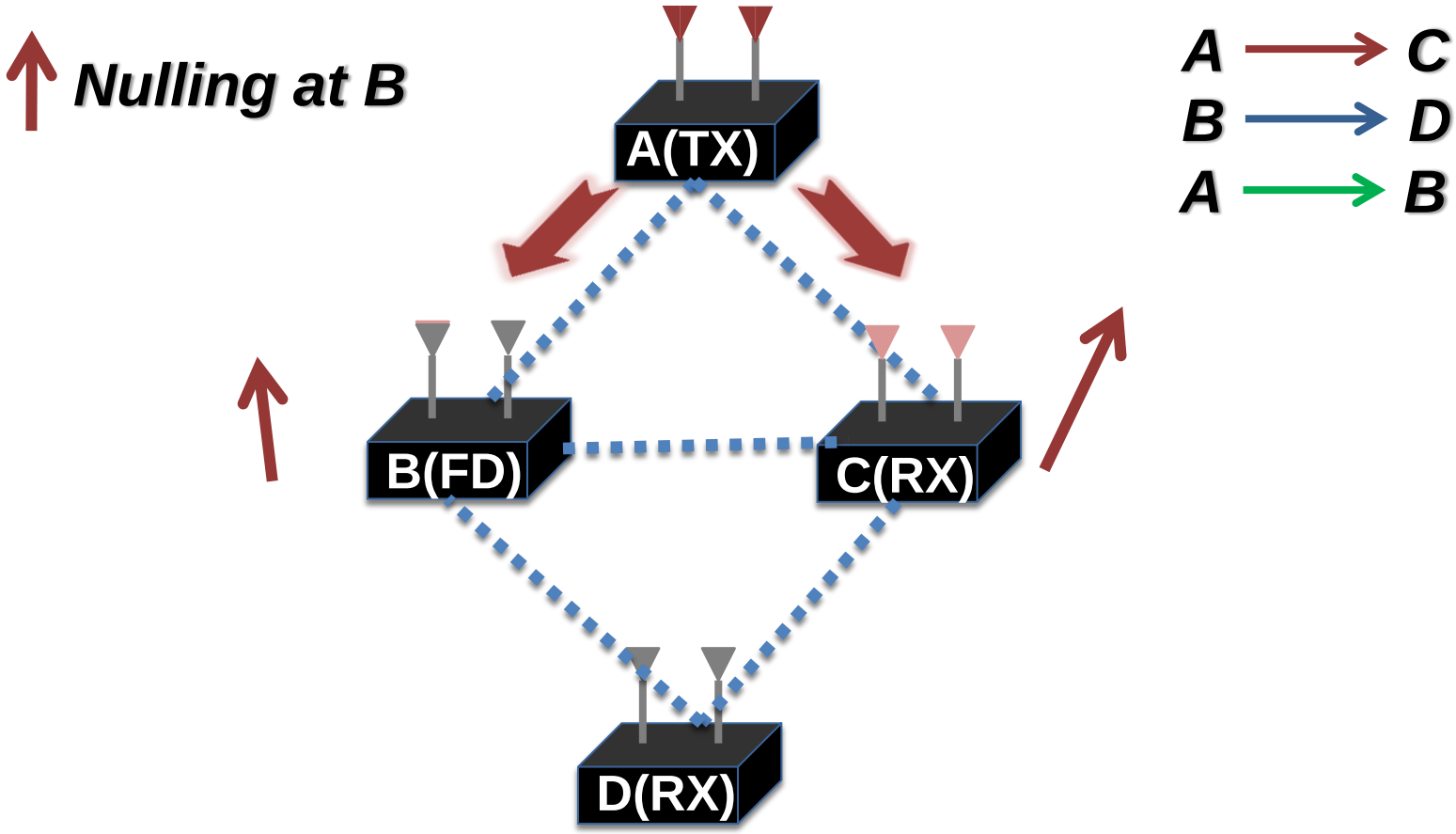
A → C
B → D
A → B

Case 2: FlexRadio

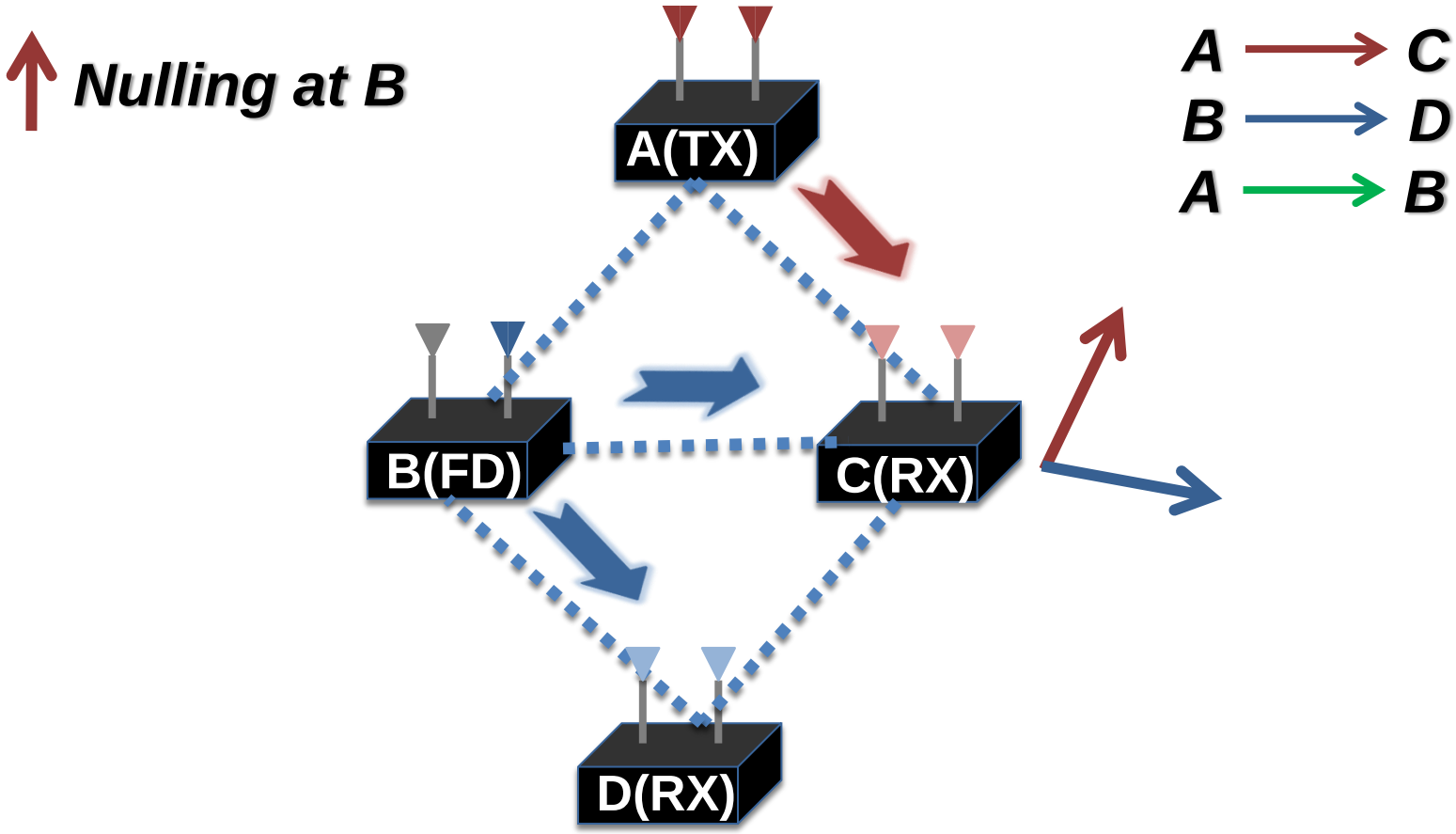


A → C
B → D
A → B

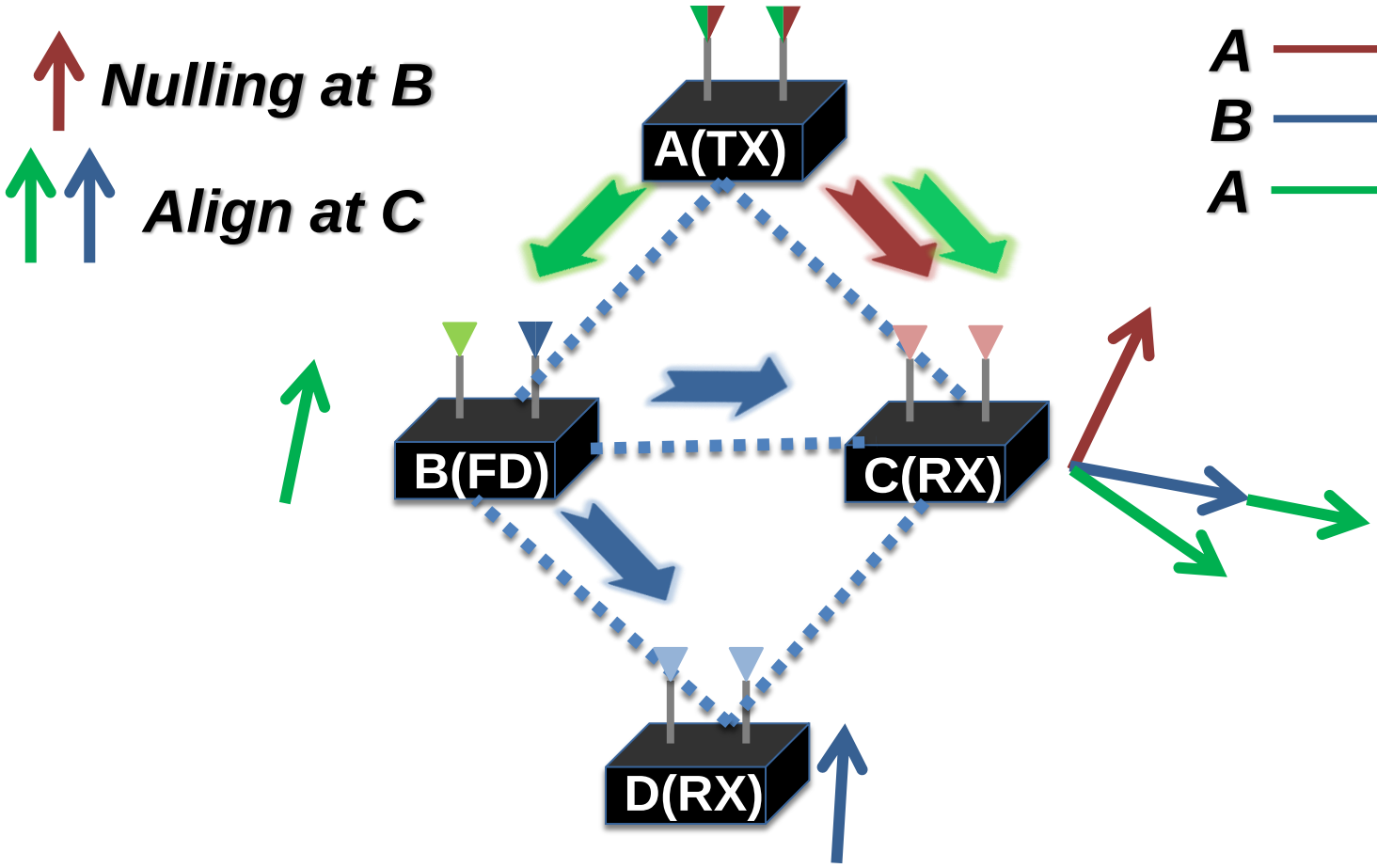
Case 2: FlexRadio



Case 2: FlexRadio



Case 2: FlexRadio

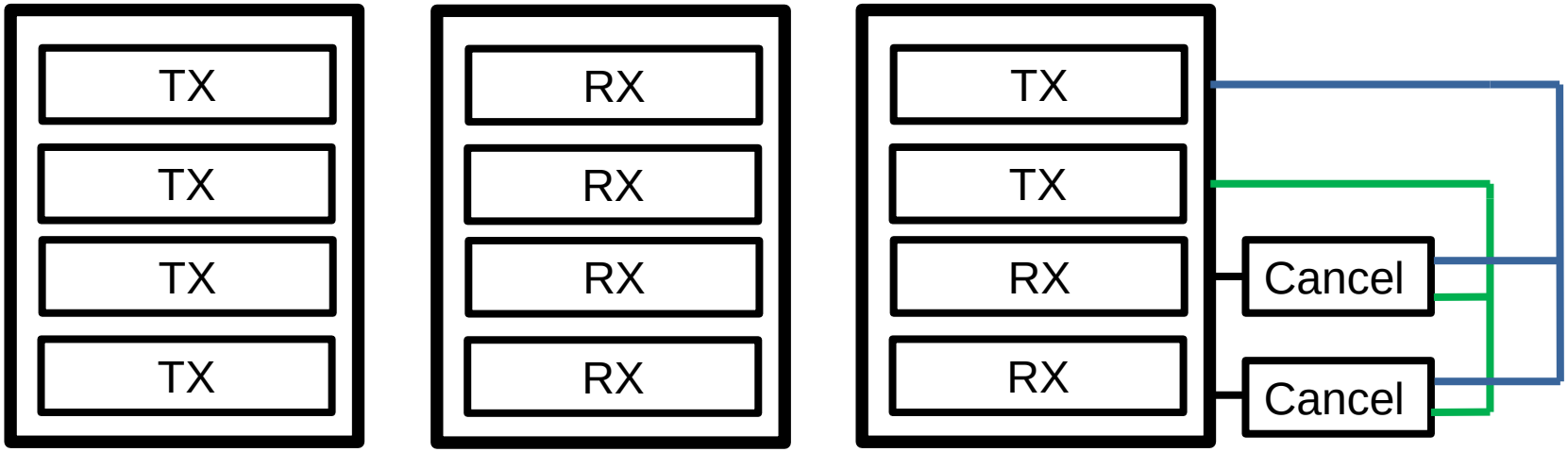


FlexRadio transmits 3 streams

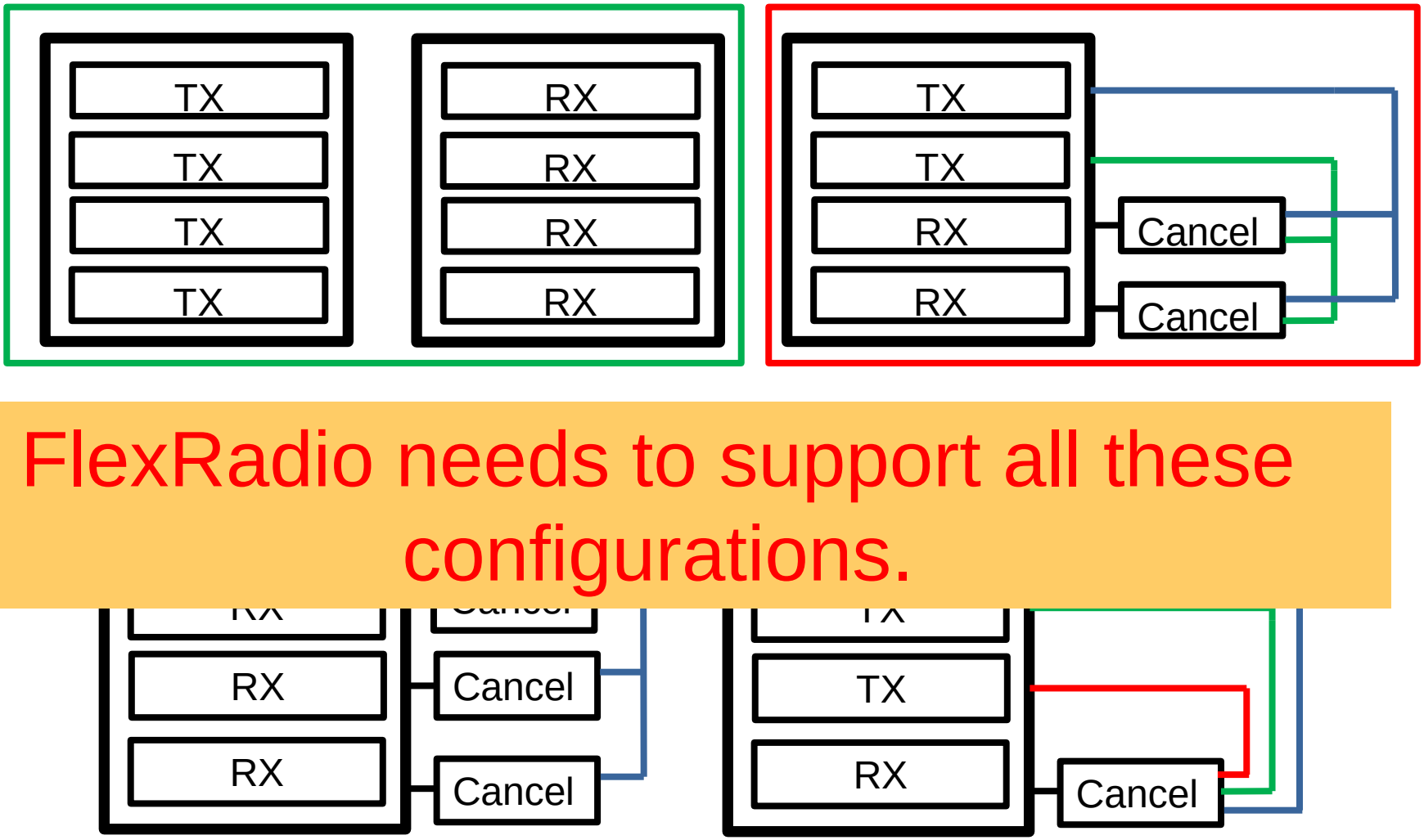


Building FlexRadio

Complexity

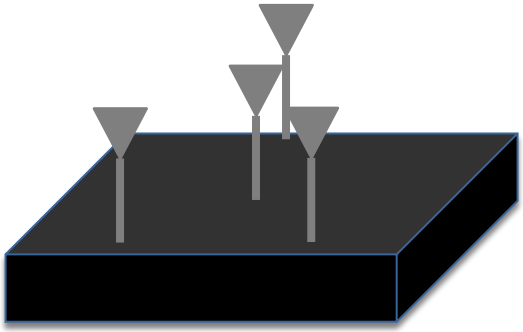


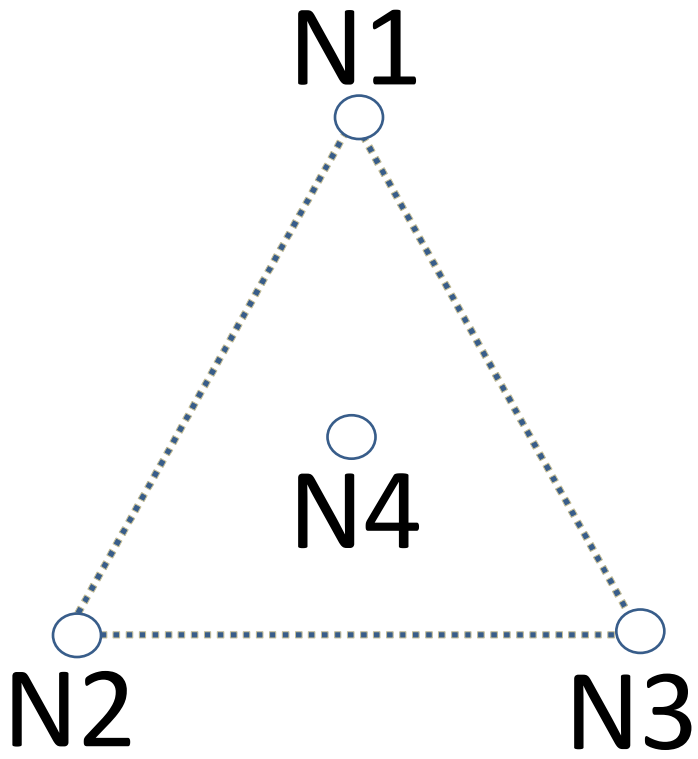
Complexity



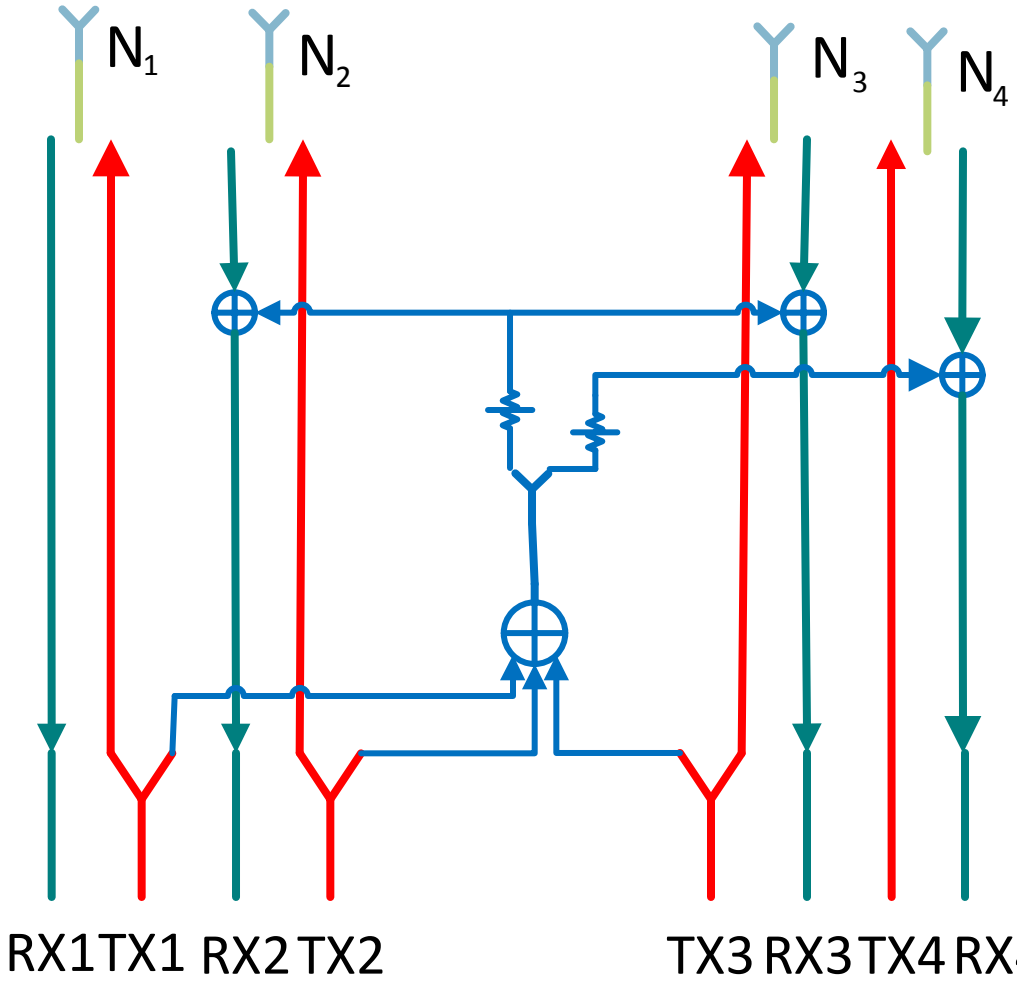
FlexRadio needs to support all these configurations.

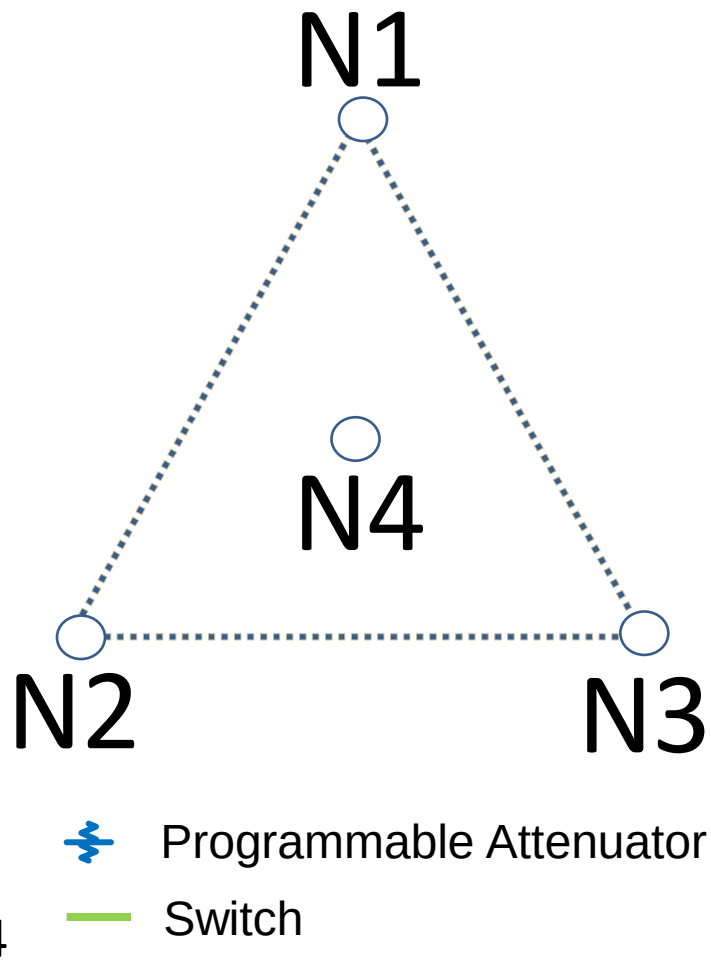
Antenna Placement



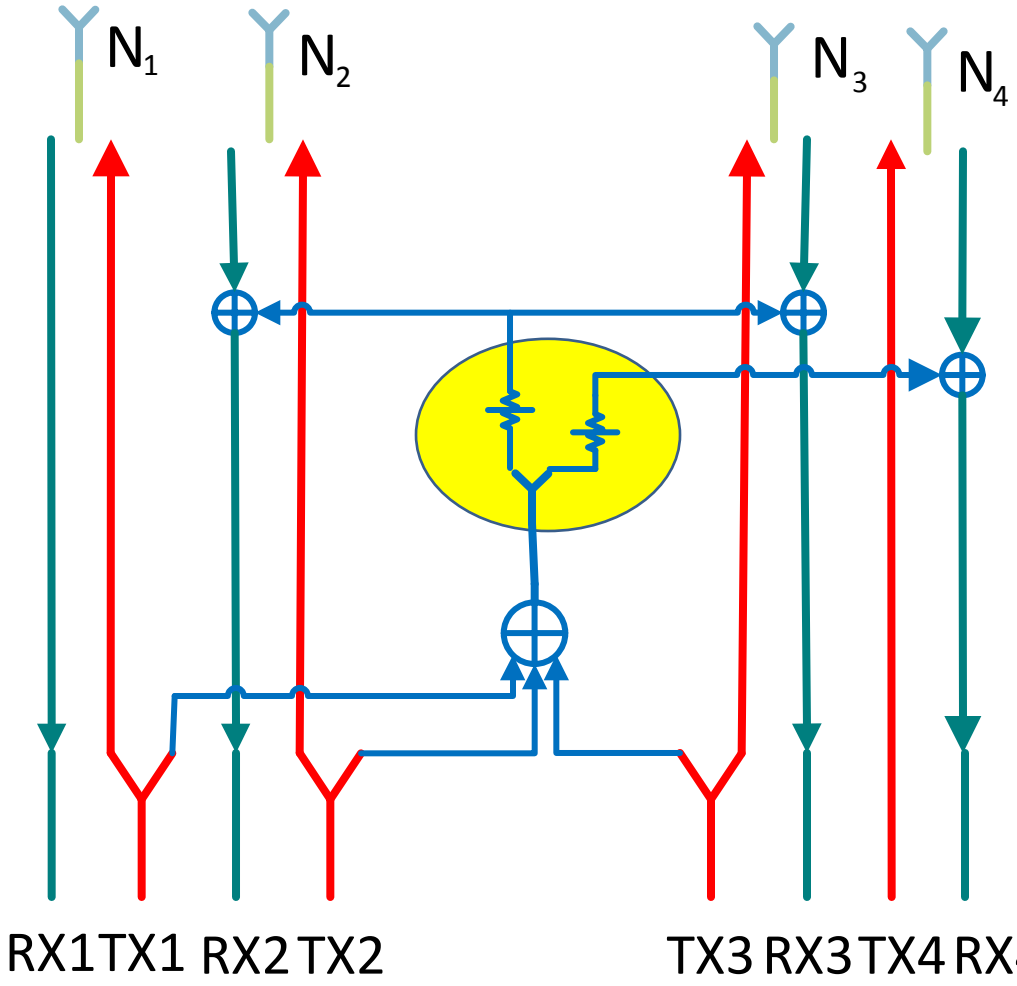


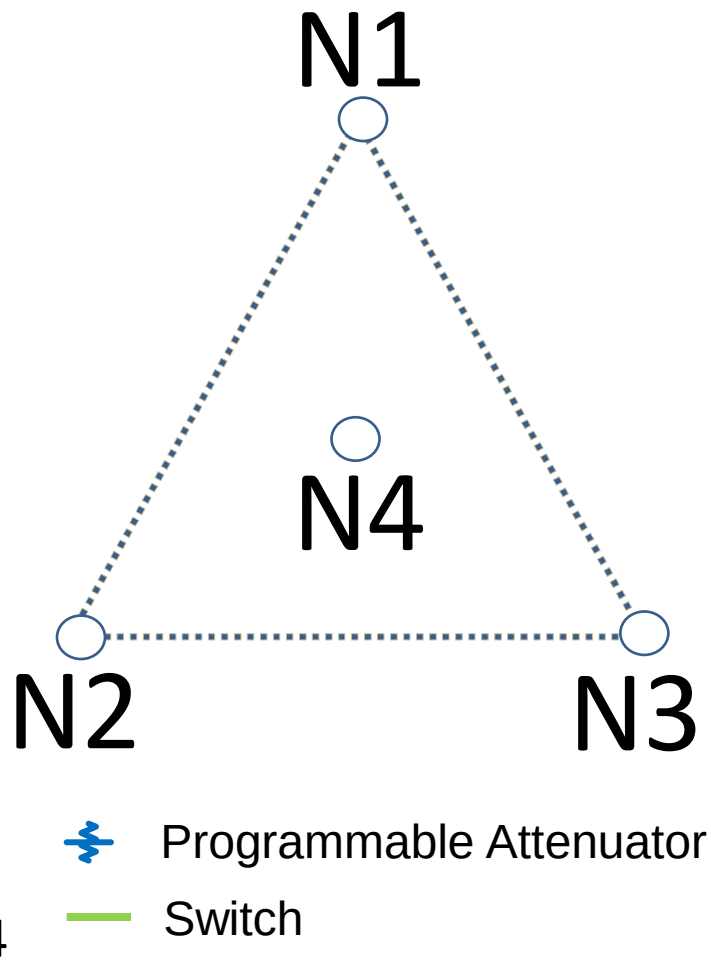
Implementing Flexibility





Implementing Flexibility

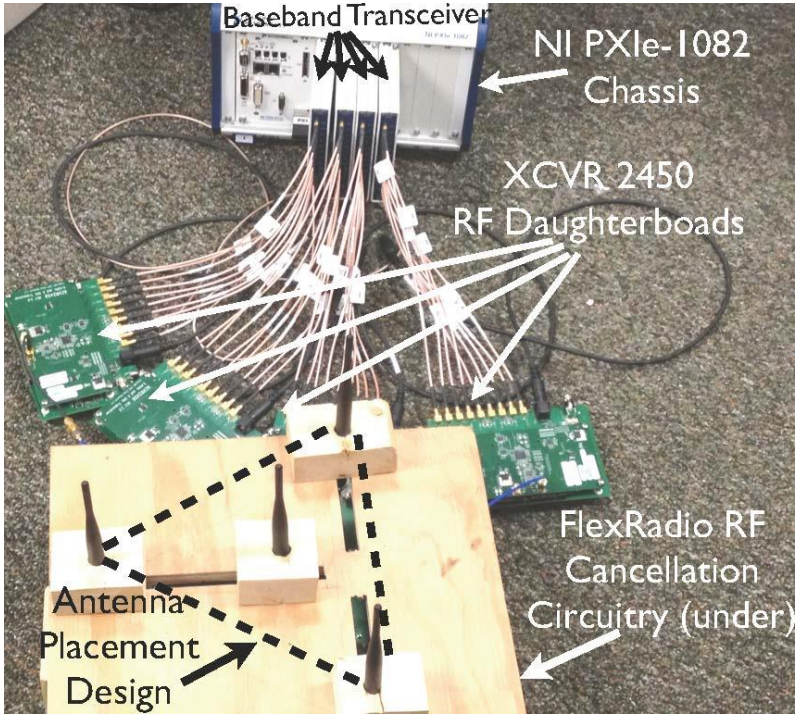


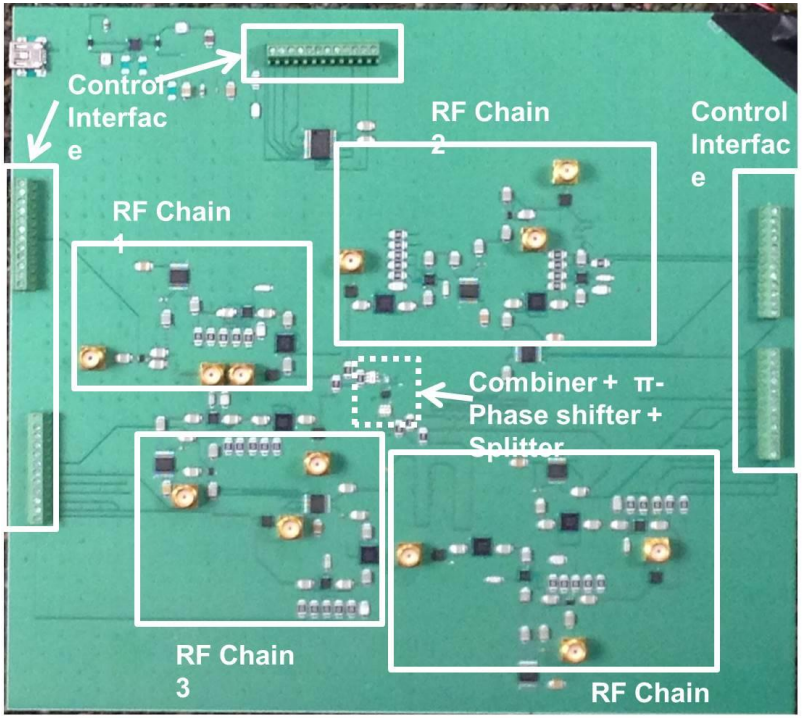


Naive Solution: 4*3 = 12 Programmable Attenuators

Our Solution: Only 2!

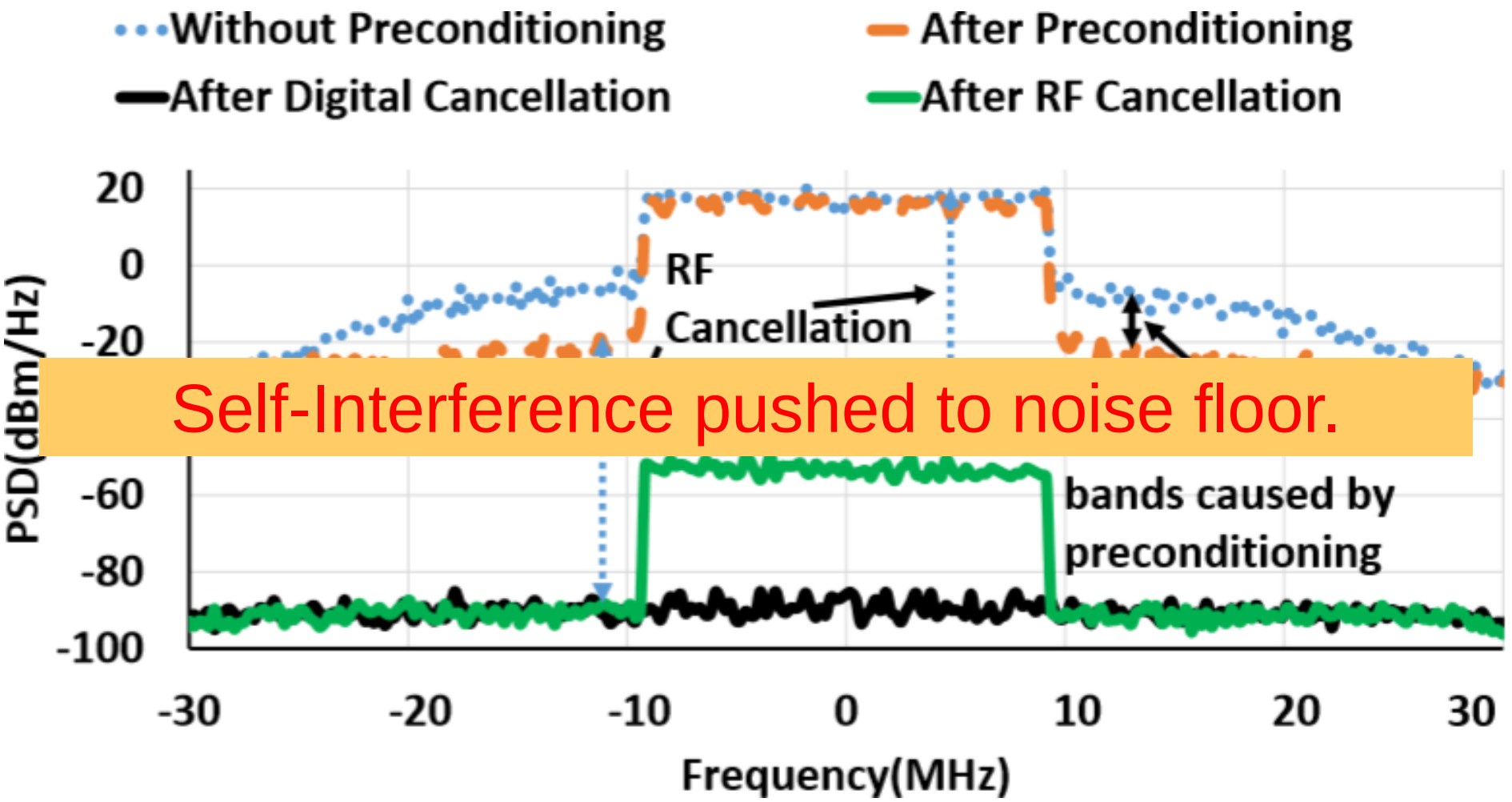
Implementation



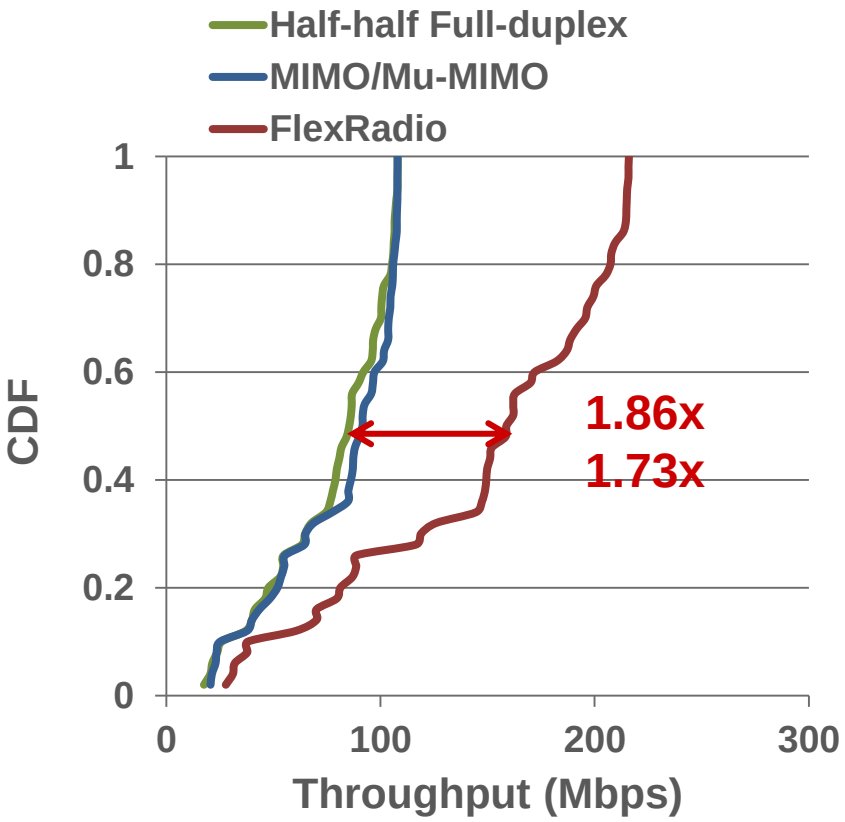


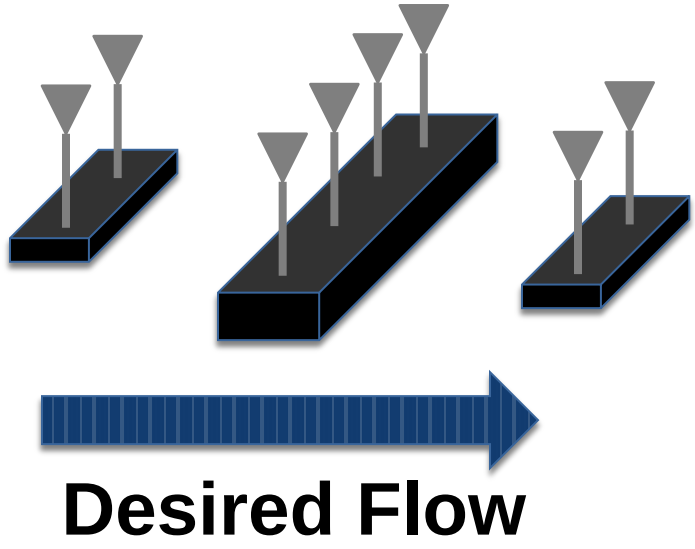
Evaluation

Cancellation Performance: 3TX/1RX

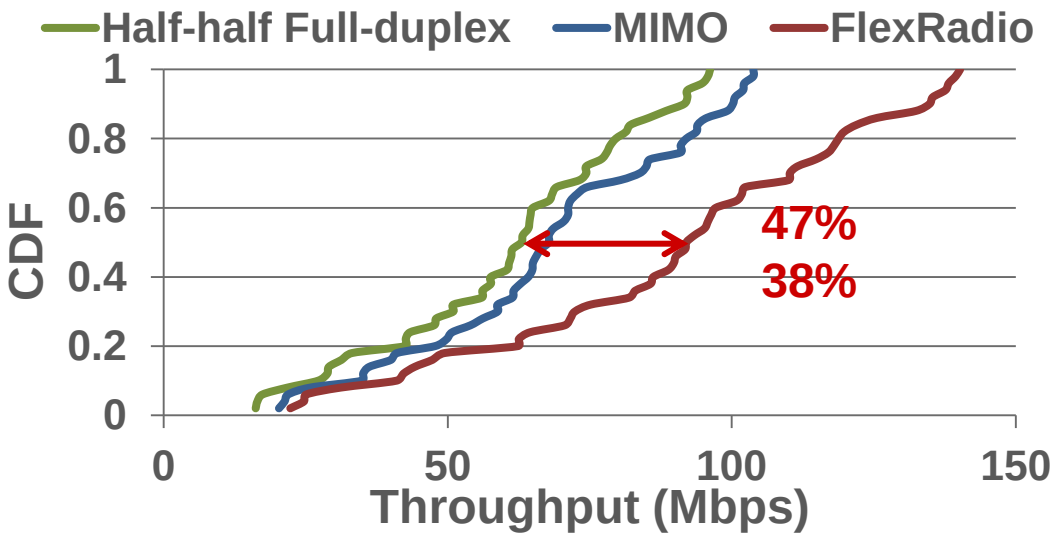


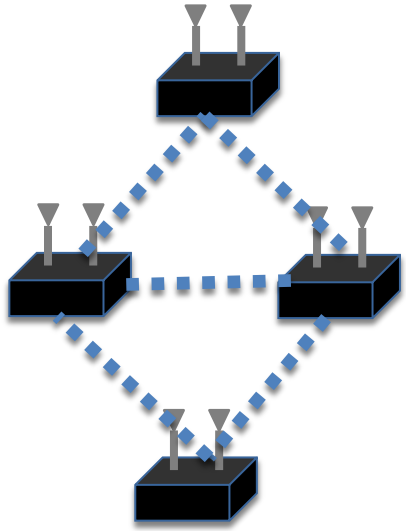
Throughput: Flow





Throughput: Topology





Conclusion

FlexRadio introduces flexible PHY layer design paradigm to maximize network performance.

Questions?