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Effect of Radio Unit Synchronization on MIMO Throughput

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INTRODUCTION TO MIMO

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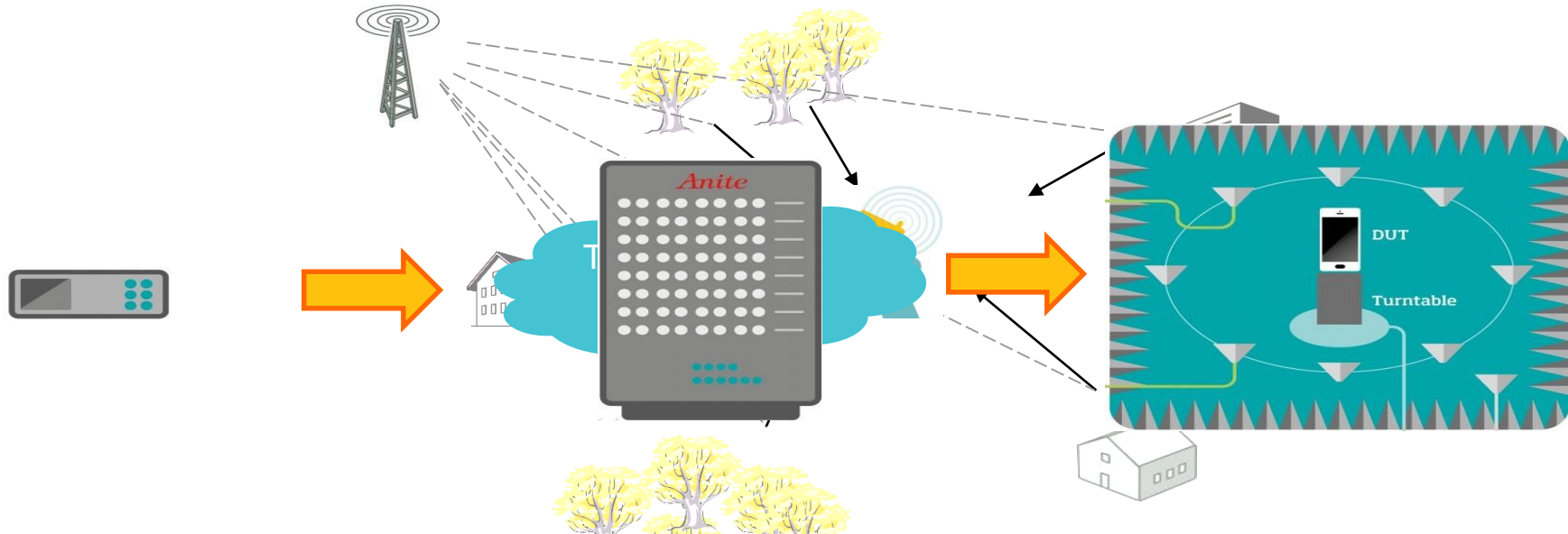
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WHAT IS MIMO?

- **Multiple Input, Multiple Output**

  - Uses 2 or more (up to 8 in LTE-A) antennas on both eNodeB and UE

  - Increases spatial diversity (leading to greater robustness)

  - Increases data throughput

eNodeB

Handset (UE)

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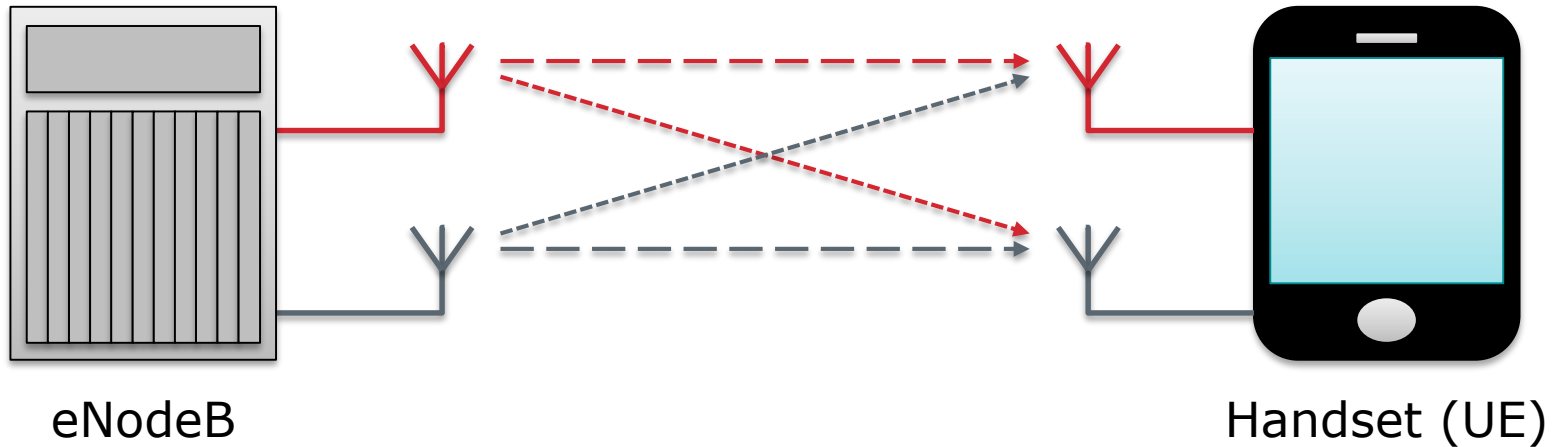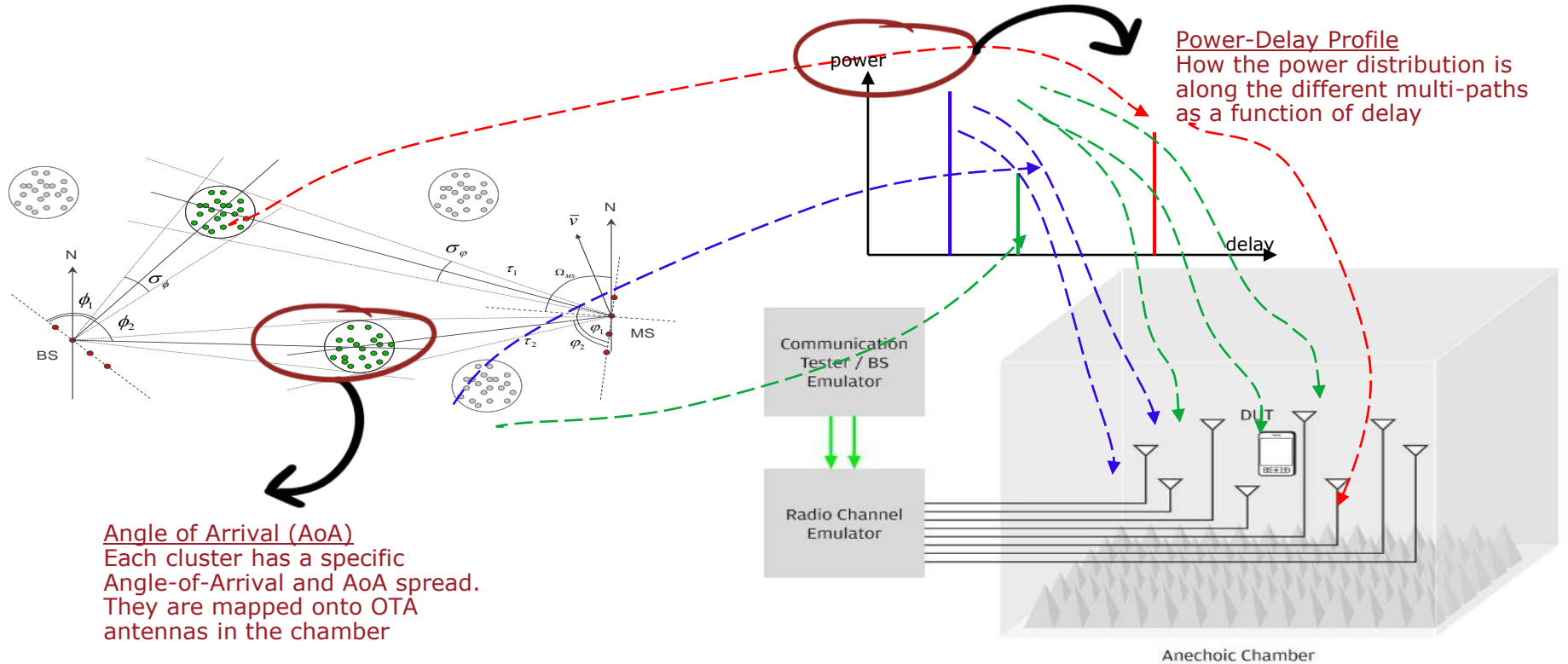
WHAT IS MIMO OTA AND TEST SETUP?

Channel model creates the typical radio conditions in which the DUT operates

Chamber presents the test environment under which the DUT is tested

DUT = Device Under Test

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BRINGING THE RADIO CHANNEL TO THE LAB

Power-Delay Profile
How the power distribution is along the different multi-paths as a function of delay

Angle of Arrival (AoA)
Each cluster has a specific Angle-of-Arrival and AoA spread. They are mapped onto OTA antennas in the chamber

Communication Tester / BS Emulator

Radio Channel Emulator

DUT

Anechoic Chamber

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WHAT ARE THE SYNC REQUIREMENTS?

- MIMO was originally defined in LTE Release 8 for up to 2 x 2 antenna configurations

- This was extended in LTE-Advanced to include up to 8 x 8 antenna configurations

- Time alignment error between two antennas is defined in 3GPP TS 36.104, clause 6.5.3:

  - The time alignment error in Tx Diversity and spatial multiplexing transmission is specified as the delay between the signals from two antennas at the antenna ports

  - The time alignment error in Tx Diversity or spatial multiplexing for any possible configuration of two transmit antennas **shall not exceed 65 ns**.

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MEASURING MIMO THROUGHPUT

MEASURING MIMO THROUGHPUT

- The performance of a MIMO scheme can be evaluated using an Channel emulator

- Various parameters of the MIMO scheme can be configured, and the throughput of the UE measured
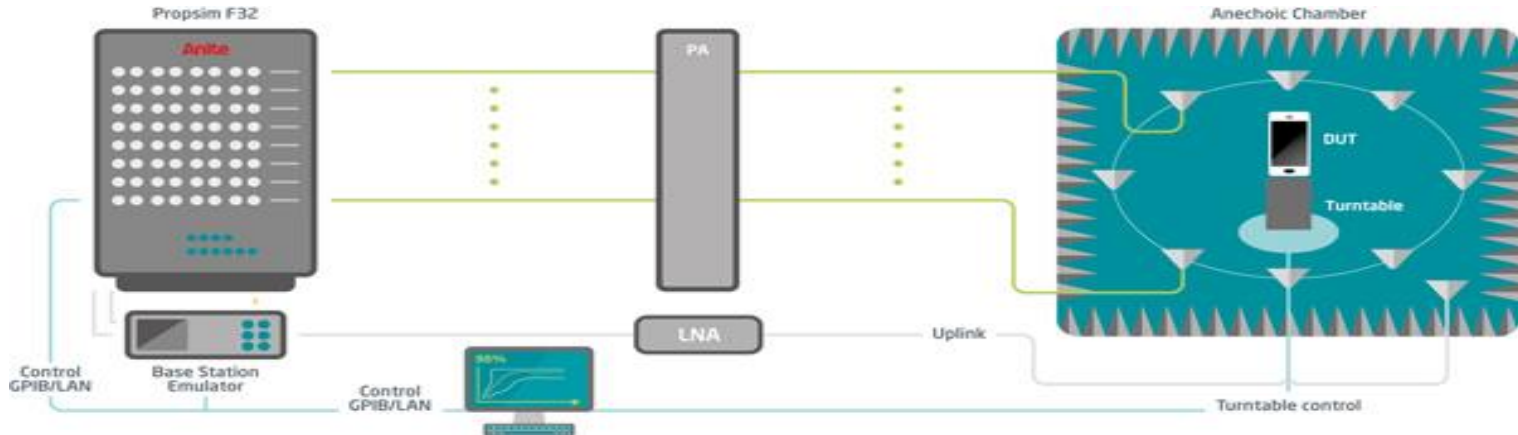
INTRODUCING TIME ALIGNMENT ERROR

- Using the Channel emulator, delay can be progressively introduced into one transmit antenna path, creating a time alignment error

- Throughput to UE measured for different delay values
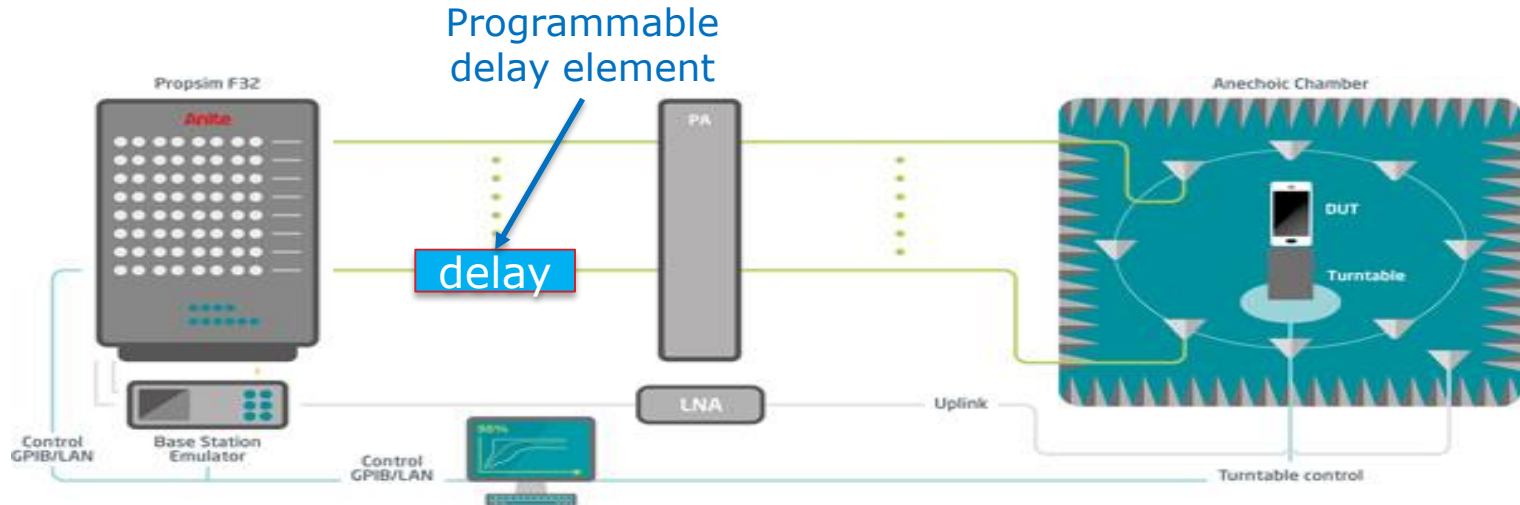
EXPERIMENTAL RESULTS
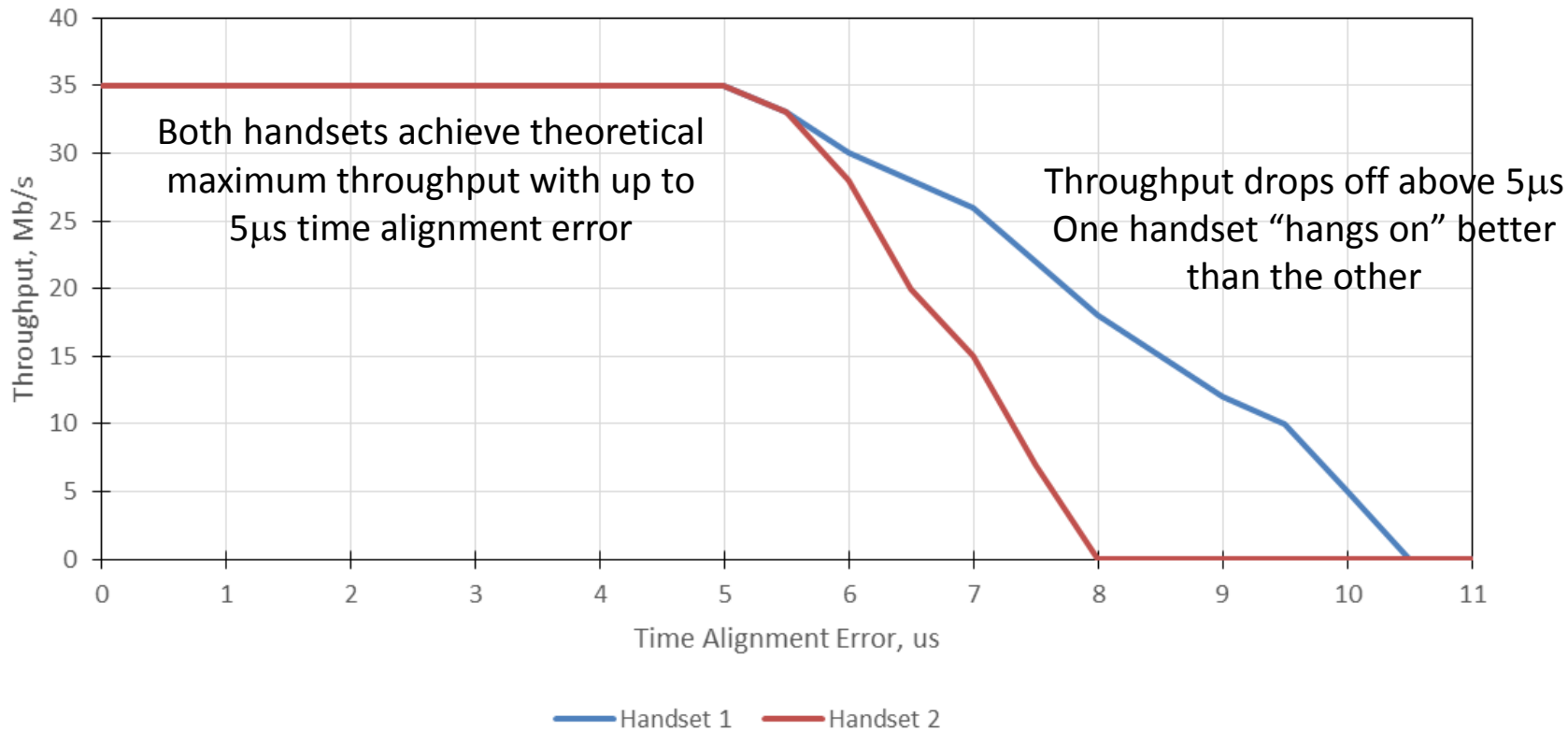
EXPERIMENTAL CONFIGURATION

MIMO configuration: 2 x 2

LTE duplex mode: FDD

Modulation scheme: 64QAM

Downlink bandwidth: 10MHz

Theoretical maximum throughput: 35.424 Mb/s

Delay introduced: 0-10μs in 500ns steps

Number of UEs tested: 2

TEST RESULTS

Both handsets achieve theoretical maximum throughput with up to 5µs time alignment error

Throughput drops off above 5µs One handset "hangs on" better than the other

Handset 1 — Handset 2

CONCLUSIONS

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- 3GPP specification for time alignment error is 65ns, but experiment shows maximum throughput is maintained up to 5μs

- Why is there such a big discrepancy?

  - Tested under "ideal conditions" – no fading, multipath etc.

  - In real environment, multipath reflections would add considerable extra delay

- Further possible work:

  - Include larger MIMO schemes

  - Introduce fading and multipath to see if the results are maintained

  - Investigate CoMP schemes (e.g. joint processing – similar to MIMO, but transmitted from separated remote antennas)

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THANK YOU FOR LISTENING!

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