Title: Improvements in System Performance due to simultaneous transmission of E-MBS and Unicast

Source: Improvements in System Performance due to simultaneous transmission of E-MBS and Unicast

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Purpose: To discuss and adopt the superposition coding scheme for broadcast and unicast symbols into 802.16m SDD .

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Superposition Coding
Of broadcast and unicast signals

MBMS
(Same content in
cells within a
broadcast zone)

Unicast
(different content in
different cells)

MBMS/Unicast
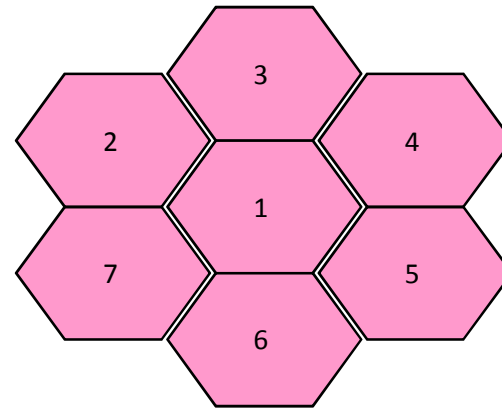Superposition
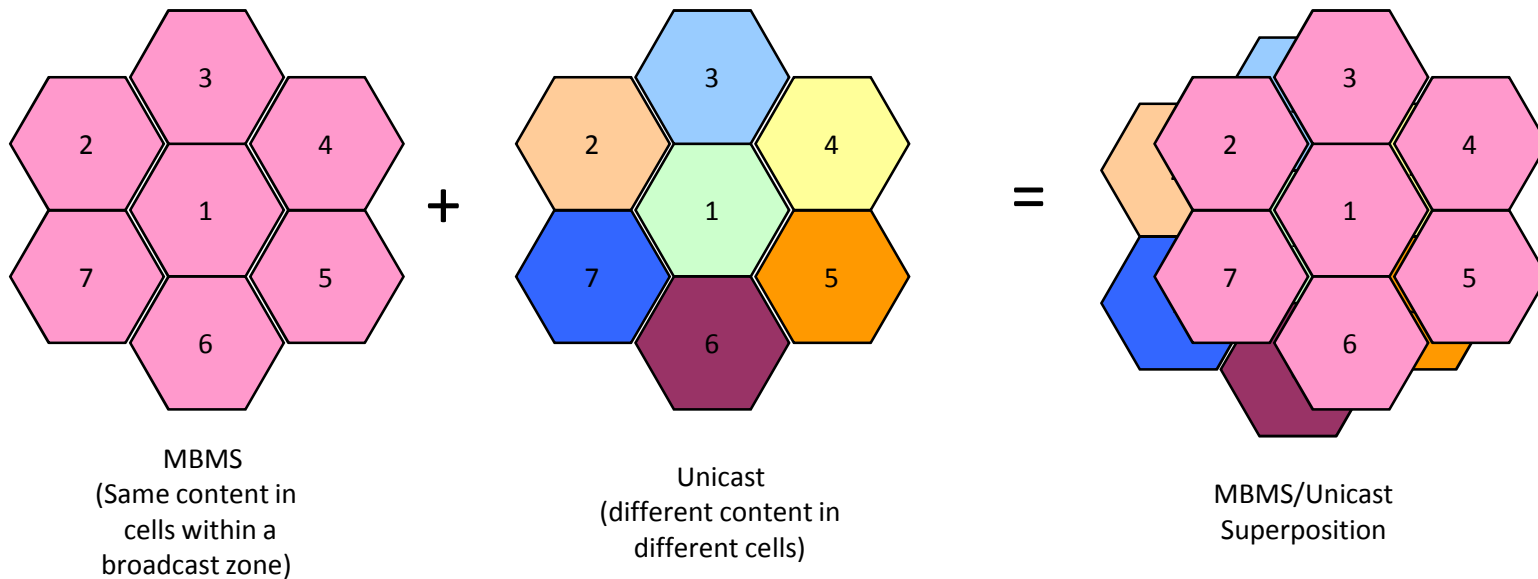
Spectrum Efficiency target for MBMS in LTE: 1 bps/Hz

Geometry: Unicast vs. Broadcast
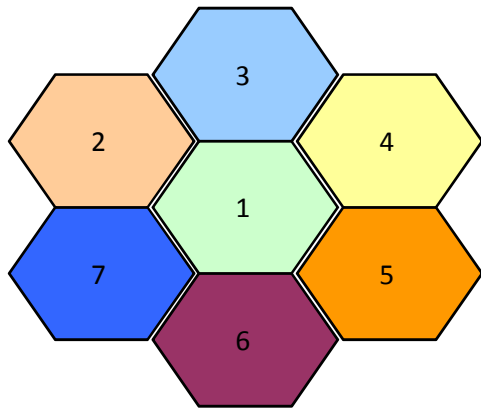
Unicast
(different content in
different cells)

MBMS
(Same content in
cells within a
broadcast zone)

$$SINR_{unicast} = \frac{P}{fP + N_0}$$

$$SINR_{broadcast} = \frac{KP}{N_0}$$

Unicast traffic is interference limited; broadcast is not.

Interference limited Unicast

Geometry CDF

More power does not improve unicast performance

More power improves broadcast performance

Legend:
- Unicast (5W BS Power)
- Broadcast (5W BS Power)
- Unicast (20W BS Power)
- Broadcast (20W BS Power)
- Unicast (80W BS Power)
- Broadcast (80W BS Power)

CDF (y-axis), Geometry (dB) (x-axis)
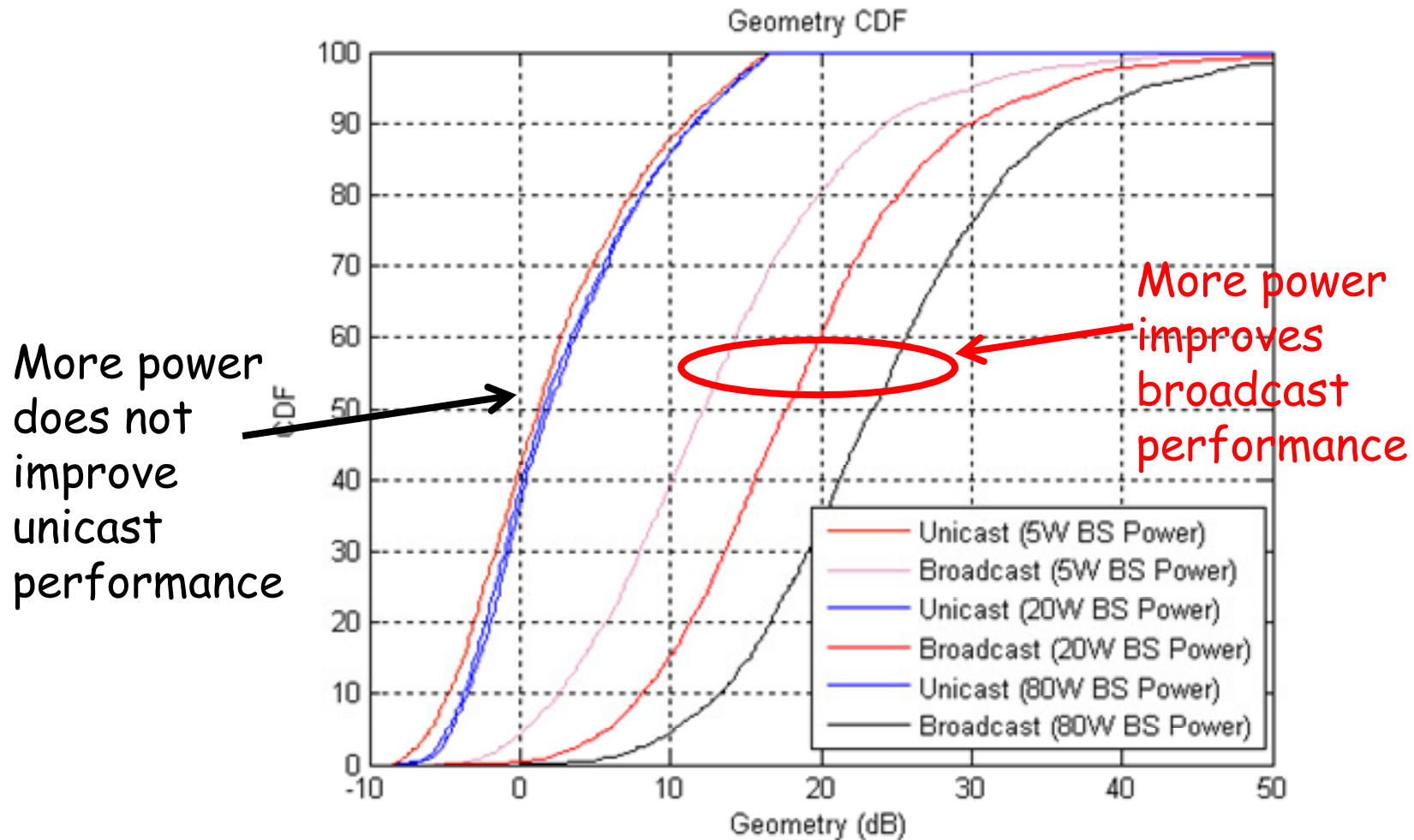
Superposition MIMO

Split power budget between unicast and MBMS signals
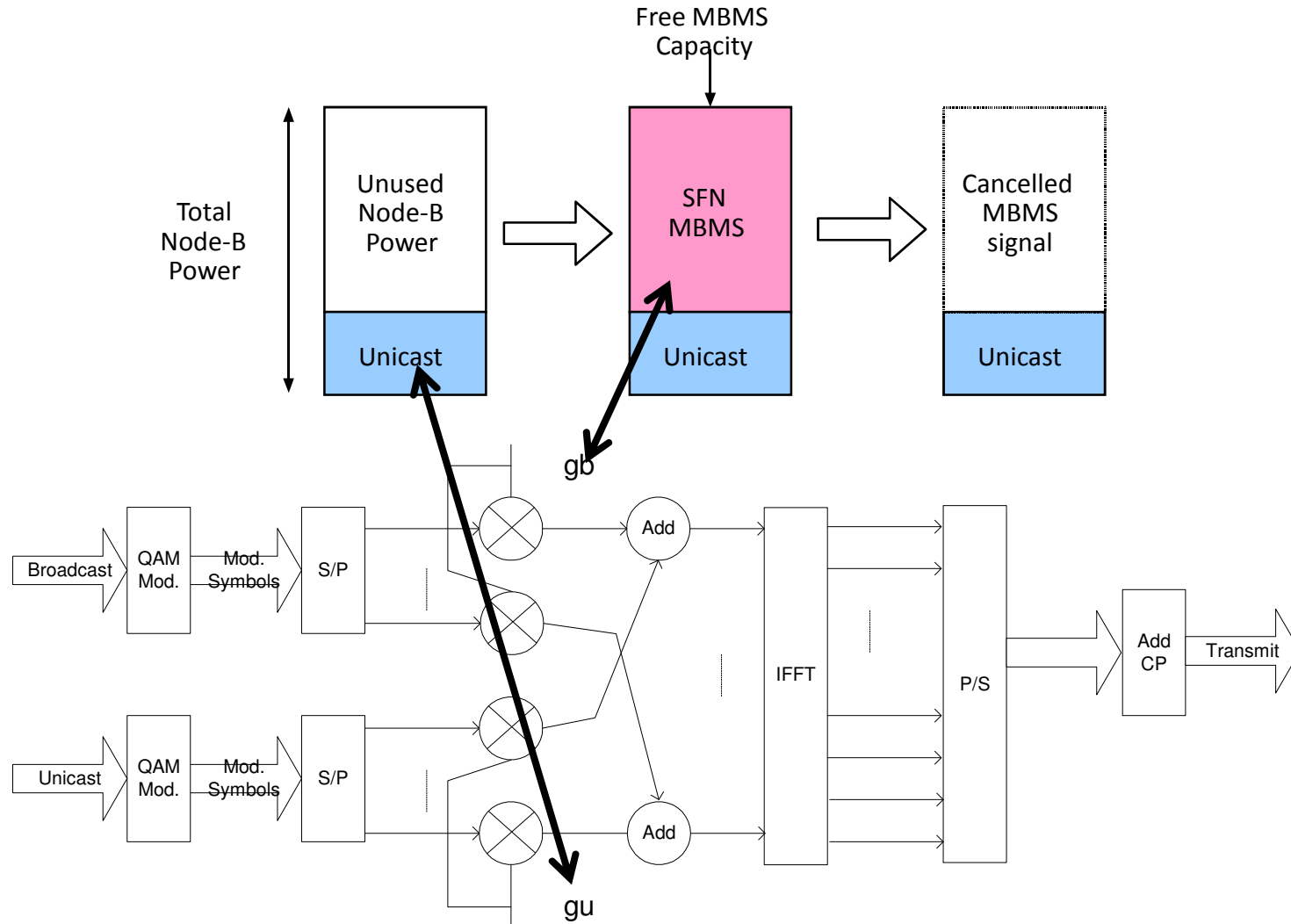
Interference cancellation

Decode broadcast MBMS signal first & cancel it from received signal to decode unicast symbols
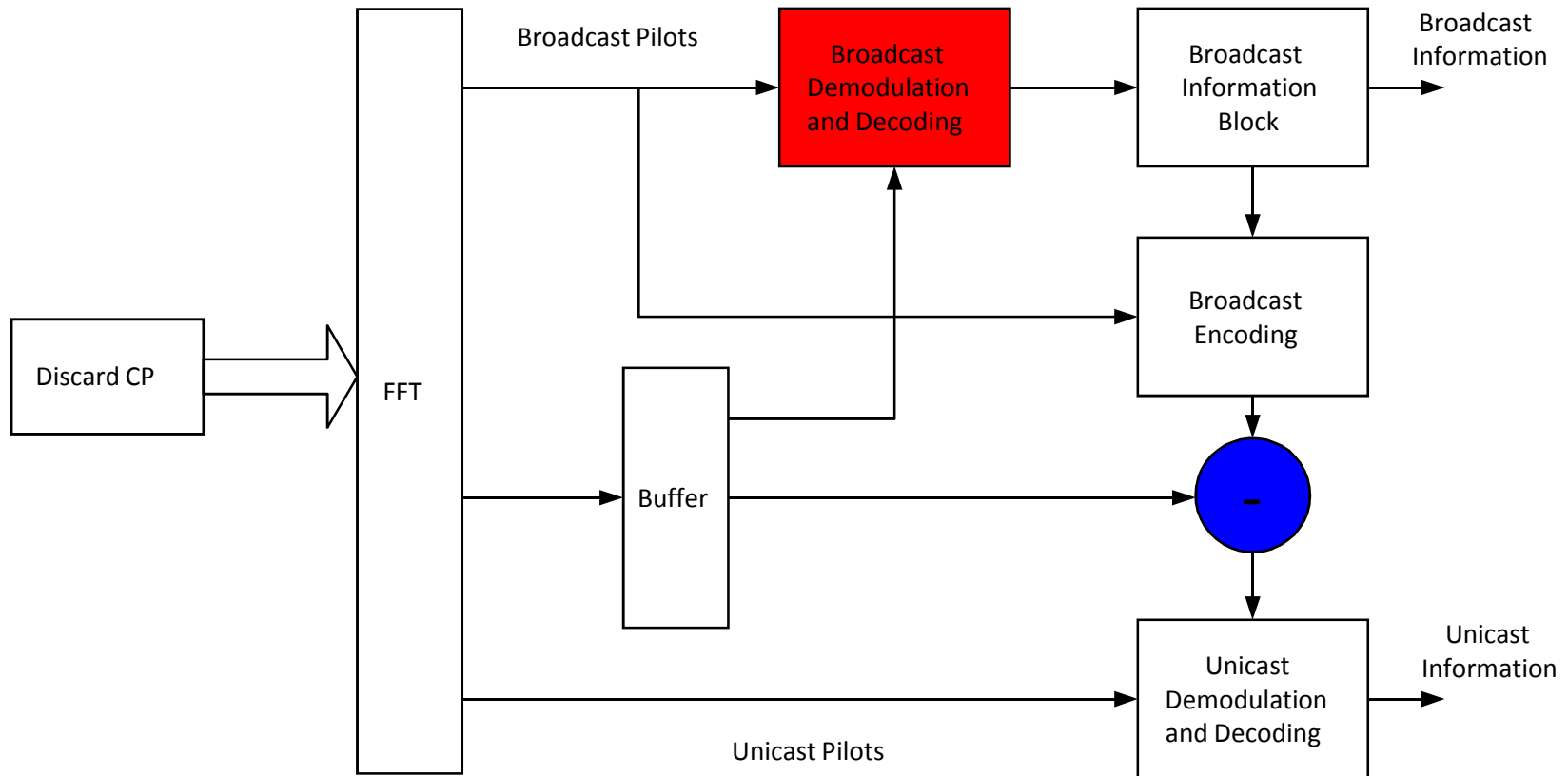
Spectral Efficiency with superposition

$$C_{broadcast} = \log_2\left(1 + \frac{\sum_i P_{Bi}}{\sum_i P_{Ui}}\right) \approx \log_2\left(1 + \frac{P_B}{P_U}\right) \quad [b/s/Hz]$$

For broadcast, the SINR is proportional to the power ratio P_B/P_U

$$C_{unicast} = \log_2\left(1 + \frac{P_U}{I_{BSIC} + fP_U + N_0}\right) \quad [b/s/Hz]$$
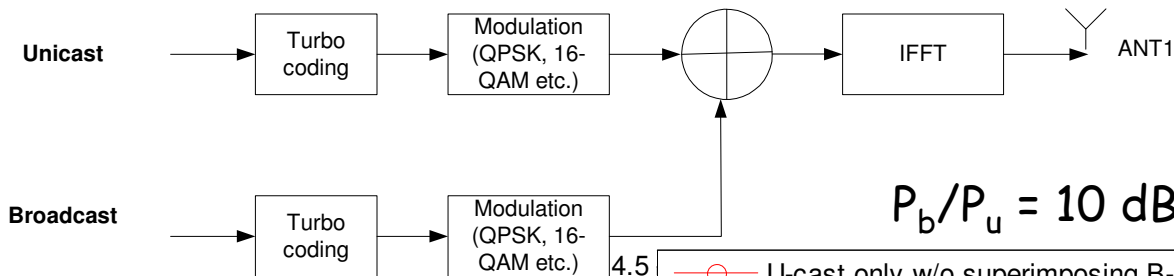
Residual interference due to imperfect interference cancellation

Noisy channel estimates
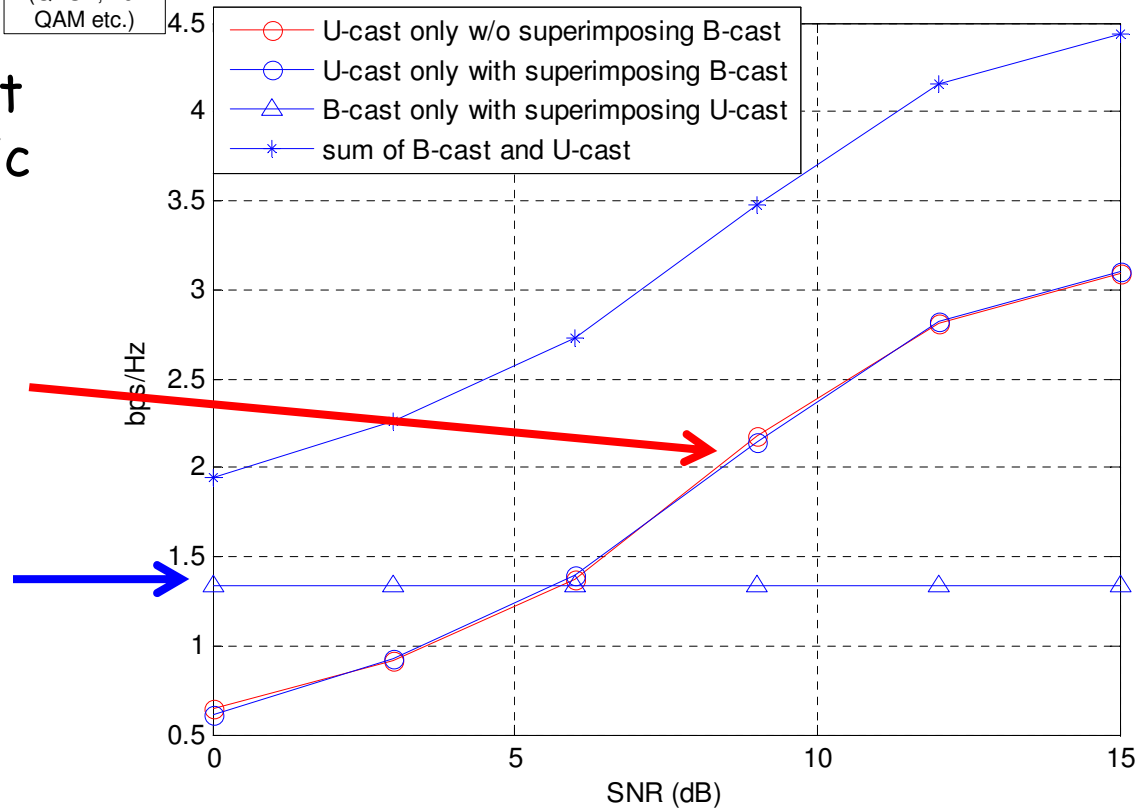
Spectral Efficiency curve - I

Perfect channel estimates for both broadcast & unicast signals

Single stream unicast and broadcast traffic

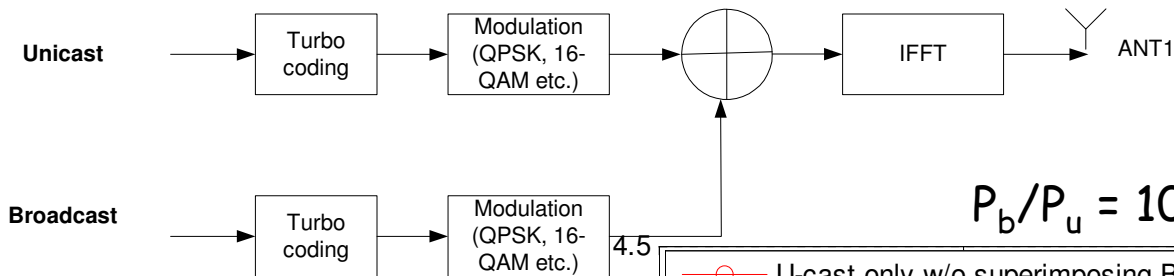No deterioration in unicast rates due to superposition

QPSK + 2/3 coding rate: 4/3 bps/Hz

$P_b/P_u = 10 \text{ dB}$

Legend:
- U-cast only w/o superimposing B-cast
- U-cast only with superimposing B-cast
- B-cast only with superimposing U-cast
- sum of B-cast and U-cast
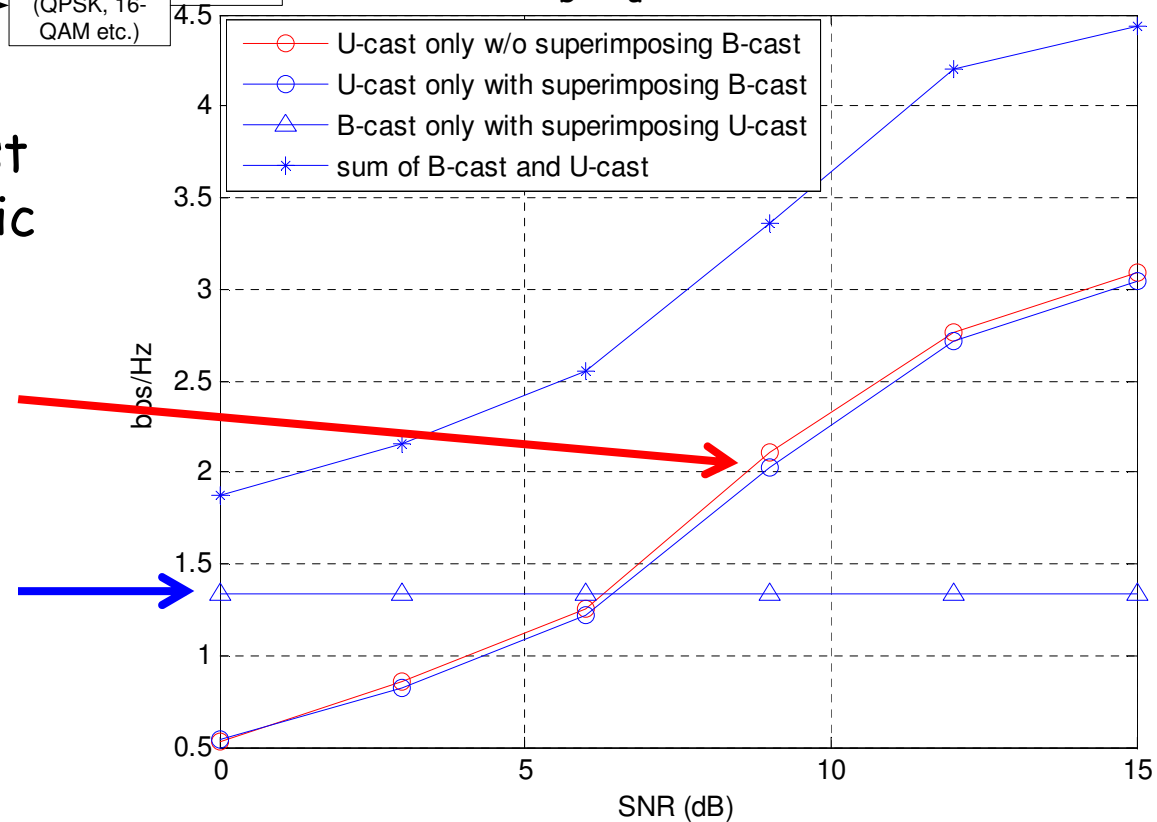
Spectral Efficiency curve - II

Imperfect channel estimates for broadcast

$P_b/P_u = 10$ dB

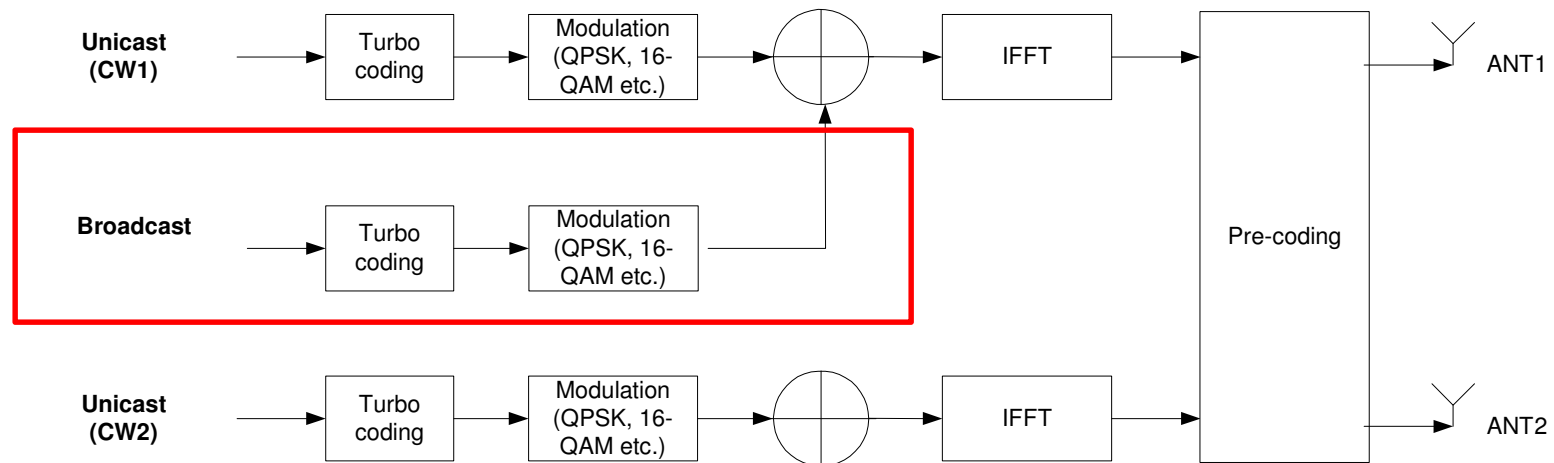Single stream unicast and broadcast traffic

Small deterioration in unicast rates due to superposition

QPSK + 2/3 coding rate: 4/3 bps/Hz

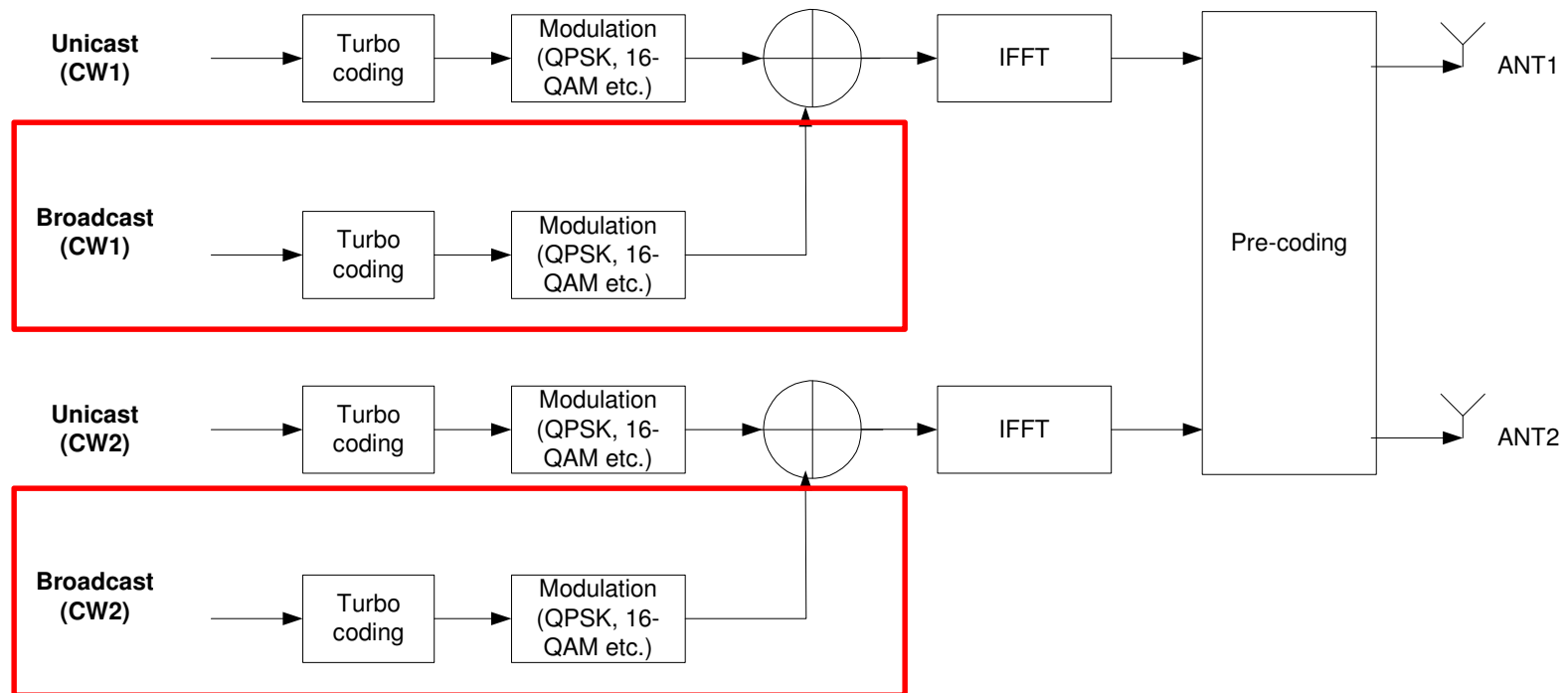# Superposition MIMO

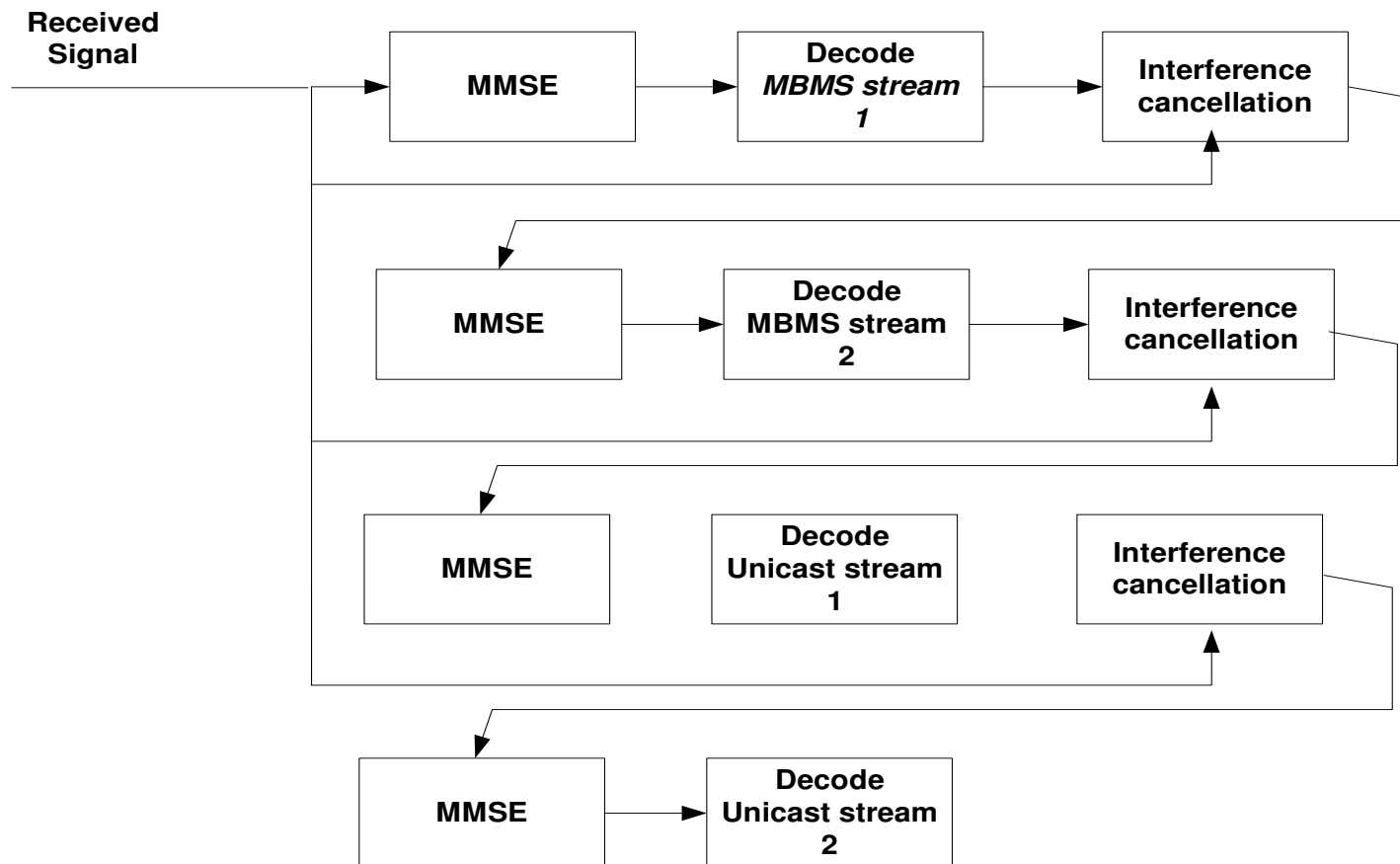## Two streams for unicast and a single stream for MBMS

Superposition MIMO

Two streams for both unicast and MBMS

Superposition MIMO

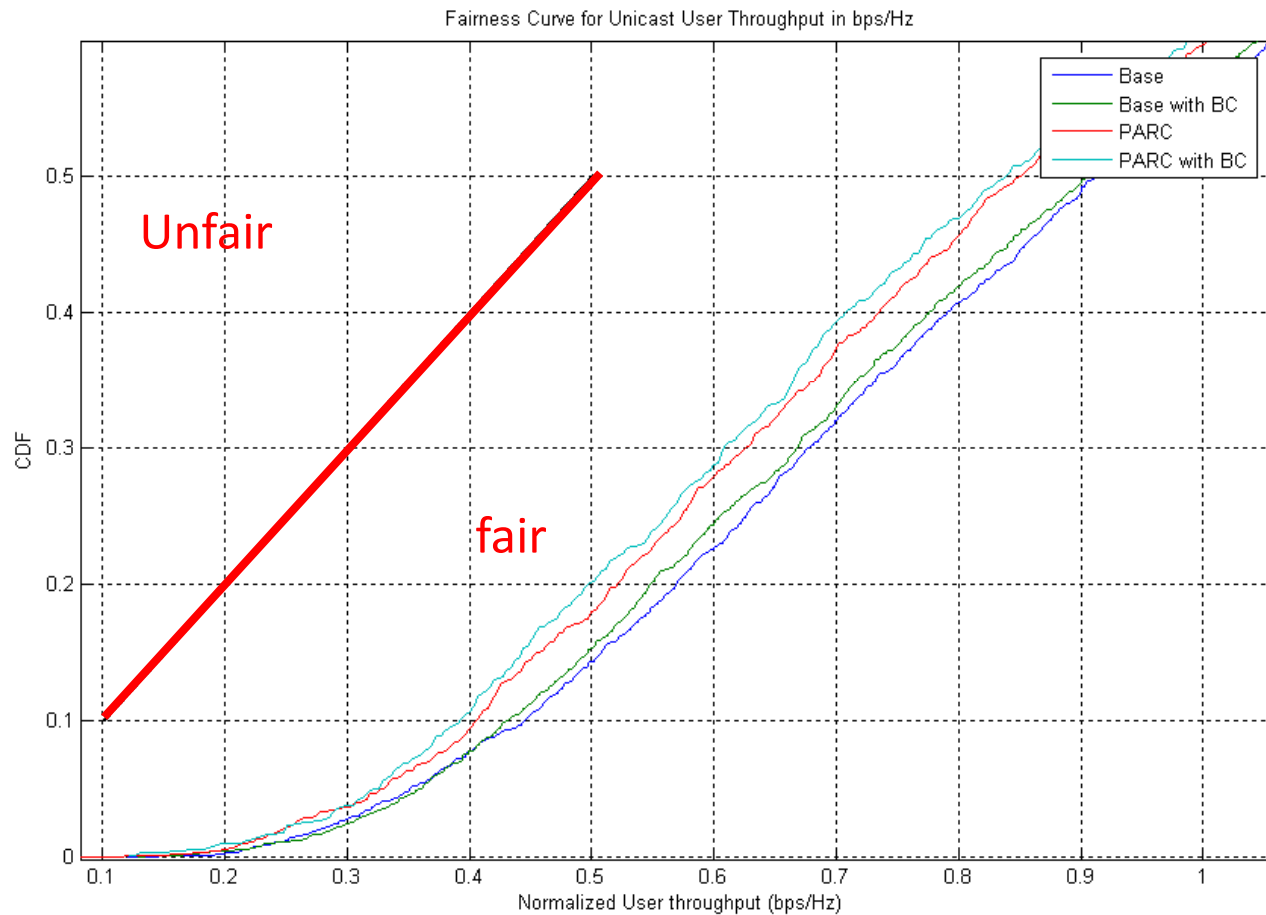Receiver Operation: Decode MBMS streams first and then decode Unicast streams

System Simulations: Throughput

	Unicast THP	Broadcast THP	Total	5% User THP
Base Line w/o MBMS Superposition	1.90	0	1.90	0.0667
Base Line with MBMS Superposition	1.89	2	3.89	0.0677
PARC w/o MBMS Superposition	2.17	0	2.17	0.0708
PARC with MBMS Superposition	2.16	2.66	4.82	0.0690

System View: Fairness

Summary

- ## More bang for the bucks
  - For a little extra power, superposition achieves improves overall system throughput and spectral efficiency without adversely affecting unicast rates
  - Simple receiver operation – MMSE with SIC
- ## Slight loss in unicast rates due to imperfect interference cancellation
  - Impact due to imperfect channel estimation
    - Mitigate loss by using a dense packing of power boosted broadcast reference signals.