Performance Comparison Between Distributed Antenna Systems and Microcellular Systems

Jiangzhou Wang
University of Kent
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Introduction

• Data rate: 10kbps in 2G => 14Mbps in 3G => 100Mbps in 3.9G => 1Gbps in future 4G

• Data rate <=> transmit power is proportional.
  • When data rate is 1Gbps, transmit power in macrocells must be huge and it is not realistic.
  • Large transmit power leads to high electricity cost mainly due to the use of much electricity by air conditioners in base stations
  • For limited transmit power, transmission distance cannot be long when data rate is very big.

• Data rate <=> coverage is a tradeoff.
The conventional macrocellular has very low spectral efficiency and power efficiency at cell edges [Xiaohu You].
Therefore, in order to support high speed mobile communications, radio transmission distance must be shortened significantly. New networking architectures must be designed by considering

- Distributed antenna systems
- Microcells
- Other network architectures (eg. relay networks)
Distributed Antenna Systems

CU: Central Unit
RAU: Remote Antenna Unit
SU: User
○ Optical Fiber
• Distributed MIMO can improve the spectrum efficiency [Xiaohu You].
Technical Challenges

- Nonlinearity of optical channels due to variations of amplitude of RF signals in OFDM, e.g. M=2048; nonlinear compensation is needed [Futon].
• Time delay in CU due to different location of RAUs (about 5µs per km in fibre): TDD mode
• Selection criterion of RAUs (one, two or more?)
  Smallest BER for the same total transmit power
• Power allocation among RAUs
  Waterfilling principle (proportional to CSI square normalized to the sum of CSI square)
• Combining techniques for spatial diversity
  Equal gain combining
Cellular Model
Co-channel interference in microcells
Co-channel interference in microcells

![Graph showing the relationship between Path Loss Exponent (\(\lambda\)) and Signal to Interference Ratio (dB). The graph indicates a linear increase in Signal to Interference Ratio as the Path Loss Exponent increases.](image-url)
DAS

1) Without BS coordination
2) With BS coordination
Performance Comparison

Without BS coordination in the DAS

Same Tx power, same BW, same number of antennas

Average Spectrum Efficiency per Sector (bits/s/Hz)

$E_s/N_0$

$\lambda = 2, 3, 4$
Without BS coordination in the DAS

The microcellular system outperforms the DAS.
With BS coordination in the DAS
With BS coordination in the DAS

Same Tx power, same BW, same number of antennas

![Graph showing average spectrum efficiency vs. $E_s/N_0$ for different $\lambda$ values. The graph compares Microcellular System and DAS with $\lambda = 2, 3, 4$.](image)
With BS coordination in the DAS

The DAS outperforms the microcellular system, including cell edge.

\[
\frac{E_s}{N_0} = 20\text{dB}
\]
Conclusions

- Future high data rate mobile communications systems need new network architectures. The basic approach is to reduce radio transmission distance.
- The microcellular system outperforms the DAS when the DAS does not have BS coordination.
- The DAS outperforms the microcellular system when the DAS has BS coordination.