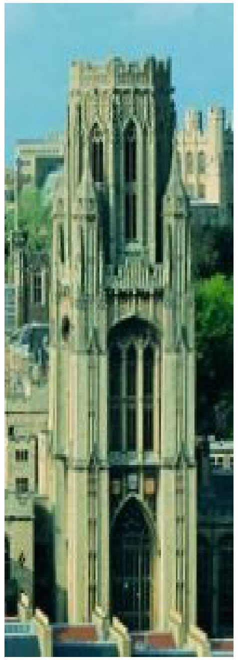

Enhancing the Performance of IEEE 802.11a Devices using Delay Diversity

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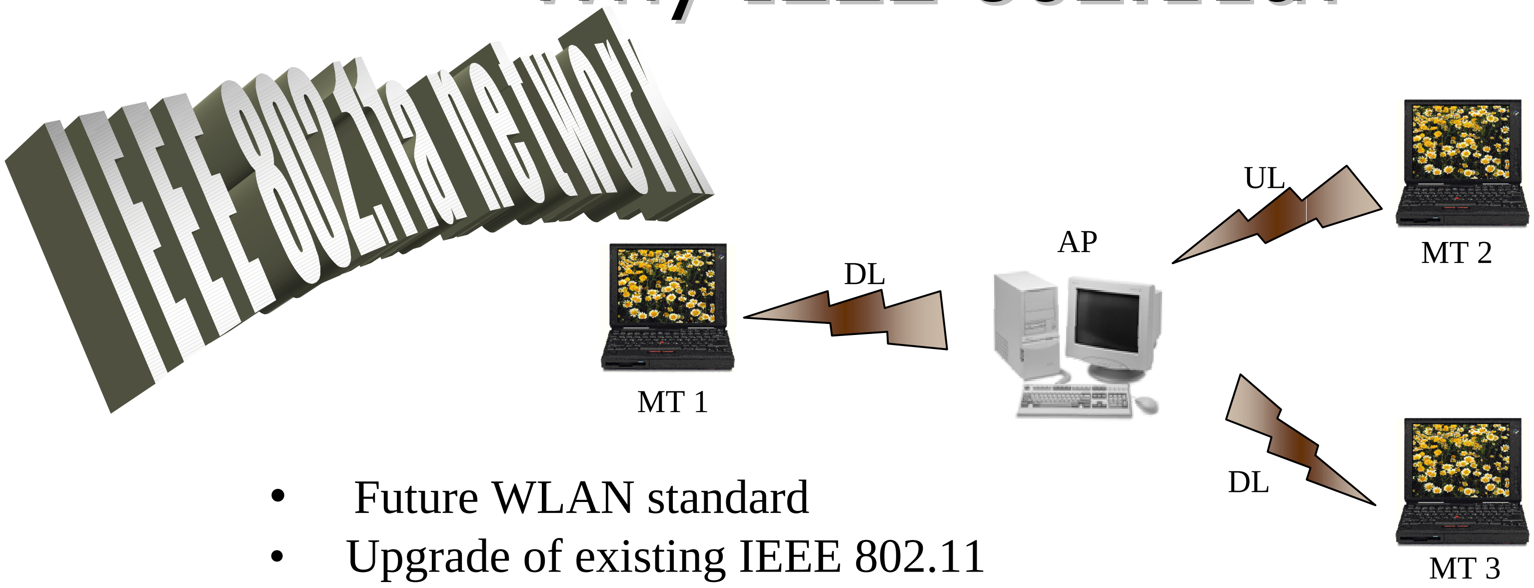
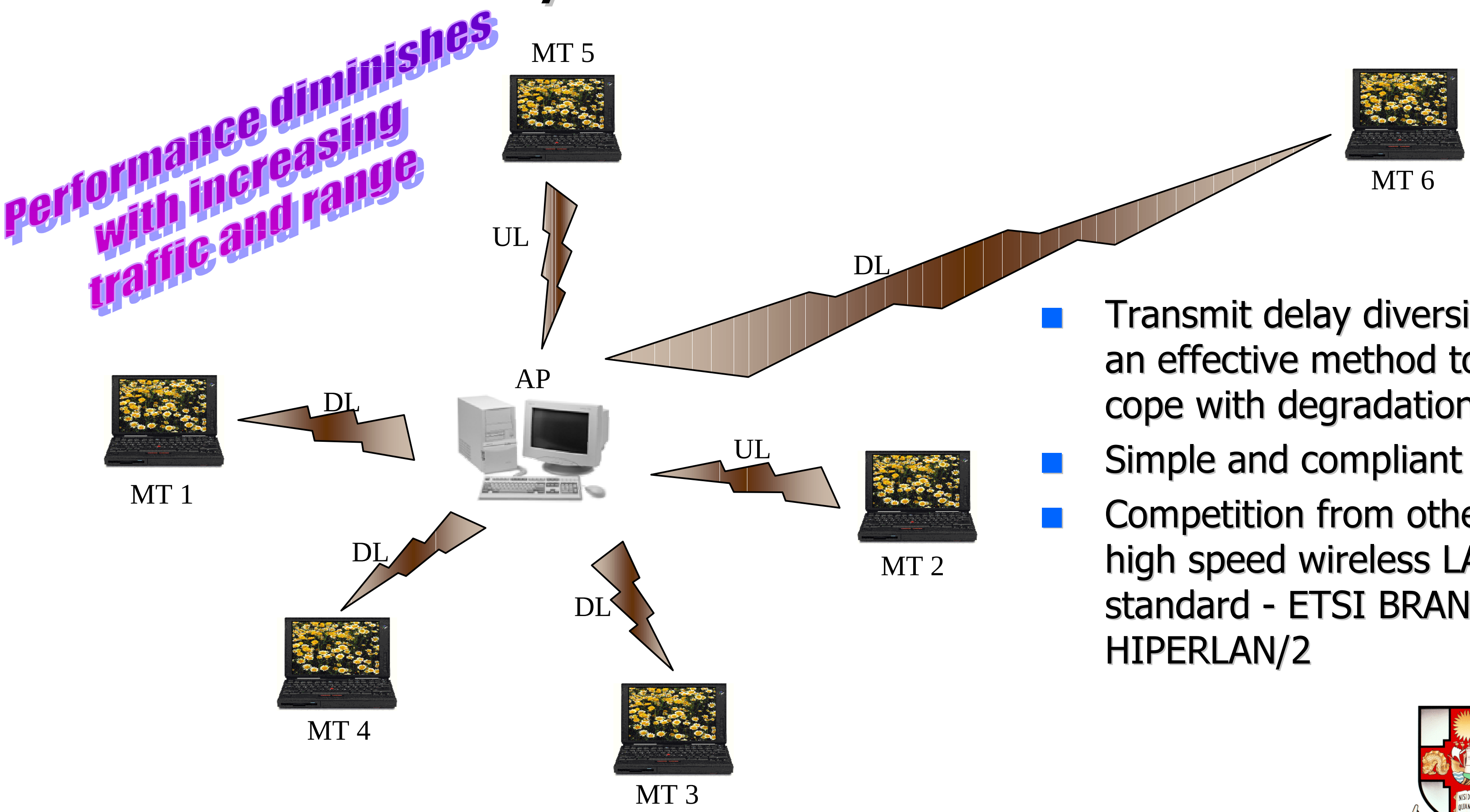
Introduction
"Why IEEE 802.11a?"



- Future WLAN standard
- Upgrade of existing IEEE 802.11 standard (1Mbps to 2Mbps)
- Utilises COFDM technology
- Bit rates of 6Mbps up to 54Mbps
- In the 5GHz band

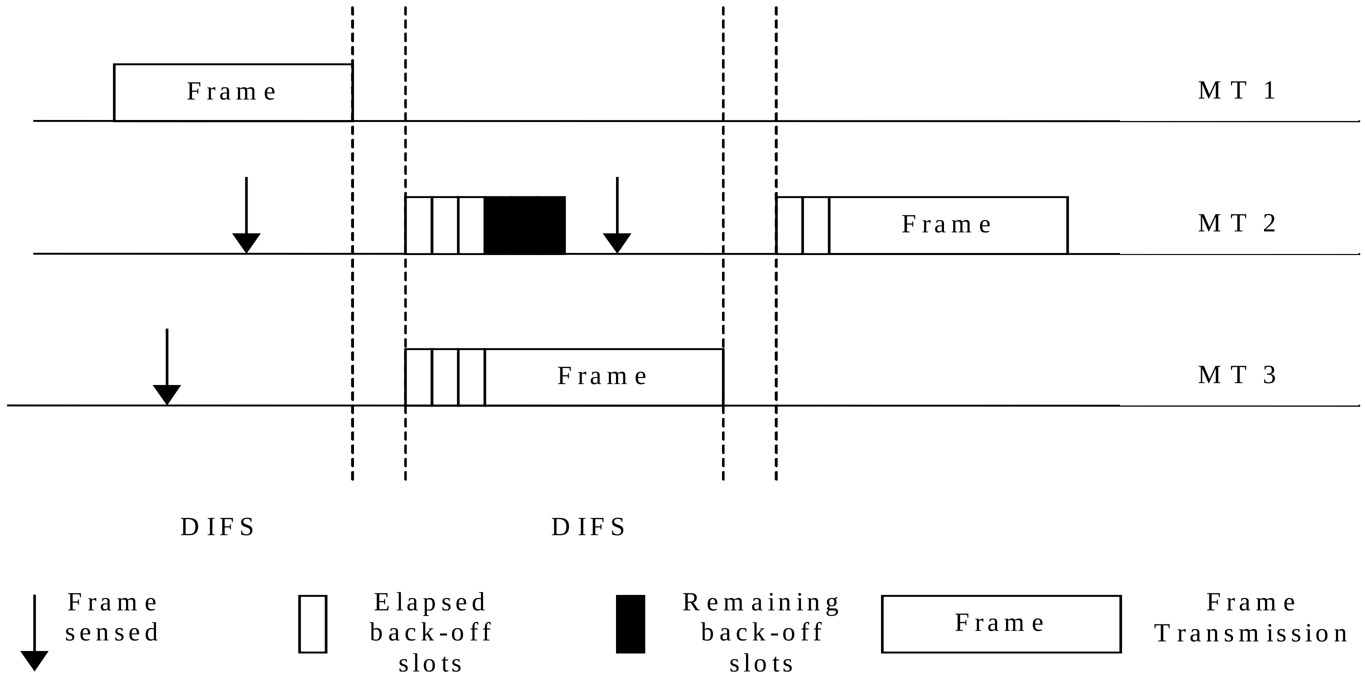
Delay diversity
"Why do we need it?"



- Transmit delay diversity an effective method to cope with degradations
- Simple and compliant
- Competition from other high speed wireless LAN standard - ETSI BRAN HIPERLAN/2

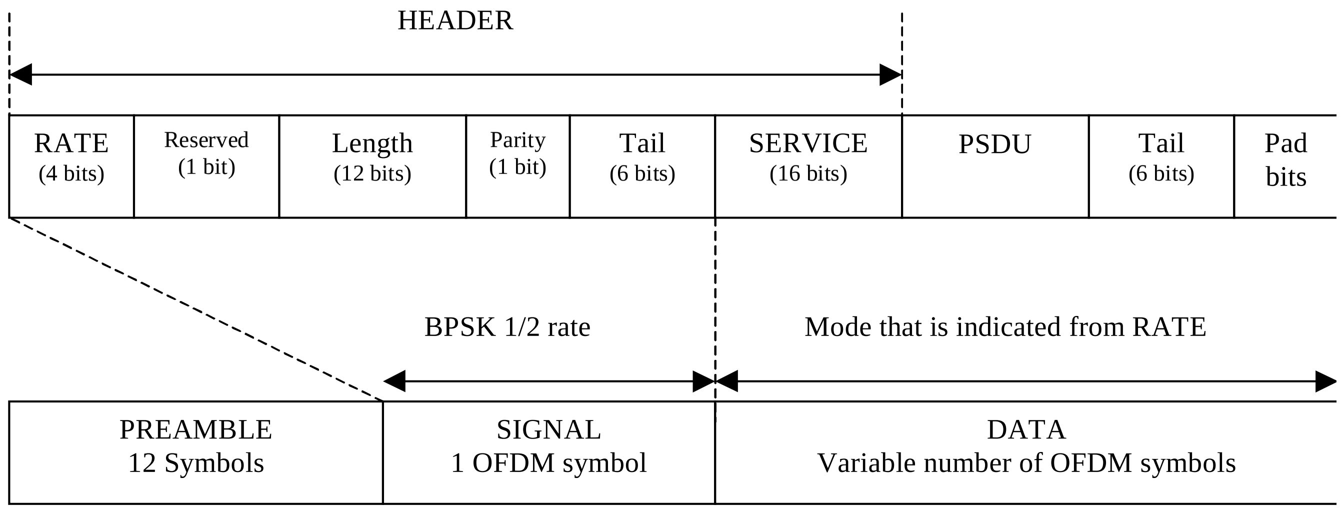
MAC protocol

- Implements CSMA/CA as basis for protocol
- In turn rely on IFS, to determine availability of medium
- Back-off time slots used to avoid collision



OFDM frame format

- Decentralised with a distributed access scheme
- OFDM frame format contains protocol specific fields
- Ad-hoc nature - frame transmissions require no AP allocation



Proposal

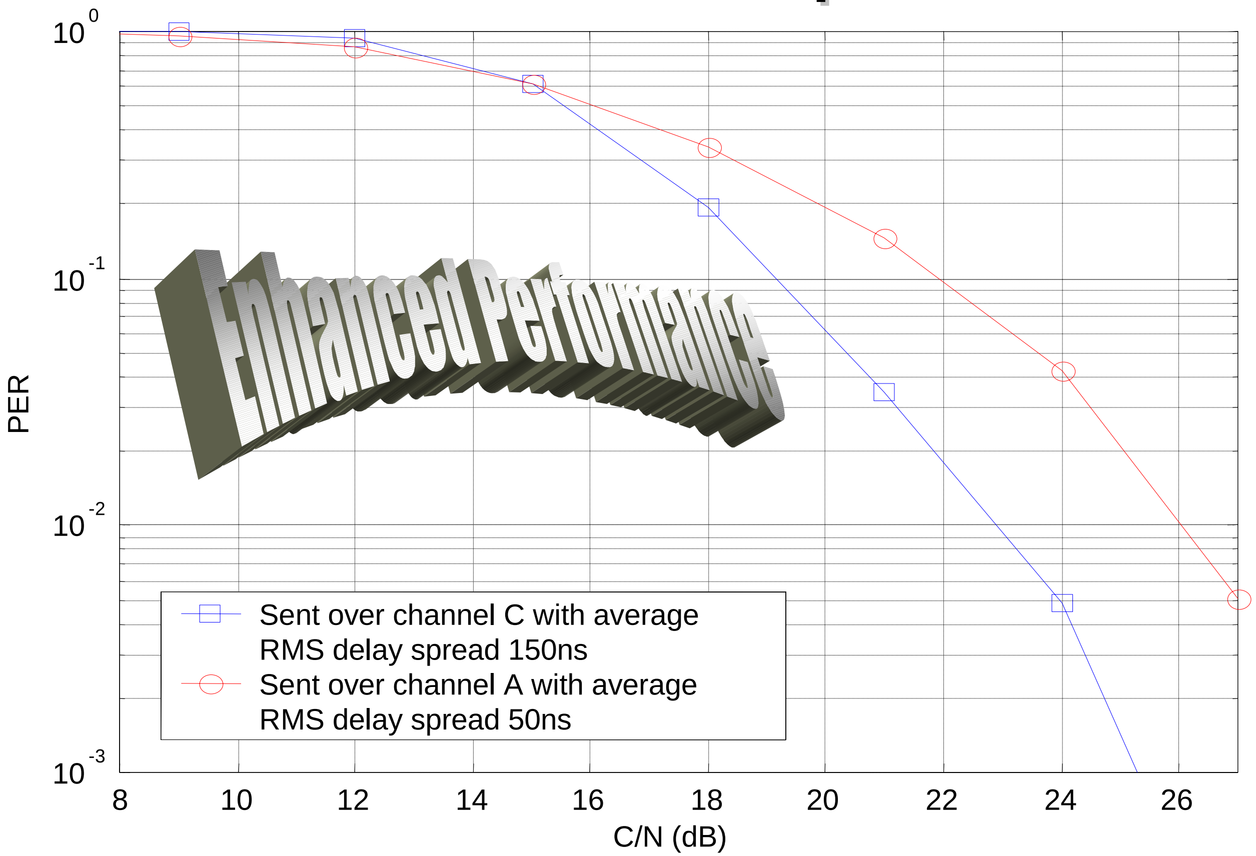
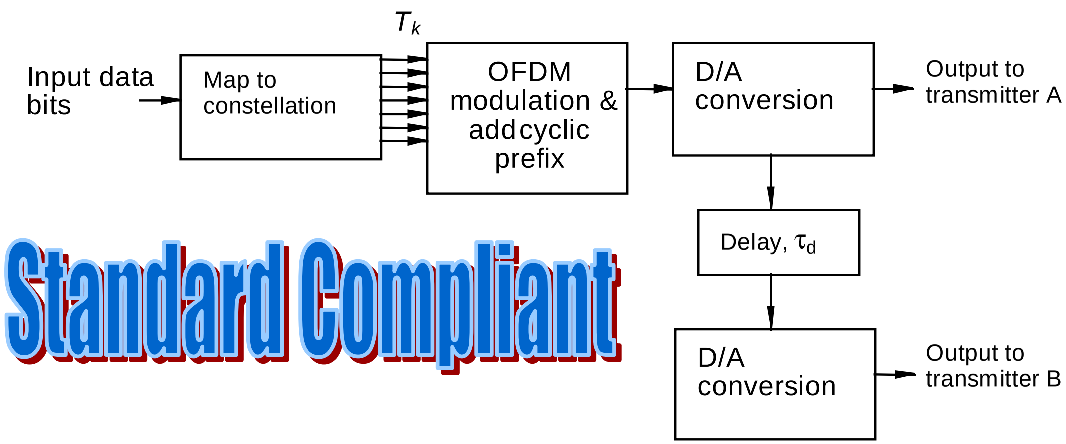


Fig. 1 shows comparison for transmissions over channel A (50ns RMS delay spread) and C (150ns RMS delay spread) using PHY layer mode 6

- Poor performance reported in IEEE/ETSI standard channel model 'A' [1]
- Suffers from inadequate frequency diversity resulting in correlated subbands
- In this scenario, the FEC could not be exploited fully
- Fig. 1 demonstrates this attribute

Proposal



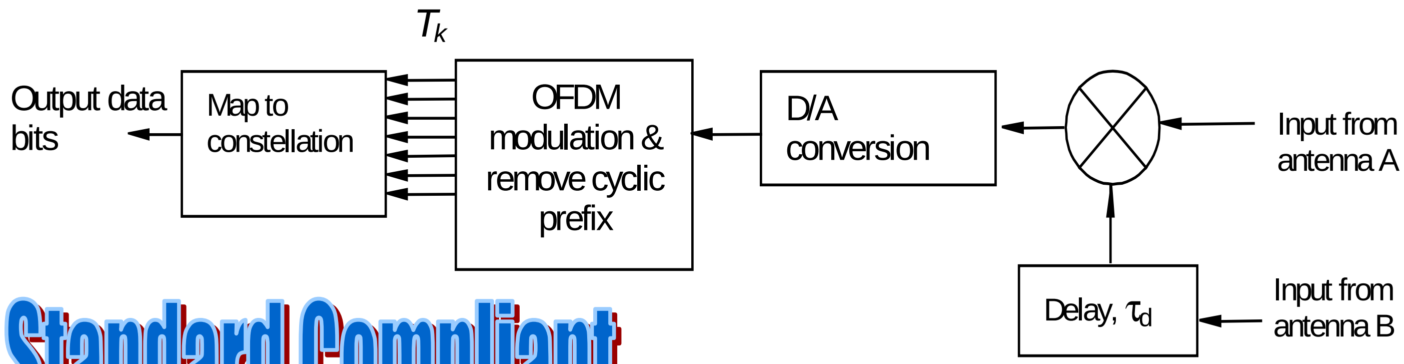
Standard Compliant

Fig. 2a Transmit delay diversity in DL applied to IEEE 802.11a standard for the AP

- Fully standard compliant
- Synthetically enhances channel by deliberately creating delay spread, thus generating a highly frequency selective channel
- Fig. 2a demonstrates the proposed antenna array configuration at the AP for the DL mode

Proposal

- Fig. 2b demonstrates the proposed antenna array configuration at the AP for the UL mode



Standard Compliant

Fig. 2b Delay diversity in UL applied to IEEE 802.11a standard for the AP

Results

- Software simulation results are used to analyse performance
- Based on soft Viterbi decoding
- Transmit power is halved between the 2 transmit antennas

Table 1: PHY Layer Modes

Mode	Modulation	Coding Rate	Bit rate [Mbps]
1	BPSK	1/2	6
2	BPSK	3/4	9
3	QPSK	1/2	12
4	QPSK	3/4	18
5	16QAM	1/2	24
6	16QAM	3/4	36
7	64QAM	3/4	54

Results

- All simulations are based on IEEE/ETSI standard channel models

Table 2: IEEE/ETSI channel models

Mode	Environment	Average RMS delay spread (ns)
A	Office NLOS	50
B	Open space/Office NLOS	100
C	Large open space NLOS	150
D	Large open space LOS	140
E	Large open space NLOS	250

Effect of delay

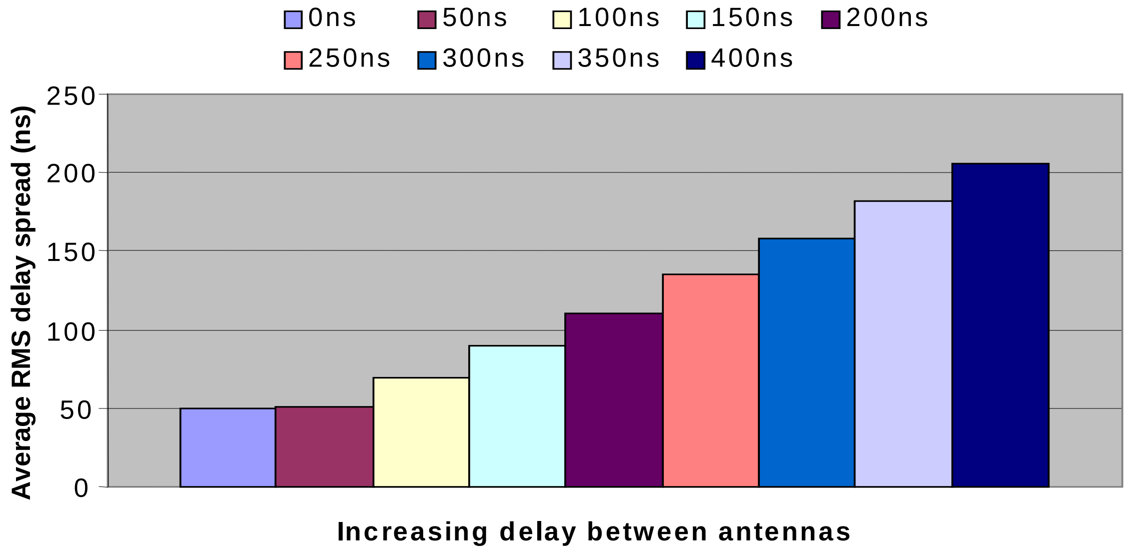


Fig. 3 RMS delay spreads for transmit delay diversity over IEEE/ETSI channels A

- Longer delay, larger average RMS delay spread
- Generate uncorrelated subbands to be exploited by FEC

Improved PER performance

- Longer delay, larger average RMS delay spread
- This is reflected by the results in figure 4
- Over channel A performance (NLOS typical office environment)

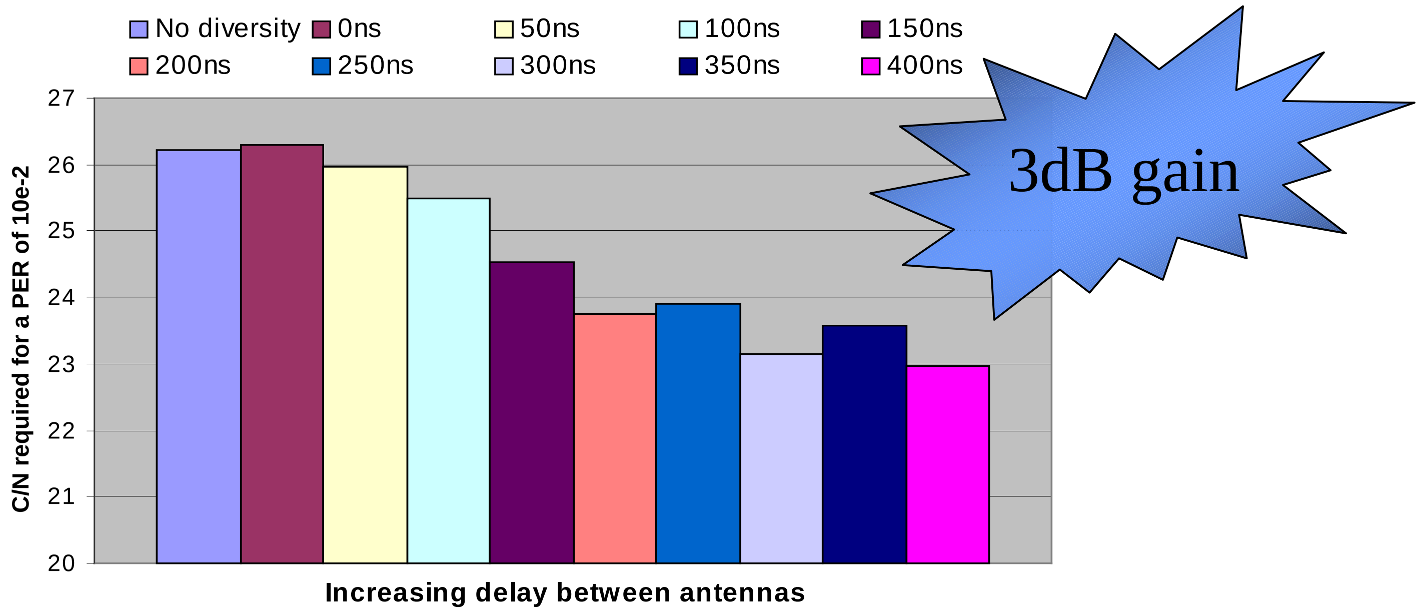


Fig. 4 PER results of PHY layer mode 6 over various enhanced channels A

Improved PER performance

- Again the improvements are highlighted against soft decoded only 802.11a and HIPERLAN/2 PER performance

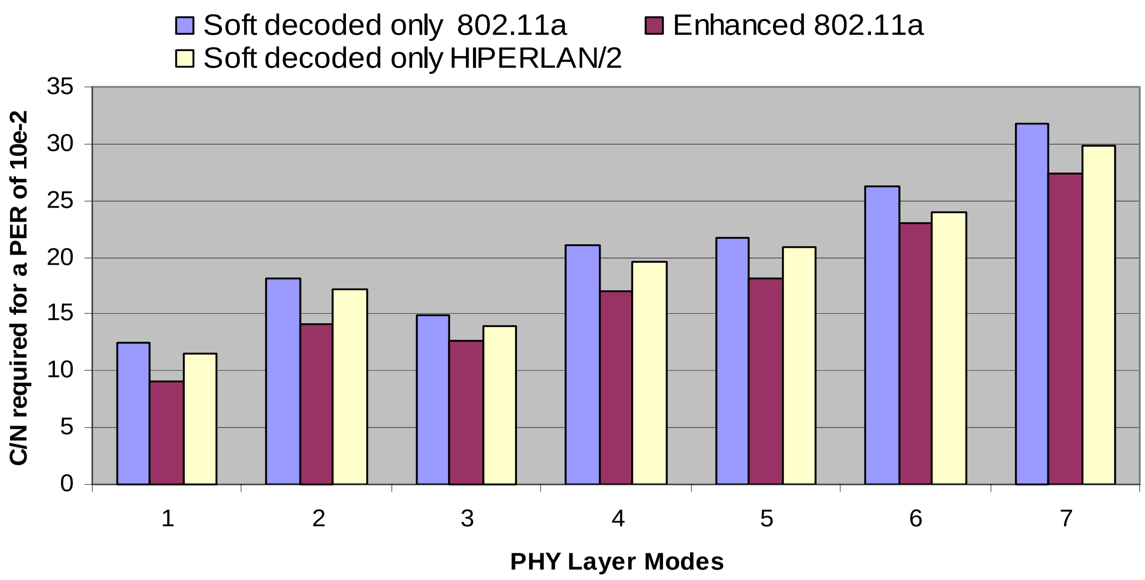


Fig. 5 PER results of various PHY layer modes over enhanced channel A with a delay of 400ns

Throughput Enhancement

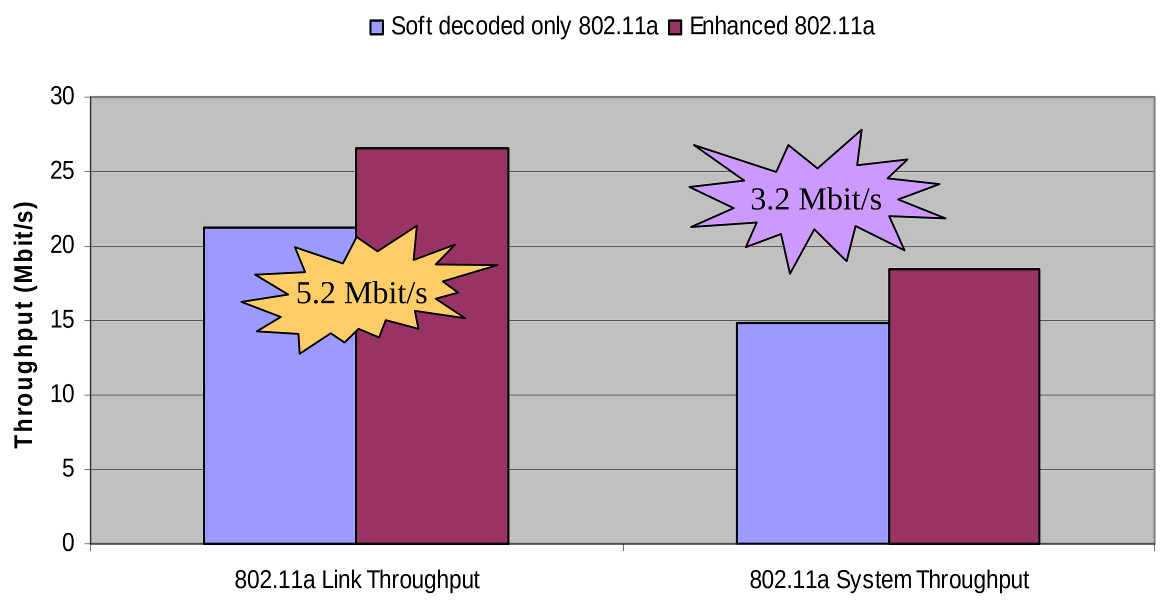


Fig. 6 Throughput link enhancements for UL and DL (30m range)

- Increased throughput with range

Dangers of ICI

- In channels with longer excess delay
- Loss of orthogonality

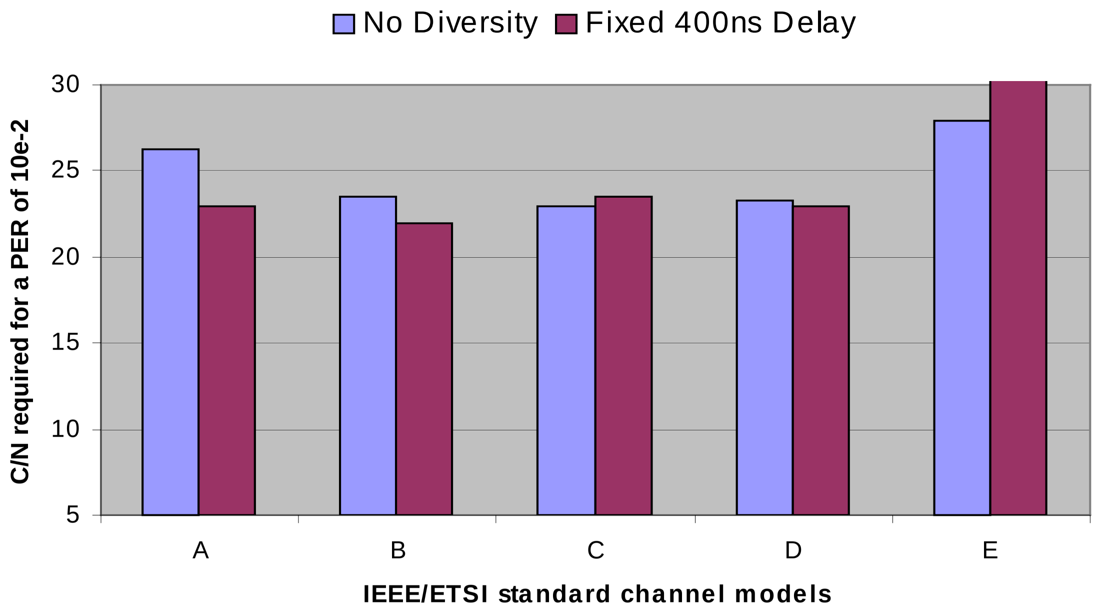


Fig. 7 Comparison of IEEE 802.11a performance for various transmit delay diversity strategies in standard channels A, B, C and D using PHY layer mode 6

Dangers of ICI

- Raises error floor

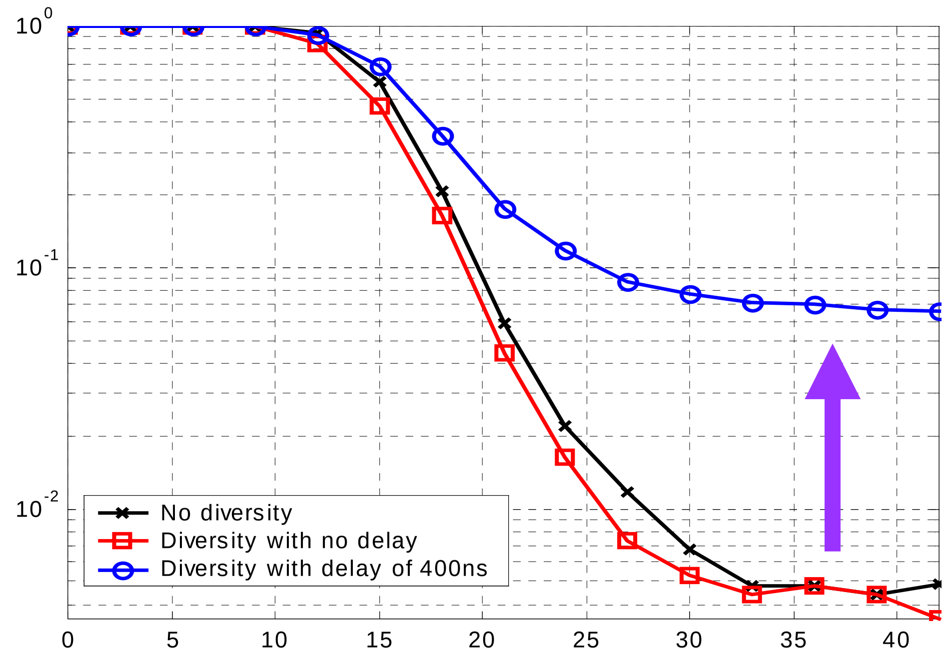
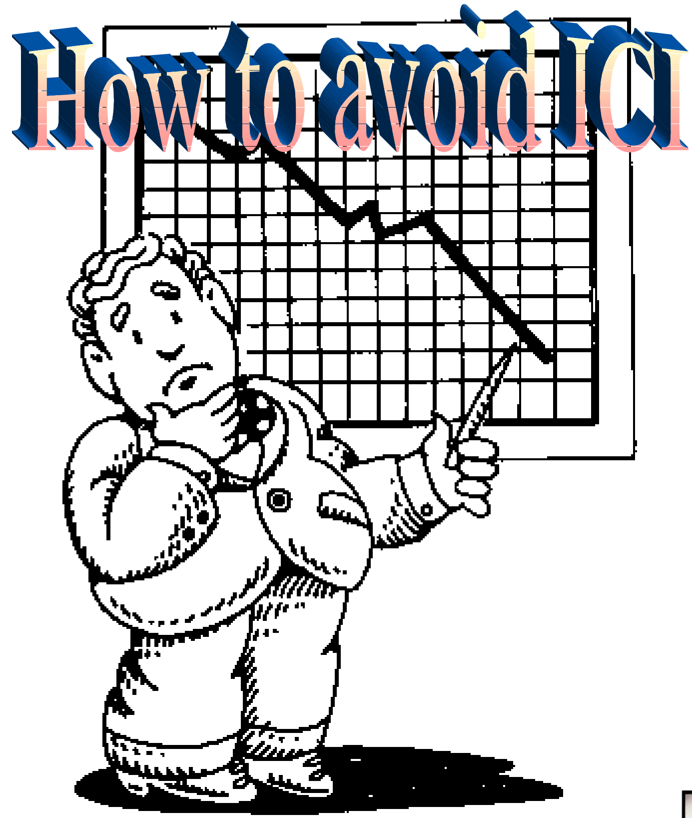


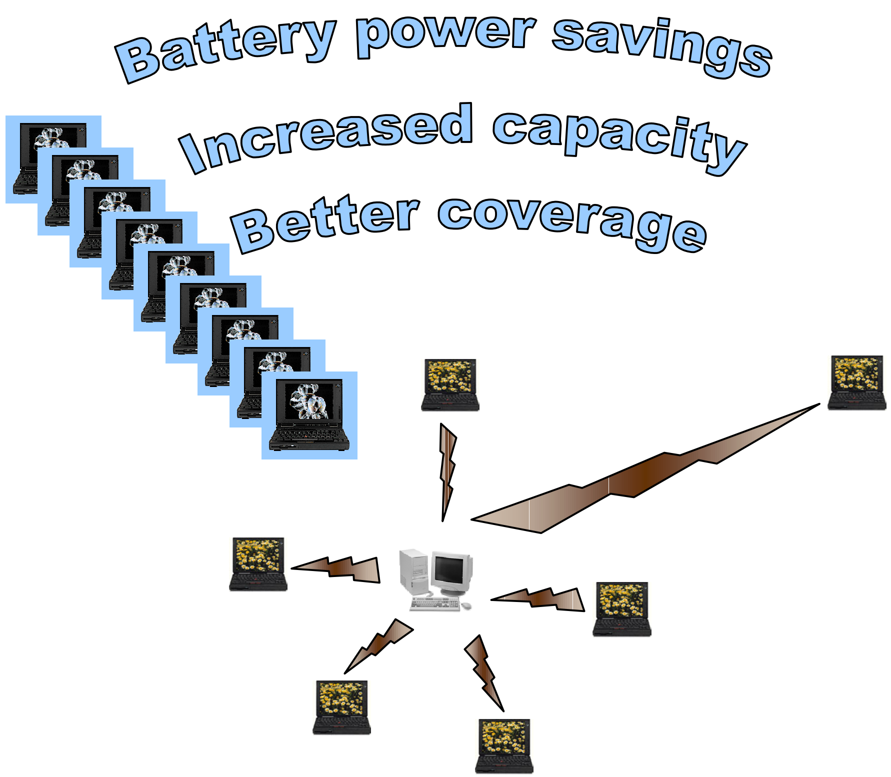
Fig.8 PER performance over channel E using PHY layer mode 6

Adaptive Control Strategy

- Avoids problem of ICI
- Estimate the channel excess delay
- Use Inverse Fourier Transform



Conclusion



- Improves performance
- Preserves nature of IEEE 802.11a - fully compliant
- Effective and simple
- Most effective in channel with low delay spreads