Indoor Wireless Communication System Performance Enhancement via Environmental Modification

by

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Abstract

High capacity wireless communication systems require efficient reuse of the available frequency spectrum. Frequency reuse in buildings can be enhanced by modifying the environment. However, the potential benefits of environmental modification need to be evaluated systematically to justify the related costs. This thesis reports the methods, the deployment strategies and the resulting system performance improvement of in-building environmental modification. In the investigation, coordinated deployment of a wireless communication system with multiple base stations is considered in several single-floor office environments. The base stations, each servicing a cell, are assumed to operate at the same set of frequencies thus adjacent interference results. Two modification methods, namely, metal reflectors and metal shields, are considered to enhance desired signals and mitigate adjacent interference, respectively. Significant impact of both methods on the propagation channel is experimentally observed. The potential benefits of deploying structural shielding to control interference are considered. The levels of adjacent interference are estimated for different shielding strategies by an experimentally-validated ray-model, and the outage probabilities are computed with an interference-limited DS-CDMA system model.

Deployment of structural shielding is shown to be most effective in drywall-partitioned environments and when the operating frequency is in the vicinity of 5 GHz. The average outage probability is shown to be reduced by approximately 94% and 90% at 1.8 GHz and 5.24 GHz, respectively, for a drywall-partitioned office environment after shielding 14% of the internal wall length. In open plan offices, the effectiveness of structural shielding is observed to diminish as the partition height reduces. Alternatively, considerable interference control is shown to be achieved by highly-reflective reflectors installed on the ceiling above the base stations. In the presence of a significant centrally-located environmental obstacle, the cost effectiveness of structural shielding deployment is shown to increase as the obstacle acts as an effective interference attenuator. If frequency selective surfaces (FSSs) are used instead of metal shields, a good shielding performance is shown to be achievable as long as the FSS stopband attenuation is maintained at above 20 dB for incident angles smaller than 50 degrees.

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Contents

List of Abbreviations and Acronyms

BER	bit-error-rate
BPSK	binary phase-shift keying
BS	base station
CDF	cumulative distribution function
CDMA	code division multiple access
DS-CDMA	direct sequence code division multiple access
DSSS	direct sequence spread spectrum
FDTD	finite-difference time-domain
FSS	frequency selective surface or frequency selective structure
FZP	Fresnel zone plate
GO	geometric optics
GPOF	generalised pencil-of-function
IFT	inverse Fourier transform
ISM	industrial, scientific and medical
LOS	line-of-sight
MPM	matrix pencil method
MT	mobile terminal
PDF	probability density function
PG	path gain
RA	receiving antenna
TA	transmitting antenna
SIR	signal-to-interference ratio
SNR	signal-to-noise ratio
SVD	singular value decomposition
UTD	uniform theory of diffraction
WLAN	wireless local area network