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Antenna Selection and Deployment Strategies for Indoor Wireless Communication Systems

by

Alex H. C. Wong

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of Doctor of Philosophy in Electrical and Electronic Engineering,
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Abstract

Effective antenna selection and deployment strategies are important for reducing co-channel interference in indoor wireless systems. Low-cost solutions are essential, and strategies that utilise simple antennas (such as directional patches) are advantageous from this perspective. However, performance is always an issue and the improvements achievable through clever antenna deployment need to be quantified. In this thesis, an experimental investigation of indoor propagation comparing the performance of directional antennas and multiple-element arrays (MEAs) with omni-directional antennas is reported. Estimation of the performance of a direct sequence code division multiple access (DS-CDMA) system operating in a variety of deployment scenarios allows the identification of a range of performance-limiting factors and the optimal deployment strategies.

It is shown that the orientation of single-element directional antennas can significantly impact on system performance compared to omni-directional antennas in traditional systems. The deployment of MEAs with an active diversity combining scheme can further improve system performance by more than one order of magnitude. From the perspective of system planning, the choice of antenna selection and deployment options depends on the current and future demand for system performance and the financial resources available. An evolutionary path has been proposed to provide a smooth transition from conventional (low-cost) to high-performance (high-cost) antenna systems as demand dictates.

Other performance-limiting factors in indoor wireless systems include the physical environment and external interference. It is also shown that electromagnetically-opaque obstacles in the environment can amplify the effectiveness of the antenna deployment by acting as physical zone boundaries that restrict interference. External interference has been shown to cause a significant degradation to the performance of an indoor system when the carrier-to-external-interference ratio (CEIR) is below 30 dB. This performance degradation can be minimised by appropriate antenna deployment, although the optimum antenna orientations depends on the strength of the external interference.

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List of Abbreviations and Acronyms

ACK	Acknowledgement
AMPS	Advanced Mobile Phone System
AWGN	additive white Gaussian noise
BER	bit-error-rate
BPSK	binary phase-shift keying
CDF	cumulative distribution function
CDMA	code division multiple access
CEIR	carrier-to-external-interference ratio
CIR	carrier-to-interference ratio
CNR	carrier-to-noise ratio
CSMA/CA	carrier-sense multiple access with collision avoidance
CSMA/CD	carrier-sense multiple access with collision detection
CTS	Clear to Send
CW	continuous-wave
DAMPS	digital advanced mobile phone system
DCOM	distributed component object model
DS	direct sum
DS-CDMA	direct sequence code division multiple access
DSMA	direct sequence multiple access
EDGE	Enhanced Data Rates for GSM Evolution
EGC	equal gain combining
EIRP	effective isotropic radiated power
FAF	floor attenuation factor
FDD	frequency division duplexing
FDMA	frequency division multiple access
FHMA	frequency hopped multiple access

FLMTS	Future Land Mobile Telephone System
FSK	frequency-shift keying
GO	geometrical optics
GPRS	General Packet Radio Service
GSM	Global System for Mobile communication
GUI	graphical user interface
i.i.d.	independent and identically distributed
ICI	inter-carrier interference
IDFT	inverse discrete Fourier transform
IFFT	inverse fast Fourier transform
i.i.d.	identical independently distributed
IMT	International Mobile Telecommunication
IS	ideal selection
ISI	inter-symbol interference
ISM	Industrial, Scientific and Medical
ITU-R	International Telecommunication Union — Radiocommunication Sector
LMCS	local multipoint communication systems
LOS	line-of-sight
MAC	medium access control
MAI	multiple-access interference
MEA	multiple-element array
MIMO	multiple-input multiple-output
MISO	multiple-input single-output
MRC	maximal gain combining
MUI	multiple-user interference
NLOS	non line-of-sight
NMT	Nordic Mobile Telephone
OFDM	orthogonal frequency division multiplexing
OFDMA	orthogonal frequency division multiple access
PCB	printed circuit board
PDC	Personal Digital Cellular
PDF	probability density function

PHY	physical
PIFA	planar inverted F-antenna
RF	radio frequency
RTS	Request to Send
RV	random variable
SDMA	space division multiple access
SIMO	single-input multiple-output
SIR	signal-to-interference ratio
SMS	short message service
SNR	signal-to-noise ratio
STC	space-time coding
SVD	singular value decomposition
TACS	Total Access Mobile communication Systems
TDD	time division duplexing
TDMA	time division multiple access
ULA	uniform linear array
UMTS	Universal Mobile Telecommunication System
UTD	uniform theory of diffraction
VCO	voltage controlled oscillator
VLSI	very large scale integration
VSWR	voltage standing wave ratio
WAF	wall attenuation factor
WECA	Wireless Ethernet Compatibility Alliance
WLAN	wireless local area network

