



# Wireless Communications

**Andrea Goldsmith**

# Wireless Communications

**ANDREA GOLDSMITH**

Stanford University



**CAMBRIDGE**  
UNIVERSITY PRESS

**DOCKET**  
**A L A R M**

Find authenticated court documents without watermarks at [docketalarm.com](https://docketalarm.com).

# WIRELESS COMMUNICATIONS

**Andrea Goldsmith**  
**Stanford University**

*The possession of knowledge does not kill the sense of wonder and mystery.*

*Anaïs Nin*

Copyright © 2005 by Cambridge University Press.

This material is in copyright. Subject to statutory exception and to the provisions of relevant collective licensing agreements, no reproduction of any part may take place without the written permission of Cambridge University Press.

# Contents

<b>1</b>	<b>Overview of Wireless Communications</b>	<b>1</b>
1.1	History of Wireless Communications . . . . .	1
1.2	Wireless Vision . . . . .	4
1.3	Technical Issues . . . . .	5
1.4	Current Wireless Systems . . . . .	7
1.4.1	Cellular Telephone Systems . . . . .	7
1.4.2	Cordless Phones . . . . .	11
1.4.3	Wireless LANs . . . . .	12
1.4.4	Wide Area Wireless Data Services . . . . .	13
1.4.5	Broadband Wireless Access . . . . .	14
1.4.6	Paging Systems . . . . .	14
1.4.7	Satellite Networks . . . . .	15
1.4.8	Low-Cost Low-Power Radios: Bluetooth and Zigbee . . . . .	15
1.4.9	Ultrawideband Radios . . . . .	16
1.5	The Wireless Spectrum . . . . .	17
1.5.1	Methods for Spectrum Allocation . . . . .	17
1.5.2	Spectrum Allocations for Existing Systems . . . . .	18
1.6	Standards . . . . .	19
<b>2</b>	<b>Path Loss and Shadowing</b>	<b>24</b>
2.1	Radio Wave Propagation . . . . .	25
2.2	Transmit and Receive Signal Models . . . . .	26
2.3	Free-Space Path Loss . . . . .	28
2.4	Ray Tracing . . . . .	29
2.4.1	Two-Ray Model . . . . .	30
2.4.2	Ten-Ray Model (Dielectric Canyon) . . . . .	33
2.4.3	General Ray Tracing . . . . .	34
2.4.4	Local Mean Received Power . . . . .	36
2.5	Empirical Path Loss Models . . . . .	36
2.5.1	The Okumura Model . . . . .	37
2.5.2	Hata Model . . . . .	37
2.5.3	COST 231 Extension to Hata Model . . . . .	38
2.5.4	Piecewise Linear (Multi-Slope) Model . . . . .	38
2.5.5	Indoor Attenuation Factors . . . . .	39
2.6	Simplified Path Loss Model . . . . .	40
2.7	Shadow Fading . . . . .	42

# Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

## Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

## Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

## Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

## API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

## LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

## FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

## E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.