

# Digital Cellular Radio

GEORGE CALHOUN



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# Digital Cellular Radio

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## *Preface*

This book is divided into six parts. Part I is a brief essay on the current state of affairs in the mobile telephone industry, and on the confusion and excitement surrounding the “digital revolution.”

Part II is a survey of the development of mobile-telephone systems in the United States, focusing on the difficulties currently being experienced by analog cellular radio — the problems which have convinced many that a new generation of technology must come in.

Part III is a presentation of some of the basic ideas and vocabulary of digital communication. Emphasis is given to the generic concepts and advantages of digital *transmission*, and to the emerging metaconcepts of the *integrated digital network*. Part III should be viewed as preparatory for the discussion of digital *radio* in Part V.

Part IV poses the basic design problems which confront the mobile communication architect. Particular attention is given to the challenge of designing a radio system to provide high-quality telephone circuits for users who are moving at high speeds through a radio-hostile urban environment. A second major consideration: how to design so as to manage interference between mobiles on the same channel and, thus, allow frequency reuse. Other design considerations include: designing for low cost, designing for compatibility with changing network characteristics, and designing for the competitive, nonmonopoly, marketplace.

Part V contains what some may consider the meat of this book: the analysis of the broad technological alternatives available to systems designers for the next generation of mobile systems.

Part VI addresses the other crucial question: How do we get there from here? How will the transition take place? Particular emphasis will be placed on the question of standards and the subsidiary issues of compatibility (backwards, forwards, and sideways) and openness to continuing technological progress.

I have not approached these questions with a narrow, particularistic solution or criterion in mind. My chief acknowledged bias is that I do not believe the current cellular technology is capable of righting itself. A few years ago this opinion would have been more controversial than it is today. Today the controversy begins when solutions are proposed.

I am virtually certain that the next generation will be digital. Again, this would have been more open to question a few years ago than it appears today. There are still, however, at least two nondigital proposals for the next generation — single sideband and narrowband FM — which have received some support. I have tried to review these fairly in Chapter 12, but I confess that I cannot actually regard them as viable alternatives for the long term.

With respect to other facets of the technological analysis, I admit to holding strong personal opinions on many of the issues addressed, and this may perhaps become evident in a few places. I believe above all else, however, that the choices for the next generation are still open; there is no definitive solution at hand.

I offer a few opinions on the regulator's dilemma — to standardize or not to standardize — in Part VI. It should be clear enough where I am stating my own opinions on this question, since they are not yet widely shared.

My focus is primarily on developments in the United States, particularly in the historical sections. The materials for a comparable historical and policy perspective on cellular developments in Japan or Europe are simply not readily available to me. I have tried to provide a brief summary of European developments in particular, as viewed from afar; I am sure that it will be found inadequate by any readers there. This deficiency will be felt most keenly in Part II and, to a lesser degree, in Part VI. It should be less of a problem in Parts III, IV, and V.

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## *Contents*

Preface	xi
Acknowledgments	xiii
Part I Introduction	1
CHAPTER 1 THE UNCERTAIN FUTURE OF MOBILE TELEPHONY	3
1.1 Marconi <i>versus</i> Bell	3
1.2 The Unique Failure of Mobile Telephony	7
1.3 The Cellular "Disaster"	12
1.4 The "Digital" Panacea	17
Part II The Age of FM	21
CHAPTER 2 MOBILE RADIO BEFORE CELLULAR: 1921–1968	23
2.1 The Pioneer Phase: 1921–1945	23
2.2 The Commercial Phase: 1946–1968	29
CHAPTER 3 THE CELLULAR IDEA: 1947–1982	39
3.1 The Evolution of the Cellular Idea	39
3.2 The Struggle for Spectrum: 1947–1970	45
3.3 Industry Politics: 1970–1982	49
3.4 Competition and the Changing Regulatory Agenda: 1970–1982	54
CHAPTER 4 CELLULAR REALITIES	63
4.1 The Cost Syndrome	68
4.1.1 Mobile Equipment Economics	68
4.1.2 Cellular System Economics	72
4.1.2.1 System Overhead Costs (Hardware)	74
4.1.2.2 Start-Up and Operating Costs	83
4.1.2.3 Cellular Pricing	86
4.2 The Performance Syndrome	92

---

4.2.1	Coverage Problems	93
4.2.2	Call-Processing Problems	98
4.2.3	Privacy and Security	103
4.2.4	Data Transmission	111
4.3	The Spectrum Efficiency Syndrome	113
4.4	The Licensing Syndrome	120
4.4.1	The Comparative-Hearings Phase	121
4.4.2	The Lottery Phase	124
4.4.3	Speculation	129
4.5	The End of an Era	134
	Part III Digital Communication: The Basics	141
	CHAPTER 5 THE REEMERGENCE OF DIGITAL COMMUNICATION	143
5.1	The Analog Revolution	143
5.2	The Digital Resurgence	146
	CHAPTER 6 THE DIGITAL VOCABULARY	151
6.1	The First Coding Stage: A/D Conversion	154
6.1.1	Sampling	154
6.1.2	Quantization	158
6.1.3	Coding	160
6.2	The Second Coding Stage: Modulation	164
6.3	Transmission and Signal Processing	168
6.3.1	Regeneration: The “Conquest of Distance”	170
6.3.2	Control of Intersymbol Interference: Recovery of the Physical Code	174
6.3.3	Error Control: Recovery of the Logical Code	177
6.3.4	Multiplexing	178
	CHAPTER 7 THE ADVANTAGES OF DIGITAL COMMUNICATION	185
7.1	The Digital Network	187
7.2	The Digital Network Is Robust	188
7.3	The Intelligence of the Digital Network	190
7.4	The Flexibility of the Digital Network	192
7.5	The Digital Network Is Generic	192
7.6	The Efficiency of the Digital Network	193
7.7	Security and the Digital Network	193
7.8	The Digital Network Is Dynamic	194
7.9	The Integrated Digital Network	195
	Part IV Design Challenges for Mobile Telephony	197
	CHAPTER 8 DESIGNING FOR THE MOBILE ENVIRONMENT	199

---

8.1	The Vocabulary of Radio	202
8.2	The Fate of the Radio Wave	206
8.2.1	Free Space Loss	206
8.2.2	Blockage (Attenuation)	207
8.2.3	Multipath	212
8.2.3.1	Delay Spread	214
8.2.3.2	Rayleigh Fading	216
8.2.3.3	Doppler Shift	220
8.3	Effects on System Performance	221
8.3.1	Path Effects	221
8.3.2	System Effects	222
8.4	Traditional Countermeasures	225
8.4.1	Fade Margins	225
8.4.2	Diversity	226
8.4.3	Supplementary Base Stations	229
8.5	Digital Countermeasures	229
8.5.1	Robust Voice Coding	231
8.5.2	Robust Modulation	232
8.5.3	Adaptive Equalization	232
8.5.4	Error Correction	235
CHAPTER 9 DESIGNING FOR FREQUENCY REUSE		239
9.1	The Engineering Implications of Frequency Reuse	240
9.2	Interference-Limited Systems	242
9.3	Cochannel Interference and the Mobile Environment	244
9.4	The Relationship Between Geographical Separation and the Reuse Factor	249
9.5	The Effect of Reduced C/I Requirements for Digital Systems	251
CHAPTER 10 OTHER DESIGN CONSIDERATIONS		255
10.1	Designing for Modularity and Geographical Flexibility	256
10.1.1	Example: Adjacent Channel Utilization	257
10.1.2	Example: Modularity and Growth	259
10.2	Designing for Low Cost	259
10.3	Designing for Compatibility with Future Network Services	260
10.4	Designing for a Competitive Marketplace	262
10.4.1	Future Proofing	262
10.4.2	Competition Among Operators	263
Part V Technological Alternatives for the Next Generation		265
CHAPTER 11 THE BROAD TECHNOLOGY ALTERNATIVES		267
11.1	The Flexibility of Digital Design	268
11.2	The Flexibility of Digital Formats	269
11.3	Analog <i>versus</i> Digital	274

---

11.4	Wideband <i>versus</i> Narrowband Systems	276
11.5	Multiplexing and Access Technique: FDMA <i>versus</i> TDMA <i>versus</i> CDMA	283
11.6	System Control Structures: Centralized <i>versus</i> Distributed Control	290
11.6.1	Nets	290
11.6.2	Interface Point	294
11.7	Summary of General Directions of the Next Generation	294
CHAPTER 12	ALTERNATIVES FOR THE RADIO LINK	297
12.1	Analog Techniques	298
12.1.1	Narrowband FM	298
12.1.2	Single-Sideband Modulation	299
12.2	Digital Techniques	303
12.2.1	Digital Modulation for Mobile Radio	304
12.2.1.1	Spectral Efficiency and Multilevel Modulation	304
12.2.1.2	Narrow Power Spectrum	309
12.2.1.3	Intersymbol Interference	312
12.2.1.4	Modulation Strategies	316
12.2.2	Voice Coding for Mobile Radio	317
12.2.2.1	Coding Strategies	318
12.2.2.2	Representative Coding Techniques	321
12.2.3	Interdependence of Coding and Modulation	334
12.2.3.1	Interdependent Design	334
12.2.3.2	Interdependent Performance	336
12.3	Spread-Spectrum Techniques	339
12.3.1	The Great Unknown	339
12.3.2	The Background of Spread Spectrum	343
12.3.3	Frequency-Hopping Spread Spectrum (FH/SS)	344
12.3.4	Direct-Sequence Spread Spectrum (DS/SS)	351
12.3.5	Performance of Spread-Spectrum Techniques	355
12.3.6	Application to Mobile-Telephone Systems	356
CHAPTER 13	ALTERNATIVE SYSTEM ARCHITECTURES: CELL LEVEL	363
13.1	FDMA Architecture	365
13.2	TDMA Architecture	369
13.3	CDMA Architecture	373
CHAPTER 14	ALTERNATIVE SYSTEM ARCHITECTURES: NETWORK LEVEL	377
14.1	Frequency Plans	378
14.2	Growth Plans	381

---

14.3	Cochannel-Interference Reduction Measures	381
14.4	Traffic and Service Objectives	383
14.5	Roaming and Related Issues	384
14.6	Interface to the Wireline Network	385
14.7	Control: Centralized <i>versus</i> Distributed	389
CHAPTER 15 CHOOSING THE FUTURE: EVALUATING THE ALTERNATIVES		393
15.1	Spectrum Efficiency	394
15.1.1	Spectral Efficiency (Information Density)	394
15.1.2	Circuit Spectrum Efficiency: Circuits per Megahertz	395
15.1.3	Geographical Spectrum Efficiency: Circuits per Square Mile	396
15.1.4	Economic Spectrum Efficiency: Cost per Circuit (per Megahertz per Square Mile)	398
15.1.5	Communication Efficiency: Improved Individual Communication Utility	398
15.1.6	Allocation Efficiency: Improved Social Utility of Communication	401
15.1.7	Improving Spectrum Efficiency	403
15.1.8	Summary	409
15.2	Cost	410
15.2.1	System Cost Comparisons	410
15.2.2	Mobile-Unit Cost Comparisons	414
15.2.3	Operating Cost Comparisons	415
15.3	Other Criteria: Modularity, Digital Compatibility, Openness to New Technology	415
15.3.1	Modularity and Geographical Flexibility	415
15.3.2	Digital Network Compatibility	416
15.3.3	Openness to New Technology	417
15.4	Summary	418
Part VI Managing the Transition		421
CHAPTER 16 A LOOK AHEAD		423
16.1	The Question of Standards	426
16.2	Looking Backward: Compatibility of the Next Generation with the Installed Analog Base	432
16.3	Looking Forward: Openness to Future Technological Change	437
16.4	Competition	438
16.5	A Modest Proposal	442
Index		445

*Part I*  
*INTRODUCTION*



# *Chapter 1*

## **THE UNCERTAIN FUTURE OF MOBILE TELEPHONY**

### **1.1 MARCONI *versus* BELL**

It is often said that we are on the verge of a “revolution” in mobile communications, a revolution that will ultimately liberate us as communication users from being tied down to a particular fixed location in the telephone network, and will provide us with an advanced voice and data communication capability in a highly portable package (one that is at least “briefcase-friendly,” and preferably “body-friendly,” in the current jargon), at a reasonable price. Today, for some, this mobile revolution is a grand vision about to become reality: like Gulliver on the beach, the whole network will soon awaken and brush away the wires that hold it fast, and rise to astound the Lilliputians (ourselves) with its far-reaching powers.

Despite a series of disappointing false starts, the communication world in the late 1980s *is* rapidly becoming more mobile for a much broader segment of communication users than ever before. Thirty years ago only a handful of people had ever used a mobile communication device of any kind. Today, the growth of Citizens Band Radio, one-way paging systems, “cordless” telephones, and especially the widespread use of radio systems in industry (at construction sites and transportation facilities, by security guards, in dispatch fleets, *et cetera*) have exposed millions of people to the technology of wireless communication and have influenced patterns of work and leisure on a wide scale.

The ability of this rapidly growing community of wireless communication users to interface to the existing *wireline* network, however, is still very limited. The “flagship” of the mobile services — interconnected mobile telephony — has experienced a rocky technical and regulatory history. For decades it remained a stunted niche business, for reasons that



encompassed both technical and economic constraints, but which were rooted in the briar-patch of telephony politics and spectrum management (or mismanagement). Even the application of the newer “cellular” architecture, far from unsnarling these difficulties, has only amplified them. While equipment costs have come down, the economics of mobile telephone *service* remain out of reach for the vast majority of potential users. The technical difficulties of scaling up the mobile architecture for large urban networks continue to frustrate system engineers. Mobile telephony is hampered by obsolete technology standards that make it very difficult, perhaps impossible, to play into the emerging digital network services on the wireline side or to handle modern data-communication requirements. The lack of privacy in today’s analog radio systems is not easily remedied (cosmetic legislation aside), and creates an imbalance between the service standards of the two networks. Finally, mobile telephony in the late 1980s has inherited a flawed regulatory process that has been designed and redesigned by a hundred interest groups, tweaked and critiqued by economists, lawyers, and engineers, scrapped and salvaged, challenged, upheld, and compromised in the courts (judicial and administrative) for more than twenty years, spanning the last years of the monolithic communication monopoly into the era of wide-open competitive markets. Regulatory goals have been put on the defensive, and regulatory mechanisms — in particular the licensing process — have devolved into a patchwork of partial solutions, from which it often seems that any semblance of policy rationale has been lost.

Today “cellular radio” stands in the spotlight, with its hopes illuminated and its deficiencies exposed, still pretending to a degree of technological permanence that once seemed more valid than it does today. We shall dwell at some length (in Part II) upon its shortcomings. The “mobile revolution” is, however, much larger than the current generation of cellular radio, and its immediate problems, although severe in some respects, should be recognized as developmental rather than fundamental. Consider a parallel case. Thirty years ago computers were bulky monstrosities: expensive, power-hungry, slow, finicky. Viewed from today’s perspective, the basic technology was inadequate. Computers were too slow for many tasks, and too fragile for most environments. It would have been inconceivable to put such computers in a car, aboard an orbiting satellite, or on someone’s desk. Yet, the breakthroughs came, and today observers would agree that computer applications are no longer restricted by technology — hardware capability and availability — as much as by the economics, architecture, and ingenuity of the software implementations. At least as far as conventional data-processing (nonreal-time) applications are concerned, the hardware is fast enough, cheap enough, and