WILLIAM WEBB

Wireless Communications

THE FUTURE



Contents

Preface		X
Acknowledgements		xvi
A	bout the Author	xix
1	Predicting the Future is a Necessary Part of Business	1
2	Previous Predictions have been Accurate	3
	2.1 Introduction	3
	2.2 There have been Huge Changes in the Telecoms Climate	3
	2.3 What we Predicted for the Period 2000–2005	(
	2.4 How Well did we do?	7
	2.5 Our Predictions for 2005–2010	8
	2.6 How Good do these Predictions Look Now?	ç
	2.7 Implications for Forecasting the Future	ç
3	How to put Together a Forecast	11
4	The Current Position	13
	4.1 The Value of a Good Understanding of the Starting Position	13
	4.2 Mobile Communications	14
	4.2.1 Cellular	14
	Introduction to Cellular [1–3]	14
	2G Cellular	15
	3G Cellular	17
	WiMax for Mobile Applications	18
	'4G' Cellular	19
	Convergent Technologies	21
	Summary for Cellular	22
	4.2.2 Private Mobile Radio	22
	Introduction	22
	Analogue Communications	23
	Digital Communications	23

iii		Contents

	4.2.3 Mobile Mesh Systems	24
	4.2.4 Cognitive Radio	25
_	4.3 Fixed wireless	27
	4.3.1 Introduction	27
	4.3.2 Key Drivers for Fixed Wireless	27
	4.3.3 Key Competitors to Fixed Wireless	28
	4.3.4 Likely Success of Fixed Wireless	28
	4.3.5 Enlarging the Market with a Nomadic Offering	29
	4.3.6 The Prognosis for Fixed Wireless	29
	4.4 Short-range Devices	30
	4.4.1 Introduction	30
	4.4.2 Overview of the Standards for Short-range Devices	31
	4.4.3 Ultra Wideband (UWB)	32
	4.4.4 Wireless LANs [5]	33
	4.4.5 BlueTooth [6]	34
	4.4.6 DECT	35
	4.4.7 Zigbee	35
	4.4.8 RFIDs	36
	4.4.9 The Prognosis for Short-range Devices	36
	4.5 Core Networks	37
	4.6 Broadcasting	39
	4.6.1 Conventional Broadcasting	39
	4.6.2 Mobile Broadcasting	41
	4.7 Industry Structure	42
	4.8 Summary	42
	4.9 Appendix: The Role for OFDM	43
	OFDM is Increasingly in Favour	. 43
	A Quick Introduction to OFDM	43
	Multipath: the Key Difference between OFDM and SCM	44
	Equalisers may become too Complex to be Realisable	45
	Problems Specific to OFDM	45
	Specific Applications	45
	So is OFDM the New 'Technology of Choice'?	48
	References	48
5	End User Demand	49
-	5.1 Why What the User Wants is Critical	49
	5.2 How People React to New Concepts	49
	5.3 Changing Patterns of Spending	51
	5.4 What they have Today	53
	5.5 What they want Now	53
	5.6 Security, Privacy and Health Concerns	55
	5.7 The Handset Subsidy Problem	56
	5.8 In Summary	57
		59
6	Technology Progress	59
	6.1 Technology is a Critical Input to any Forecast	
	6.2 Key Technical Fundamentals: The 'True' Laws	60

	٦

	6.3 Key Technical Observations: The 'Empirical' Laws	62
	6.3.1 Moore's Law	62
	6.3.2 Metcalfe's Law	63
	6.3.3 Gilder's Law	64
	6.3.4 Cooper's Law	65
	6.3.5 Edholm's Law	67
	6.3.6 Growth in Disk Size	68
	6.3.7 Goodhart's Law	70
	6.3.8 Laws or Trends?	70
	6.4 Technologies on the 'Radar Screen'	70
	6.4.1 Technologies Enhancing the Efficiency of Transmission	71
	Software-defined Radio	71
	Smart Antennas	71
	Wireless Mesh Networking	72
	Interference Cancellation	73
	Cognitive Radio	74
	6.4.2 Technologies Lowering Cost: Backhaul	74
	6.4.3 Technologies Enhancing Interaction with Terminals	76
	6.4.4 Technologies Leading to 'Artificial Intelligence'	84
	6.4.5 Compression Technologies	85
	6.5 Technology Prognosis: No Key Breakthroughs	85
	6.6 Implications for the Future	85
	References	86
7	7 Major World Events	87
	7.1 Introduction	87
	7.2 World Events	87
	7.3 Events in Related Industries	89
	7.4 Summary	90
	7.5 The Next Chapters	90
8	8 Future Military Wireless Solutions	91
•	Paul S. Cannon and Clive R. Harding	
	8.1 Introduction	91
	8.2 Operational Context	92
	8.3 Technical Features Important to Secure and Robust Global Military	
	Communications	93
	8.4 New Platforms and Missions: Their Impact on Military Communication Sy	stems 94
	8.4.1 Impact of Unmanned Vehicles	94
	8.4.2 Impact of High-Altitude Platforms (HAPs)	95
	8.4.3 Impact of Future Infantry Soldier Technology	96
	8.4.4 Impact of Wireless Sensor Networks	96
	8.5 Developments in Military Communications Systems	97
	8.5.1 Introduction	97
	8.5.2 Very Low-Frequency (VLF) Communications	97
	8.5.3 High-Frequency (HF) Communications	98
	8.5.4 Terrestrial VHF, UHF and SHF Tactical Communications	99
	8.5.5 Satellite Communications	100
	8.6 Emerging Communications Techniques	103
	8.6.1 Introduction	103
	C. C. I ATTE COMPLETO	

x Contents

	8.6.2 Ad-hoc Networks	103
	8.6.3 Disruption-Tolerant Networks (DTN)	103
	8.6.4 Software-Defined Radio (SDR)	103
	8.6.5 Environmental Modelling for Communications Management	104
	8.6.6 Spectrum Management and Utilisation	107
	8.6.7 Smart Antennas for Military Communications	109
	8.6.8 The Push to Higher RF Frequencies and Laser Communications	109
	8.6.9 Ultra Wideband (UWB) Techniques	110
	8.6.10 Communications Security	110
	8.7 Some Emerging Technologies with Communications Relevance	111
	8.7.1 Introduction	111
	8.7.2 Beyond Silicon Technologies	111
	8.7.3 Potential of Nanotechnology	111
	8.7.4 Quantum Cryptography and Quantum Computing	112
	8.7.5 Negative Refractive Materials and Their Applications	113
	8.7.6 Low-power High-stability Reference Sources	113
	8.7.7 Power Sources	113
	8.8 The Role for Commercial Off-the-shelf for Military Communications	114
	8.9 Summary and Conclusions	114
	Acknowledgements	115
	References	115
	Biographies	115
9	From the Few to the Many: Macro to Micro	117
	Peter Cochrane	
	9.1 In the Beginning	117
	9.2 The Need for Planning, Regulation and Control	118
	9.3 Some General Trends	120
	9.4 What do People Want and Need?	122
	9.5 What can People Expect/Have?	123
	9.6 Likely Technology Developments	124
	9.6.1 Home and Office	124
	9.6.2 Manufacturing, Retail and Logistics	126
	9.6.3 Logistics of Things and People	126
	9.6.4 Parasitic Networks	127
	9.6.5 Mobile Sensor Networks	128
	9.7 Clusters of People and Things	128
	9.8 Finally	129
	Biography	131
10	The Role of Ad-hoc Technology in the Broadband Wireless Networks	
10	of the Future	133
	Gary Grube and Hamid Ahmadi	
	10.1 Introduction	133
	10.2 The Need for Flexible Wireless Broadband Solutions	134
	10.3 Current and Emerging Models of Peer-to-Peer Broadband	
	Connectivity	136
	10.3.1 Wireless Home Networks	136
	10.3.2 Military Applications	137
	10.3.3 Public Safety	137

		10.3.4 Private and Public Transportation	138
		10.3.5 Metro-area Broadband Networks	139
		10.3.6 Mining and Manufacturing	139
		10.3.7 Corporate Networks	139
		10.3.8 Sensor Networks and Things-to-Things Communication	140
	10.4	Enabling the Next Generation of Ad-hoc Connectivity	140
	10.5	Types of Ad-hoc Network	142
		10.5.1 Autonomous Peer-to-Peer Networks	142
		10.5.2 Hybrid Mesh Networks	143
	10.6	Integrated Ad-hoc and Wide Area Networks	144
		10.6.1 Linking of Ad-hoc Workgroups	144
		10.6.2 Extension of carrier broadband networks	144
		10.6.3 Enhanced Network Performance	144
	10.7	Enabling Technologies	145
		10.7.1 Self-configuration and Self-organisation	145
		10.7.2 Multi-hopping and Dynamic Routing of Data Packets	145
		10.7.3 Smart Sensors and Devices	146
		10.7.4 Location-awareness	146
		10.7.5 Low-power and Energy-scavenging Technologies	146
		10.7.6 End User Control over Preferences and Privacy	147
	10.8	New Business and Usage Models	147
	10.9	Benefits of Ad-hoc Technology Wireless Carriers and Internet Providers	150
		10.9.1 Incumbent Wireless Carriers	150
		10.9.2 Cable Broadband Operators	150
		10.9.3 'Mom and Pop' Wisps	151
		10.9.4 Greenfield Operators	151
		10.9.5 Marketers	151
	10.10	A Decentralised Future and Boundless Opportunities	152
		Reference	152
		Biographies	153
11	Inter	ference and Our Wireless Future	155
	Denn	is A. Roberson	
	11.1	Introduction	155
		History	156
	11.3	Spectrum Scarcity	157
		Regulatory Directions Toward Scarcity Amelioration	157
	11.5	Scarcity Amelioration Approaches	162
	11.6	Emerging Wireless Communications Devices and Systems	162
		References	165
		Biography	166
12		e Ages of Future Wireless Communications	167
		s Saunders	
	12.1	Introduction	167
	12.2	The Age of Wireless Proliferation: 2007 to 2011	169
		12.2.1 Introduction	169
		12.2.2 Services and Applications	170
		12.2.3 Devices	172
		12.2.4 Infrastructure	173

xii Contents

	12.2.5 Air Interfaces	173
	12.2.6 Spectrum	174
	12.3 The Age of Wireless Similarity: 2012 to 2016	175
	12.3.1 Introduction	175
	12.3.2 Services and Applications	175
	12.3.3 Devices	176
	12.3.4 Infrastructure	176
	12.3.5 Air Interfaces	177
	12.3.6 Spectrum	178
	12.4 The Age of Wireless Mundanity: 2017 to 2026	179
	12.4.1 Introduction	179
	12.4.2 Services and Applications	179
	12.4.3 Devices	180
	12.4.4 Infrastructure	180
	12.4.5 Air Interfaces	181
	12.4.6 Spectrum	181
	12.5 Conclusions and Summary	182
	Reference	183
	Biography	184
13	Mobile Cellular Radio Technology Disruption	185
	Stephen Temple CBE	
	13.1 Extrapolating from the Past 25 Years of Public Mobile Radio	185
	13.2 The Law of Large Network Momentum	187
	13.3 Third-generation W-CDMA Future	188
	13.4 Fourth-generation Technology	190
	13.5 Where does this Leave the Switch-off of GSM?	192
	13.6 The 3G Cellular Radio Network Landscape Ten Years from now	194
	13.7 Convergence as a Disruptive Force	195
	13.7.1 Convergence: Mobile and Broadcasting	195
	13.7.2 Convergence: Internet and Telephone Services	197
	13.7.3 Convergence and the 'Battle for the Home'	198
	Broadband Heavy-user Homes	200
	Broadband Light-user Homes	202
	Homes with no DSL Connection	203
	13.7.4 Convergence and the Evolution of Mobile Handsets	203
	13.7.5 Summary Impact of Convergence as a Disruptive Force	204
	13.8 The Blindside Forces of Disruption	205
	13.8.1 Governments	205
	13.8.2 Regulatory Loose Cannons	206
	13.8.3 Disruptive Competitors	207
	13.8.4 Disruptive Suppliers	207
	13.8.5 Gyrating Financial Markets	208
	13.8.6 Unpredictable Customers	208
	13.8.7 Disruptive Technologies	209
	13.8.8 The Global Perspective	209
	13.8.9 Summary Vision of the 'Blindside' Forces	210
	13.9 Conclusions	210
	Biography	211

Contents

14	Assimilating the Key Factors	213
	14.1 Introduction	213
	14.2 Summary of the Current Position	213
	14.3 Summary of End User Demand	214
	14.4 Summary from Technology Advances Section	214
	14.5 Summary from the Contributors	215
	Paul Cannon	215
	Peter Cochrane	216
	Gary Grube and Hamid Ahmadi	216
	Dennis Roberson	216
	Simon Saunders	217
	Stephen Temple	217
	14.6 Key Factors brought out by the Contributors	218
	14.6.1 Areas not Included in Previous Discussion	218
	Connectivity	218
	Backhaul	219
	Applications	219
	Technology	219
	Regulation	219
	14.6.2 Areas of Disagreement	219
	14.7 Reaching a Verdict on the Areas of Disagreement	220
	14.8 Drawing these Key Factors Together	221
15	The Future Roadmap	223
	15.1 Introduction	223
	15.2 Predictions for 2011	223
	15.3 Predictions for 2016	227
	15.4 Predictions for 2021	232
	15.5 Predictions for 2026	233
	15.6 Key New Applications	235
	15.7 Key New Technologies	236
	15.8 Key Changes in Networks	237
	15.9 Major Growth Areas	238
	15.10 Areas we Predict Will not be Successful	238
	15.11 Implications for Stakeholders	239
	Manufacturers	239
	Operators	239
	Service Providers	240
	Regulators	240
	Academics and Researchers	240
	15.12 Differences from the Prediction Made in 2000	241
	15.13 The Future in a Page	243
	15.14 And the Elevator Pitch	244
Lis	st of Acronyms	245
Ind	dex	249