

OPTIMIZING NETWORKS: GLOBAL MARKETS FOR SMALL CELLS AND CARRIER WI-FI



IFT108A
March 2014

Shalini R
Project Analyst

ISBN: 1-56965-756-4

bcc | Research
Market Forecasting

BCC Research
49 Walnut Park, Building 2
Wellesley, MA 02481 USA
866-285-7215 (toll-free within the USA),
or (+1) 781-489-7301
www.bccresearch.com
information@bccresearch.com

TABLE OF CONTENTS

TOPIC	PAGE NO.
CHAPTER 1 INTRODUCTION	2
STUDY GOALS AND OBJECTIVES	3
REASONS FOR DOING THE STUDY	3
SCOPE OF THE REPORT	4
INTENDED AUDIENCE	5
METHODOLOGY	6
INFORMATION SOURCES	6
AUTHOR'S CREDENTIALS	6
RELATED BCC RESEARCH REPORTS	6
BCC RESEARCH WEBSITE	7
DISCLAIMER	7
CHAPTER 2 EXECUTIVE SUMMARY	9
<i>SUMMARY TABLE DOLLAR SALES OF SMALL CELLS AND CARRIER-WI-FI DEVICES, BY DEVICE TYPE, THROUGH 2019 (\$ MILLIONS)</i>	9
<i>SUMMARY FIGURE DOLLAR SALES OF SMALL CELLS AND CARRIER-WI-FI DEVICES, BY DEVICE TYPE, 2014 AND 2019 (\$ MILLIONS)</i>	9
CHAPTER 3 QUALITATIVE AND QUANTITATIVE OVERVIEW OF SMALL CELLS AND CARRIER-WI-FI DEVICES	13
DEFINITIONS	13
MARKET OVERVIEW	13
BREAK DOWN BY DEVICE TYPE	13
<i>TABLE 1 SHIPMENT SALES OF SMALL CELLS AND CARRIER-WI-FI DEVICES, BY DEVICE TYPE, THROUGH 2019 (THOUSANDS OF UNITS)</i>	14
SMALL-CELL CATEGORY-FEMTOCELL DEVICES	15
INTRODUCTION	15
Modus Operandi	15
LTE and Femtocells	16
Case Study-Femtocells Offered by Ubiquisys	16
Drivers and Challenges	16
SMALL-CELL CATEGORY-PICOCELL DEVICES	17
INTRODUCTION	17
Modus Operandi	18
Case Study-100LP Picocell Offered by BelAir	18
Case Study-NanoBTS Picocell Offered by IP Access	19
Drivers and Challenges	19
SMALL-CELL CATEGORY-MICROCELL DEVICES	20
INTRODUCTION	20
Drivers and Challenges	20
CARRIER WI-FI	21
INTRODUCTION	21
Need for Carrier Wi-Fi	21
Passpoint-the Ultimate Enabler for Carrier Wi-Fi	22
Case Study-Ericsson	23
Drivers and Challenges	23

TOPIC	PAGE NO.
GLOSSARY OF KEY TERMS AND TECHNOLOGIES	23
BLUETOOTH	23
Relevance to Small Cells and Carrier Wi-Fi	23
Larger Description	23
DIRECTIVITY	25
Relevance to Small Cells and Carrier Wi-Fi	25
Larger Description	25
DIVERSITY	25
Relevance to Small Cells and Carrier Wi-Fi	25
Larger Description	25
EFFICIENCY	25
Relevance to Small Cells and Carrier Wi-Fi	25
Larger Description	26
ELECTROMAGNETIC (EM) WAVE	26
Relevance to Small Cells and Carrier Wi-Fi	26
Larger Description	26
EQUIVALENT ISOTROPICALLY RADIATED POWER (EIRP)	26
Relevance to Small Cells and Carrier Wi-Fi	26
Larger Description	26
FADING	27
Relevance to Small Cells and Carrier Wi-Fi	27
Larger Description	27
FRACTAL ANTENNA	27
Relevance to Small Cells and Carrier Wi-Fi	27
Larger Description	27
FREQUENCY AND WAVELENGTH	28
Relevance to Small Cells and Carrier Wi-Fi	28
Larger Description	28
FREQUENCY BANDS	28
Relevance to Small Cells and Carrier Wi-Fi	28
Larger Description	28
GLOBAL POSITIONING SYSTEM	29
Relevance to Small Cells and Carrier Wi-Fi	29
Larger Description	29
GPS in Mobile Phones	30
A-GPS	31
Location-Based Services	31
GLOBALNAYA NAVIGATSIONNAYA SPUTNIKOVAYA SISTEMA (GLONASS)	31
Relevance to Small Cells and Carrier Wi-Fi	31
Larger Description	31
IMPEDANCE	32
Relevance to Small Cells and Carrier Wi-Fi	32
Larger Description	32
ISM BAND	32
Relevance to Small Cells and Carrier Wi-Fi	32
Larger Description	32
MAXWELL'S THEOREM	32

TOPIC	PAGE NO.
Relevance to Small Cells and Carrier Wi-Fi	32
Larger Description	32
NEAR-FIELD COMMUNICATION	33
Relevance to Small Cells and Carrier Wi-Fi	33
Larger Description	33
PATCH ANTENNAS	34
Relevance to Small Cells and Carrier Wi-Fi	34
Larger Description	34
POLARIZATION	34
Relevance to Small Cells and Carrier Wi-Fi	34
Larger Description	34
RFID	35
Relevance to Small Cells and Carrier Wi-Fi	35
Larger Description	35
POWER GAIN	35
Relevance to Small Cells and Carrier Wi-Fi	35
Larger Description	35
Q-FACTOR	36
Relevance to Small Cells and Carrier Wi-Fi	36
Larger Description	36
RADIATION PATTERN	36
Relevance to Small Cells and Carrier Wi-Fi	36
Larger Description	36
SIDE LOBES	36
Relevance to Small Cells and Carrier Wi-Fi	36
Larger Description	37
SMART ANTENNA	37
Relevance to Small Cells and Carrier Wi-Fi	37
Larger Description	37
MIMO Antenna	38
WAVEGUIDES	38
Relevance to Small Cells and Carrier Wi-Fi	38
Larger Description	38
ENABLING TECHNOLOGIES FOR SMALL CELLS AND CARRIER WI-FI-CELLULAR STANDARDS	39
GSM	39
General Packet Radio Service	40
Enhanced Data Rates for GSM Evolution	41
UNIVERSAL MOBILE TELECOMMUNICATIONS SYSTEM	41
LONG-TERM EVOLUTION	42
CDMA	42
WORLDWIDE INTEROPERABILITY FOR MICROWAVE ACCESS	43
MOBILE BROADBAND-SIMULTANEOUS GAME CHANGER AND CHALLENGE FOR NETWORK DESIGNERS	44
ENABLING TECHNOLOGIES FOR SMALL CELLS AND CARRIER WI-FI-WI-FI	45
INTRODUCTION, HISTORY AND MODUS OPERANDI	45
WI-FI IN MOBILE PHONES	46
BENEFITS AND CHALLENGES	46

TOPIC	PAGE NO.
Wi-Fi Security	46
6LoWPAN	48
CHAPTER 4 GLOBAL MARKETS FOR SMALL CELLS AND CARRIER-WI-FI DEVICES-A DETAILED BREAKDOWN	50
END APPLICATIONS	50
INTRODUCTION	50
Residential	50
Enterprises	50
Hotspots	50
Other Outdoor and Indoor Applications	51
MARKET OVERVIEW	51
TABLE 2 DOLLAR SALES OF SMALL CELLS AND CARRIER-WI-FI DEVICES, BY END APPLICATION, THROUGH 2019 (\$ MILLIONS)	51
TABLE 3 SHIPMENT SALES OF SMALL CELLS AND CARRIER-WI-FI DEVICES, BY END APPLICATION, THROUGH 2019 (THOUSANDS OF UNITS)	52
GEOGRAPHICAL REGIONS	53
INTRODUCTION	53
Americas	53
EMEA	54
APAC	55
MARKET OVERVIEW	56
TABLE 4 DOLLAR SALES OF SMALL CELLS AND CARRIER-WI-FI DEVICES, BY GEOGRAPHICAL REGION, THROUGH 2019 (\$ MILLIONS)	56
TABLE 5 SHIPMENT SALES OF SMALL CELLS AND CARRIER-WI-FI DEVICES, BY GEOGRAPHICAL REGION, THROUGH 2019 (THOUSANDS OF UNITS)	58
CELLULAR WAVEFORM GENERATIONS	58
INTRODUCTION	59
2G	59
3G	59
4G	59
MARKET OVERVIEW	59
TABLE 6 DOLLAR SALES OF SMALL CELLS, BY CELLULAR WAVEFORM GENERATION, THROUGH 2019 (\$ MILLIONS)	59
TABLE 7 SHIPMENT SALES OF SMALL CELLS, BY CELLULAR WAVEFORM GENERATION, THROUGH 2019 (THOUSANDS OF UNITS)	60
CLOSER LOOK AT FEMTOCELL DEVICES	61
BREAKDOWN BY END APPLICATION	61
TABLE 8 DOLLAR SALES OF FEMTOCELL DEVICES, BY END APPLICATION, THROUGH 2019 (\$ MILLIONS)	61
TABLE 9 SHIPMENT SALES OF FEMTOCELL DEVICES, BY END APPLICATION, THROUGH 2019 (THOUSANDS OF UNITS)	62
BREAKDOWN BY GEOGRAPHICAL REGION	63
TABLE 10 DOLLAR SALES OF FEMTOCELL DEVICES, BY GEOGRAPHICAL REGION, THROUGH 2019 (\$ MILLIONS)	63
TABLE 11 SHIPMENT SALES OF FEMTOCELL DEVICES, BY GEOGRAPHICAL REGION, THROUGH 2019 (THOUSANDS OF UNITS)	64
BREAKDOWN BY CELLULAR WAVEFORM GENERATION	65
TABLE 12 DOLLAR SALES OF FEMTOCELLS, BY CELLULAR WAVEFORM GENERATION, THROUGH 2019 (\$ MILLIONS)	65

TOPIC	PAGE NO.
<i>TABLE 13 SHIPMENT SALES OF FEMTOCELLS, BY CELLULAR WAVEFORM GENERATION, THROUGH 2019 (THOUSANDS OF UNITS)</i>	66
<i>CLOSER LOOK AT PICOCELL DEVICES</i>	67
<i>BREAKDOWN BY END APPLICATION</i>	67
<i>TABLE 14 DOLLAR SALES OF PICOCELL DEVICES, BY END APPLICATION, THROUGH 2019 (\$ MILLIONS)</i>	67
<i>TABLE 15 SHIPMENT SALES OF PICOCELL DEVICES, BY END APPLICATION, THROUGH 2019 (THOUSANDS OF UNITS)</i>	68
<i>BREAKDOWN BY GEOGRAPHICAL REGION</i>	69
<i>TABLE 16 DOLLAR SALES OF PICOCELL DEVICES, BY GEOGRAPHICAL REGION, THROUGH 2019 (\$ MILLIONS)</i>	69
<i>TABLE 17 SHIPMENT SALES OF PICOCELL DEVICES, BY GEOGRAPHICAL REGION, THROUGH 2019 (THOUSANDS OF UNITS)</i>	70
<i>BREAKDOWN BY CELLULAR WAVEFORM GENERATION</i>	70
<i>TABLE 18 DOLLAR SALES OF PICOCELLS, BY CELLULAR WAVEFORM GENERATION, THROUGH 2019 (\$ MILLIONS)</i>	71
<i>TABLE 19 SHIPMENT SALES OF PICOCELLS, BY CELLULAR WAVEFORM GENERATION, THROUGH 2019 (THOUSANDS OF UNITS)</i>	72
<i>CLOSER LOOK AT MICROCELL DEVICES</i>	72
<i>BREAKDOWN BY END APPLICATION</i>	73
<i>TABLE 20 DOLLAR SALES OF MICROCELL DEVICES, BY END APPLICATION, THROUGH 2019 (\$ MILLIONS)</i>	73
<i>TABLE 21 SHIPMENT SALES OF MICROCELL DEVICES, BY END APPLICATION, THROUGH 2019 (THOUSANDS OF UNITS)</i>	74
<i>BREAKDOWN BY GEOGRAPHICAL REGION</i>	74
<i>TABLE 22 DOLLAR SALES OF MICROCELL DEVICES, BY GEOGRAPHICAL REGION, THROUGH 2019 (\$ MILLIONS)</i>	75
<i>TABLE 23 SHIPMENT SALES OF MICROCELL DEVICES, BY GEOGRAPHICAL REGION, THROUGH 2019 (THOUSANDS OF UNITS)</i>	75
<i>BREAKDOWN BY CELLULAR WAVEFORM GENERATION</i>	76
<i>TABLE 24 DOLLAR SALES OF MICROCELLS, BY CELLULAR WAVEFORM GENERATION, THROUGH 2019 (\$ MILLIONS)</i>	77
<i>TABLE 25 SHIPMENT SALES OF MICROCELLS, BY CELLULAR WAVEFORM GENERATION, THROUGH 2019 (THOUSANDS OF UNITS)</i>	78
<i>CLOSER LOOK AT CARRIER-WI-FI DEVICES</i>	78
<i>BREAKDOWN BY END APPLICATION</i>	79
<i>TABLE 26 DOLLAR SALES OF CARRIER-WI-FI DEVICES, BY END APPLICATION, THROUGH 2019 (\$ MILLIONS)</i>	79
<i>TABLE 27 SHIPMENT SALES OF CARRIER-WI-FI DEVICES, BY END APPLICATION, THROUGH 2019 (THOUSANDS OF UNITS)</i>	80
<i>BREAKDOWN BY GEOGRAPHICAL REGION</i>	81
<i>TABLE 28 DOLLAR SALES OF CARRIER-WI-FI DEVICES, BY GEOGRAPHICAL REGION, THROUGH 2019 (\$ MILLIONS)</i>	81
<i>TABLE 29 SHIPMENT SALES OF CARRIER-WI-FI DEVICES, BY GEOGRAPHICAL REGION, THROUGH 2019 (THOUSANDS OF UNITS)</i>	82
<i>ANALYSIS OF INDIVIDUAL END APPLICATIONS</i>	83
<i>RESIDENTIAL END APPLICATION</i>	83
<i>TABLE 30 DOLLAR SALES OF SMALL CELLS AND CARRIER-WI-FI DEVICES TO THE RESIDENTIAL END APPLICATION, BY GEOGRAPHICAL REGION, THROUGH 2019 (\$ MILLIONS)</i>	83

TOPIC	PAGE NO.
<i>TABLE 31 SHIPMENT SALES OF SMALL CELLS AND CARRIER-WI-FI DEVICES TO THE RESIDENTIAL END APPLICATION, BY GEOGRAPHICAL REGION, THROUGH 2019 (THOUSANDS OF UNITS)</i>	84
ENTERPRISE END APPLICATION	85
<i>TABLE 32 DOLLAR SALES OF SMALL CELLS AND CARRIER-WI-FI DEVICES TO THE ENTERPRISE END APPLICATION, BY GEOGRAPHICAL REGION, THROUGH 2019 (\$ MILLIONS)</i>	85
<i>TABLE 33 SHIPMENT SALES OF SMALL CELLS AND CARRIER-WI-FI DEVICES TO THE ENTERPRISE END APPLICATION, BY GEOGRAPHICAL REGION, THROUGH 2019 (THOUSANDS OF UNITS)</i>	86
HOTSPOT END APPLICATION	86
<i>TABLE 34 DOLLAR SALES OF SMALL CELLS AND CARRIER-WI-FI DEVICES TO THE HOTSPOT END APPLICATION, BY GEOGRAPHICAL REGION, THROUGH 2019 (\$ MILLIONS)</i>	87
<i>TABLE 35 SHIPMENT SALES OF SMALL CELLS AND CARRIER-WI-FI DEVICES TO THE HOTSPOT END APPLICATION, BY GEOGRAPHICAL REGION, THROUGH 2019 (THOUSANDS OF UNITS)</i>	88
OTHER OUTDOOR AND INDOOR END APPLICATION	88
<i>TABLE 36 DOLLAR SALES OF SMALL CELLS AND CARRIER-WI-FI DEVICES TO THE OTHER OUTDOOR AND INDOOR END APPLICATION, BY GEOGRAPHICAL REGION, THROUGH 2019 (\$ MILLIONS)</i>	89
<i>TABLE 37 SHIPMENT SALES OF SMALL CELLS AND CARRIER-WI-FI DEVICES TO THE OTHER OUTDOOR AND INDOOR END APPLICATION, BY GEOGRAPHICAL REGION, THROUGH 2019 (THOUSANDS OF UNITS)</i>	90
CHAPTER 5 STAKEHOLDER CATEGORY ANALYSIS AND KEY PLAYER OVERVIEW	92
HARDWARE OEMS	92
INTELLECTUAL-PROPERTY OWNERS	93
SOFTWARE AND FIRMWARE DEVELOPERS	93
SEMICONDUCTOR-DEVICE DEVELOPERS	93
PROVIDERS OF TESTING, BACKHAUL CONNECTIVITY AND OTHER ASSOCIATED DEVICES AND SOLUTIONS	94
OVERVIEW OF KEY PLAYERS	94
AGILENT	94
Overview	94
Association with Small Cells and Carrier Wi-Fi	94
Analysis and Implications	95
AIRVANA	95
Overview	95
Association with Small Cells and Carrier Wi-Fi	95
Analysis and Implications	96
ALCATEL-LUCENT	96
Overview	96
Association with Small Cells and Carrier Wi-Fi	96
Analysis and Implications	97
ALTERA	97
Overview	97
Association with Small Cells and Carrier Wi-Fi	97
Analysis and Implications	98
ALVARION	98

TOPIC	PAGE NO.
Overview	98
Association with Small Cells and Carrier Wi-Fi	98
Analysis and Implications	98
ANYFI	99
Overview	99
Association with Small Cells and Carrier Wi-Fi	99
Analysis and Implications	99
ARICENT	100
Overview	100
Association with Small Cells and Carrier Wi-Fi	100
Analysis and Implications	100
ARUBA	100
Overview	101
Association with Small Cells and Carrier Wi-Fi	101
Analysis and Implications	101
BRIDGEWAVE	101
Overview	101
Association with Small Cells and Carrier Wi-Fi	101
Analysis and Implications	102
CISCO	102
Overview	102
Association with Small Cells and Carrier Wi-Fi	102
Analysis and Implications	102
ERICSSON	103
Overview	103
Association with Small Cells and Carrier Wi-Fi	103
Analysis and Implications	103
HUAWEI	104
Overview	104
Association with Small Cells and Carrier Wi-Fi	104
Analysis and Implications	104
IP.ACCESS	104
Overview	105
Association with Small Cells and Carrier Wi-Fi	105
Analysis and Implications	105
JUNIPER	105
Overview	105
Association with Small Cells and Carrier Wi-Fi	106
Analysis and Implications	106
MAXIM INTEGRATED	106
Overview	106
Association with Small Cells and Carrier Wi-Fi	106
Analysis and Implications	106
MIMOON	107
Overview	107
Association with Small Cells and Carrier Wi-Fi	107
Analysis and Implications	107

TOPIC	PAGE NO.
MINDSPEED	108
Overview	108
Association with Small Cells and Carrier Wi-Fi	108
Analysis and Implications	108
NEC	108
Overview	109
Association with Small Cells and Carrier Wi-Fi	109
Analysis and Implications	109
QUALCOMM	109
Overview	109
Association with Small Cells and Carrier Wi-Fi	110
Analysis and Implications	110
RADISYS	110
Overview	110
Association with Small Cells and Carrier Wi-Fi	110
Analysis and Implications	111
SAMSUNG	111
Overview	111
Association with Small Cells and Carrier Wi-Fi	111
Analysis and Implications	111
TEXAS INSTRUMENTS (TI)	112
Overview	112
Association with Small Cells and Carrier Wi-Fi	112
Analysis and Implications	112
UBEEAIRWALK	113
Overview	113
Association with Small Cells and Carrier Wi-Fi	113
Analysis and Implications	113
XIRRUS	113
Overview	113
Association with Small Cells and Carrier Wi-Fi	114
Analysis and Implications	114
ZYXEL	114
Overview	114
Association with Small Cells and Carrier Wi-Fi	115
Analysis and Implications	115
CHAPTER 6 U.S. PATENT ANALYSIS	117
INTRODUCTION	117
TRENDS BY CATEGORY	117
BACKHAUL, INTEGRATION, COVERAGE AND DIRECTIVITY MANAGEMENT	118
END-APPLICATION AND LOCATION-SPECIFIC FEATURES	118
EQUIPMENT DESIGN AND DEVELOPMENT	118
HANDOVER, INTERFERENCE, FREQUENCY AND TRAFFIC MANAGEMENT	119
INSTALLATION, CONFIGURATION, OPERATIONS AND MAINTENANCE MANAGEMENT	120
SUBSCRIBER ACCESS, AUTHENTICATION AND MANAGEMENT	120
VOICE AND DATA PAYLOAD ROUTING, PROCESSING AND MANAGEMENT	121

TOPIC	PAGE NO.
<i>TABLE 38 U.S. PATENTS RELATED TO SMALL CELLS AND CARRIER WI-FI, 1976-JANUARY 2014, BY CATEGORY</i>	121
TRENDS BY YEAR	122
<i>TABLE 39 U.S. PATENTS RELATED TO SMALL CELLS AND CARRIER WI-FI, 1976-JANUARY 2014, BY YEAR OF ASSIGNMENT</i>	122
TRENDS BY COUNTRY	122
<i>TABLE 40 U.S. PATENTS RELATED TO SMALL CELLS AND CARRIER WI-FI, 1976-JANUARY 2014, BY COUNTRY (NUMBER OF PATENTS/%)</i>	123
TRENDS BY ASSIGNEE	124
<i>TABLE 41 ASSIGNEES OF FOUR OR MORE U.S. PATENTS RELATED TO SMALL CELLS AND CARRIER WI-FI, 1976-JANUARY 2014</i>	124

LIST OF TABLES

TABLE HEADING	PAGE NO.
SUMMARY TABLE DOLLAR SALES OF SMALL CELLS AND CARRIER-WI-FI DEVICES, BY DEVICE TYPE, THROUGH 2019 (\$ MILLIONS)	9
TABLE 1 SHIPMENT SALES OF SMALL CELLS AND CARRIER-WI-FI DEVICES, BY DEVICE TYPE, THROUGH 2019 (THOUSANDS OF UNITS)	14
TABLE 2 DOLLAR SALES OF SMALL CELLS AND CARRIER-WI-FI DEVICES, BY END APPLICATION, THROUGH 2019 (\$ MILLIONS)	51
TABLE 3 SHIPMENT SALES OF SMALL CELLS AND CARRIER-WI-FI DEVICES, BY END APPLICATION, THROUGH 2019 (THOUSANDS OF UNITS)	52
TABLE 4 DOLLAR SALES OF SMALL CELLS AND CARRIER-WI-FI DEVICES, BY GEOGRAPHICAL REGION, THROUGH 2019 (\$ MILLIONS)	56
TABLE 5 SHIPMENT SALES OF SMALL CELLS AND CARRIER-WI-FI DEVICES, BY GEOGRAPHICAL REGION, THROUGH 2019 (THOUSANDS OF UNITS)	58
TABLE 6 DOLLAR SALES OF SMALL CELLS, BY CELLULAR WAVEFORM GENERATION, THROUGH 2019 (\$ MILLIONS)	59
TABLE 7 SHIPMENT SALES OF SMALL CELLS, BY CELLULAR WAVEFORM GENERATION, THROUGH 2019 (THOUSANDS OF UNITS)	60
TABLE 8 DOLLAR SALES OF FEMTOCELL DEVICES, BY END APPLICATION, THROUGH 2019 (\$ MILLIONS)	61
TABLE 9 SHIPMENT SALES OF FEMTOCELL DEVICES, BY END APPLICATION, THROUGH 2019 (THOUSANDS OF UNITS)	62
TABLE 10 DOLLAR SALES OF FEMTOCELL DEVICES, BY GEOGRAPHICAL REGION, THROUGH 2019 (\$ MILLIONS)	63
TABLE 11 SHIPMENT SALES OF FEMTOCELL DEVICES, BY GEOGRAPHICAL REGION, THROUGH 2019 (THOUSANDS OF UNITS)	64
TABLE 12 DOLLAR SALES OF FEMTOCELLS, BY CELLULAR WAVEFORM GENERATION, THROUGH 2019 (\$ MILLIONS)	65
TABLE 13 SHIPMENT SALES OF FEMTOCELLS, BY CELLULAR WAVEFORM GENERATION, THROUGH 2019 (THOUSANDS OF UNITS)	66
TABLE 14 DOLLAR SALES OF PICOCELL DEVICES, BY END APPLICATION, THROUGH 2019 (\$ MILLIONS)	67
TABLE 15 SHIPMENT SALES OF PICOCELL DEVICES, BY END APPLICATION, THROUGH 2019 (THOUSANDS OF UNITS)	68
TABLE 16 DOLLAR SALES OF PICOCELL DEVICES, BY GEOGRAPHICAL REGION, THROUGH 2019 (\$ MILLIONS)	69
TABLE 17 SHIPMENT SALES OF PICOCELL DEVICES, BY GEOGRAPHICAL REGION, THROUGH 2019 (THOUSANDS OF UNITS)	70
TABLE 18 DOLLAR SALES OF PICOCELLS, BY CELLULAR WAVEFORM GENERATION, THROUGH 2019 (\$ MILLIONS)	71
TABLE 19 SHIPMENT SALES OF PICOCELLS, BY CELLULAR WAVEFORM GENERATION, THROUGH 2019 (THOUSANDS OF UNITS)	72
TABLE 20 DOLLAR SALES OF MICROCELL DEVICES, BY END APPLICATION, THROUGH 2019 (\$ MILLIONS)	73
TABLE 21 SHIPMENT SALES OF MICROCELL DEVICES, BY END APPLICATION, THROUGH 2019 (THOUSANDS OF UNITS)	74
TABLE 22 DOLLAR SALES OF MICROCELL DEVICES, BY GEOGRAPHICAL REGION, THROUGH 2019 (\$ MILLIONS)	75
TABLE 23 SHIPMENT SALES OF MICROCELL DEVICES, BY GEOGRAPHICAL REGION, THROUGH 2019 (THOUSANDS OF UNITS)	75
TABLE 24 DOLLAR SALES OF MICROCELLS, BY CELLULAR WAVEFORM GENERATION, THROUGH 2019 (\$ MILLIONS)	77

TABLE HEADING	PAGE NO.
TABLE 25 SHIPMENT SALES OF MICROCELLS, BY CELLULAR WAVEFORM GENERATION, THROUGH 2019 (THOUSANDS OF UNITS)	78
TABLE 26 DOLLAR SALES OF CARRIER-WI-FI DEVICES, BY END APPLICATION, THROUGH 2019 (\$ MILLIONS)	79
TABLE 27 SHIPMENT SALES OF CARRIER-WI-FI DEVICES, BY END APPLICATION, THROUGH 2019 (THOUSANDS OF UNITS)	80
TABLE 28 DOLLAR SALES OF CARRIER-WI-FI DEVICES, BY GEOGRAPHICAL REGION, THROUGH 2019 (\$ MILLIONS)	81
TABLE 29 SHIPMENT SALES OF CARRIER-WI-FI DEVICES, BY GEOGRAPHICAL REGION, THROUGH 2019 (THOUSANDS OF UNITS)	82
TABLE 30 DOLLAR SALES OF SMALL CELLS AND CARRIER-WI-FI DEVICES TO THE RESIDENTIAL END APPLICATION, BY GEOGRAPHICAL REGION, THROUGH 2019 (\$ MILLIONS)	83
TABLE 31 SHIPMENT SALES OF SMALL CELLS AND CARRIER-WI-FI DEVICES TO THE RESIDENTIAL END APPLICATION, BY GEOGRAPHICAL REGION, THROUGH 2019 (THOUSANDS OF UNITS)	84
TABLE 32 DOLLAR SALES OF SMALL CELLS AND CARRIER-WI-FI DEVICES TO THE ENTERPRISE END APPLICATION, BY GEOGRAPHICAL REGION, THROUGH 2019 (\$ MILLIONS)	85
TABLE 33 SHIPMENT SALES OF SMALL CELLS AND CARRIER-WI-FI DEVICES TO THE ENTERPRISE END APPLICATION, BY GEOGRAPHICAL REGION, THROUGH 2019 (THOUSANDS OF UNITS)	86
TABLE 34 DOLLAR SALES OF SMALL CELLS AND CARRIER-WI-FI DEVICES TO THE HOTSPOT END APPLICATION, BY GEOGRAPHICAL REGION, THROUGH 2019 (\$ MILLIONS)	87
TABLE 35 SHIPMENT SALES OF SMALL CELLS AND CARRIER-WI-FI DEVICES TO THE HOTSPOT END APPLICATION, BY GEOGRAPHICAL REGION, THROUGH 2019 (THOUSANDS OF UNITS)	88
TABLE 36 DOLLAR SALES OF SMALL CELLS AND CARRIER-WI-FI DEVICES TO THE OTHER OUTDOOR AND INDOOR END APPLICATION, BY GEOGRAPHICAL REGION, THROUGH 2019 (\$ MILLIONS)	89
TABLE 37 SHIPMENT SALES OF SMALL CELLS AND CARRIER-WI-FI DEVICES TO THE OTHER OUTDOOR AND INDOOR END APPLICATION, BY GEOGRAPHICAL REGION, THROUGH 2019 (THOUSANDS OF UNITS)	90
TABLE 38 U.S. PATENTS RELATED TO SMALL CELLS AND CARRIER WI-FI, 1976-JANUARY 2014, BY CATEGORY	121
TABLE 39 U.S. PATENTS RELATED TO SMALL CELLS AND CARRIER WI-FI, 1976-JANUARY 2014, BY YEAR OF ASSIGNMENT	122
TABLE 40 U.S. PATENTS RELATED TO SMALL CELLS AND CARRIER WI-FI, 1976-JANUARY 2014, BY COUNTRY (NUMBER OF PATENTS/%)	123
TABLE 41 ASSIGNEES OF FOUR OR MORE U.S. PATENTS RELATED TO SMALL CELLS AND CARRIER WI-FI, 1976-JANUARY 2014	124

LIST OF FIGURES

FIGURE TITLE	PAGE NO.
SUMMARY FIGURE DOLLAR SALES OF SMALL CELLS AND CARRIER-WI-FI DEVICES, BY DEVICE TYPE, 2014 AND 2019 (\$ MILLIONS)	9