DON'T FIX WHAT ISN'T BROKEN: THE EXTRAORDINARY RECORD OF INNOVATION AND SUCCESS IN THE CELLULAR INDUSTRY UNDER EXISTING LICENSING PRACTICES

Keith Mallinson[*]

INTRODUCTION[**]

The cellular industry has brought fast rates of innovation and consumer adoption operating under existing laws and standard-setting organization ("SSO") policies governing intellectual property and licensing over the last 25 years. These developments have made changes in the daily lives of billions of people at a speed unequalled in history. In large part, this is because industry-led innovation has helped to put cellular devices in the hands of many new users. Remarkably, at around 7.5 billion subscriber connections by June 2015, basic cellular telephony has already achieved extraordinary, worldwide penetration, given the estimated global adult population of 5.0 billion.[1]

The technology, industry and consumer revolution in cellular phones did not happen by chance, and it was not the result of minor, obvious or inevitable adjustments to existing technologies. Instead, the increased performance provided by each new standard required the invention of many new and complex technologies and systems. These would not have been developed without a large and steadily increasing level of research and development ("R&D") investment by the industry.

Additionally, improvements in devices and services have both driven and been driven by new technologies, in what can be called a "virtuous circle" of innovation. For example, new capabilities (such as higher resolution cameras and display screens) are included in devices to take advantage of faster data rates, which in turn increase consumer data downloading and uploading. This boosts network demand, and in turn motivates innovators to develop still more powerful technologies to support even faster data rates and multiply network capacity.

---

[*] Founder of WiseHarbor. This paper was produced at the request of Qualcomm. It relies on many different reports by independent industry analysts. All opinions in this report are entirely of the author.

[**] An appendix containing a full glossary of technical terms follows this Article.

[1] International Data Base World Population by Age and Sex, U.S. CENSUS BUREAU, http://www.census.gov/population/international/data/idb/worldpop.php (last visited May 15, 2016).

All of this beneficial change occurred with the use of substantial amounts of patented technology. Notwithstanding the high level of patented technology incorporated in mobile communication devices, existing SSO licensing policies, and voluntary fair, reasonable, and non-discriminatory ("FRAND") commitments have ensured widespread access to the required intellectual property, with the result that ever-increasing numbers of device manufacturers are competing globally.

Technology innovation encouraged by competition among these manufacturers has brought new capabilities and reduced costs, while competition has passed much of those savings through to consumers around the world. The result has been continual and indeed radical improvements in the ratio of performance to price year after year in the three-decade history of the cellular industry.

This Article argues that the enormous value produced by patented technologies—as compared to the relatively low costs to producers of obtaining that technology—enables the explosion of innovation and market development occurring around the world, indicating that patent royalties are far from excessive.

Part I of this Article describes the rapid global success of cellular technologies. Part II then discusses the reasons behind this growth. Specifically, research and development funded by licensing fees allowed for this innovation. Part III explains that the existing FRAND obligations set by SSOs have allowed for competition without stifling but instead encouraging R&D. Finally, Part IV explains that because patent royalties promote R&D while not blunting competition, the benefits of intellectual property protection for both companies and consumers far outweigh licensing costs. Thus, because the current system promotes innovation, the patent community should be hesitant to suggest radical changes.

I. THE RAPID GLOBAL SUCCESS OF CELLULAR TECHNOLOGIES

Since the launch of the first analog cellular networks in Japan, Scandinavia, and the United States around 1980,[2] cellular communications have advanced in a succession of large and small upgrades. These upgrades have improved the user experience both by offering higher-quality services and reducing costs. For example, the switch from analog to 2G digital in the 1990s made the exploitation of scarce radio spectrum much more efficient: it accommodated many more users, with a higher quality of service and at much reduced costs. More recently, 3G and 4G technical improvements have provided the much quicker connection speeds and lower latency (i.e., time delay for data to transit the network) required for the satisfying end-

[2] MINGTAO SHI, TECHNOLOGY BASE OF MOBILE CELLULAR OPERATORS IN GERMANY AND CHINA: A COMPARATIVE STUDY FROM THE PERSPECTIVE OF THE RESOURCE-BASED VIEW 63 (2007).

user experiences provided by modern smartphones, which were not available before 2005. Successive generations of mobile technology have continued to massively increase performance. For example, end-user data rates have increased well over 1,000-fold since 1991.[3] With the first commercial services of GPRS in 2000, this 2G GSM technology initially provided users with data speeds of up to 56 kilobits per second.[4] By around 2005 in most developed nations, 3G UMTS with WCDMA provided users up to 384 kbps.[5] Technology enhancements to WCDMA with HSDPA and HSPA+ then provided ever-increasing speeds from megabits per second to tens of megabits per second.[6] Today, 4G Long-Term-Evolution ("LTE") networks are providing users in excess of 100,000 kbps (100 Mbps).[7] This series of innovations has changed the world dramatically. These end-user connections include GSM (with 4.0 billion connections), WCDMA/HSPA (with 1.9 billion connections), CDMA2000 (with 385 million connections) and LTE (with 613 million connections since the first service launch in December 2009).[8]

A. *The Development and Adoption of 3G and 4G Cellular Technology*

In recent years and to the present, innovation and the rapid consumer adoption of new cellular technologies continue faster than ever.

Until the introduction of multi-megabit-per-second HSDPA, the vast majority of the world's cellular operators adhering to 3GPP standards could provide data speeds of no more than the few hundred kilobits-per-second rates provided by WCDMA.[9] HSDPA, providing data rates of several megabits per second, was first launched in the United States by AT&T in De-

---

3 *See* ERICSSON, HSPA, THE UNDISPUTED CHOICE FOR MOBILE BROADBAND (May 2007), http://www.tacs.eu/Analyses/White Papers/ericsson WP-HSPA_the_undisputed_choice_for_mobile_broadband_Rev_a.pdf.

4 *See General Packet Radio Service (GPRS)*, ETSI, http://www.etsi.org/technologies-clusters/technologies/mobile/gprs (last visited June 1, 2016).

5 UMTS FORUM, 3G/UMTS EVOLUTION: TOWARDS A NEW GENERATION OF BROADBAND MOBILE SERVICES 2, 10 (2006), http://tacs.eu/Analyses/WirelessNetworks/MultiMedia_PDFs_Papers_3G-UMTS-Evolution-white-paper-Dec-2006%5B1%5D.pdf.

6 *Id.* at 10.

7 VERIZON, THE VERIZON WIRELESS 4G LTE NETWORK: TRANSFORMING BUSINESS WITH NEXT-GENERATION TECHNOLOGY 8 (2012), https://business.verizonwireless.com/content/dam/b2b/resources/LTE_FutureMobileTech_WP.pdf.

8 *Q1 2015 Figures*, GSMA INTELLIGENCE, https://gsmaintelligence.com (last visited May 17, 2016) (subscription required). The number of connections tends to significantly exceed the number of subscribers because a single user may use more than one phone, or a phone plus a tablet, eReader, or PC with a cellular connection.

9 UMTS FORUM, *supra* note 5, at 10.

cember 2005 with national network rollout in 2006.[10] Improved data rates, in turn, made possible the significant rise of "smartphones," with a revolution in hardware and device capabilities, which began in earnest with the introduction of the 3G iPhone and Android devices in 2008. Within just four years from these launches, these modern smartphones (i.e., cellular phones with high-level operating systems) comprised almost half of the cellular devices sold worldwide. By Q4 2014, smartphones represented 73 percent of all mobile phone sales worldwide.[11]

The rapid shift to smartphones has been made possible and been driven by rapid technological advances that enable ever-faster cellular data rates. This innovation has transformed the purpose of cellular communications. What, until the latter part of the last decade, was primarily a means of voice and simple text communication is now overwhelmingly used for the high-bandwidth data that smartphones both consume and generate. Usage includes viewing web pages, downloading video, uploading photographs and video, on-line gaming, immediate dissemination of such content through social media platforms, audio and video streaming including video conferencing.

Time-to-market from standardization to implementation in networks and devices was quicker with LTE than with previous technology generations. For example, the first release of the UMTS standard (Release 99) was in 1999; the first commercial launch of that standard with WCDMA technology was in October 2001 by NTT DoCoMo in Japan.[12] In comparison, the first release of the LTE standard (Release 8) was in 2008; the first commercial launch was in December 2009 by TeliaSonera, a telecom operator in Scandinavia.[13]

Furthermore, carriers and consumers have adopted LTE-capable networks and smartphones at faster rates than with 3G. U.S.-frontrunner Verizon first launched LTE in 2010.[14] Thereafter, carriers around the world began rapidly rolling out LTE networks. According to the Global mobile Suppliers Association ("GSA"), by April 9, 2015, 393 LTE operators had commercially launched LTE in 138 countries with 107 of those commer-

---

10 3G AMERICAS, 3GPP MOBILE BROADBAND INNOVATION PATH TO 4G: RELEASE 9, RELEASE 10 AND BEYOND: HSPA+, LTE/SAE AND LTE-ADVANCED 5 (Feb. 2010), http://www.3g4g.co.uk/Broadband/MB_WP_3GAmericas_1002.pdf.

11 *See* Keith Mallinson, Founder, Wise Harbor, Presentation at the 2015 Annual CPIP Conference: Mobile Tech: IP in an Interconnected World, Smartphone Market Success 4 (Oct. 1, 2015), http://www.wiseharbor.com/pdfs/WiseHarbor-Mallinson-GMU-CPIP-Oct-2015.pdf [hereinafter Mallinson, Smartphone Market Success].

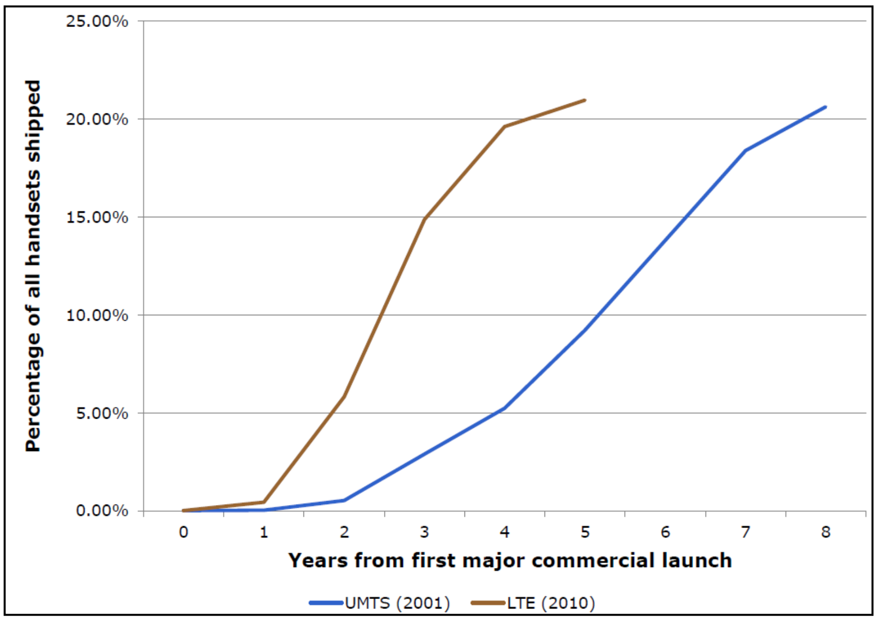
12 Ian Poole, UMTS 3G History, RADIO-ELECTRONICS, http://www.radio-electronics.com/info/cellulartelecomms/umts/3g-history.php (last visited May 15, 2016).

13 TeliaSonera Launches First Commercial LTE Network, FIERCEWIRELESS (Dec. 14, 2009), http://www.fiercewireless.com/story/teliasonera-launches-first-commercial-lte-network/2009-12-14.

14 Kevin C. Tofel, Verizon's 4G LTE Service Arrives Dec. 5 with 3G Prices, GIGAOM (Dec. 1, 2010), http://gigaom.com/2010/12/01/verizon-lte-4g-launch/.

cially launching LTE in the previous year.[15] In the United States, *all* the major mobile operators (and many smaller ones too) now claim to have introduced "4G services." Worldwide, a total of 644 operators in 181 countries are investing in LTE.[16] LTE-Advanced deployment continues as a major trend with 116 operators investing in radio-carrier aggregation technology.[17] As operators roll out LTE networks, consumers have been rapidly acquiring 4G LTE devices, as illustrated in Figure 1, which compares consumer adoption for 4G LTE and 3G UMTS/WCDMA.

Figure 1: Adoption Rate Increasing from 3G to 4G with LTE[18]



This is not the end of the story. Operators' network investments are ongoing beyond current LTE technologies: further improved cellular tech-

15 *Evolution to LTE Report*, 4G MARKET & TECH. UPDATE (Global Mobile Suppliers Ass'n, Sawbridgeworth, U.K.), Apr. 9, 2015, http://www.voiceage.com/pdfs/hdv_zone_Snapshot_VoLTE_extract_GSA_Evolution_to_LTE_report_090415.pdf.

16 *Id.*

17 LTE-Advanced Carrier Aggregation Deployments: Peak Speeds Report (116 Networks Launched), GSA, (last visited May 15, 2016).

18 Mallinson, Smartphone Market Success, *supra* note 11, at 8.

nologies are expected to be rolled out by 2020,[19] and thereafter with the proposed introduction of a fifth generation mobile standard and associated technologies.[20] The Next Generation Mobile alliance of the world's leading mobile operators is positioning 5G to address the demands and business contexts of 2020 and beyond.[21] The objective is to provide much higher average and minimum end-user data speeds, a hundred-fold increase in network capacity, very high reliability, much lower latency (in the 1-10ms range) and very long battery life for certain use cases, among other improvements.[22]

The technological advancement, rate and extent of market growth in cellular products and services including smartphones and tablets exceeds that for other consumer products and services including radio, TV, PC, landline telephone, and Internet.[23] The adoption of advanced technologies is usually closely linked to a country's GDP with countries with higher GDPs adopting new technologies faster than countries with lower GDPs.[24] But mobile phones have completely bucked that trend.[25] Smartphone adoption has been rapid in comparison to other products in the United States, and even faster in other countries with lower GDPs.

---

19 Keith Mallinson, *2020 Vision for LTE*, 3GPP (June 20, 2012), http://www.3gpp.org/news-events/press-clippings/1261-2020-vision-for-lte; *see also* Jeanette Wannstrom & Keith Mallinson, *Heterogeneous Networks in LTE*, 3GPP, http://www.3gpp.org/technologies/keywords-acronyms/1576-hetnet (last visited May 17, 2016). ETSI, on behalf of 3GPP, commissioned the authors to write these papers.

20 *ITU Towards "IMT for 2020 and Beyond"*, ITU, http://www.itu.int/en/ITU-R/study-groups/rsg5/rwp5d/imt-2020/Pages/default.aspx (last visited May 17, 2016).

21 NEXT GENERATION MOBILE NETWORKS ALL., NGMN 5G WHITE PAPER 9 (2015), https://www.ngmn.org/uploads/media/NGMN_5G_White_Paper_V1_0.pdf.

22 *Id.*; *see also* SAMSUNG ELEC. R&D CTR., 5G VISION 16 (2015), http://www.samsung.com/global/business-images/insights/2015/Samsung-5G-Vision-0.pdf.

23 One report noted that "[d]ramatic performance improvements in mobile communications standards have propelled mobile to become the fastest adopted technology of all time." Julio Bezerra et al., *The Mobile Revolution: How Mobile Technologies Drive a Trillion-Dollar Impact*, BOSTON CONSULTING GRP. (Jan. 15, 2015), https://www.bcgperspectives.com/content/articles/telecommunications_technology_business_transformation_mobile_revolution/. Mobile phones including smartphones are personal devices for which penetration is most-exactingly measured as a percentage of population. TVs, landline phones, Internet connections and in many cases PCs are shared among households or even on a more widespread basis. Penetration metrics for the latter are therefore typically on a much less exacting basis with several people per household on average. On a like-for-like basis, mobile phone and smartphone adoption rates are even quicker relatively than for these other products and services.

24 DIEGO COMIN & BART HOBIJN, FED. RESERVE BANK OF N.Y., CROSS-COUNTRY TECHNOLOGY ADOPTION: MAKING THE THEORIES FACE THE FACTS 9 (2003), https://www.newyorkfed.org/medialibrary/media/research/staff_reports/sr169.pdf.

25 Sebastian Anthony, *Smartphones Set to Become the Fastest Spreading Technology in Human History*, EXTREMETECH (May 9, 2012), http://www.extremetech.com/computing/129058-smartphones-set-to-become-the-fastest-spreading-technology-in-human-history.

In addition to providing higher data rates, cellular technology innovations are also significant because they reduce operators' costs and increase network capacity. Importantly, the many technology innovations that make up the LTE standard have made possible a large increase in usage efficiency for the limited amount of radio spectrum available. Spectrum is very costly for most operators.[26] Investing in new technology to use available spectrum more efficiently is, therefore, essential to reduce such costs and maximize returns on investment. Research published by the UK telecommunications regulator Ofcom in 2011 showed that LTE would provide 2.3 times the network capacity achieved by the existing 3G technologies while using the same amount of spectrum, rising to a 5.5 times gain by 2020.[27] Increasing capacity by upgrading to LTE provides two benefits: (1) very significantly lowering the cost per gigabyte (including spectrum and equipment costs) of data transported in network and terminal equipment and (2) accommodating the enormous demand growth. Those benefits are essential to supporting the advanced, and ever increasing, features on smartphones and consumer demand for high-bandwidth functions, including audio and video streaming with services such as Spotify and Netflix, respectively.

B. *Other Performance Improvements Made Possible by New Cellular Technologies*

Improving capabilities provided by new cellular technologies over many years are not limited to radically faster data rates and increased efficiency in use of spectrum. A few among the numerous additional benefits include:

---

[26] For example, auctions held in Europe in 2000 and 2001 for 3G mobile communications licenses raised cumulatively over $100 billion. Paul Klemperer, *How (Not) to Run Auctions: The European 3G Telecom Auctions*, 46 EUR. ECON. REV. 829, 829-30 (2002). In the U.K., alone, the auction for 3G licenses in 2000 raised nearly £22.5 billion ($37.1 billion). NAT'L AUDIT OFFICE, THE AUCTION OF RADIO SPECTRUM FOR THE THIRD GENERATION OF MOBILE TELEPHONES 17 (Oct. 19, 2001), https://www.nao.org.uk/wp-content/uploads/2001/10/0102233.pdf. More recently, the 700 MHz wireless spectrum auction in the United States in 2008 raised $19 billion. Stephen Labaton, *Wireless Spectrum Auction Raises $19 Billion*, N.Y. TIMES (Mar. 19, 2008), http://www.nytimes.com/2008/03/19/technology/19fcc.html?_r=0. The US AWS-3 auctions raised almost $45 billion for 65 MHz of spectrum. *AWS-3 Auction Results: AT&T Leads with $18.2B, Verizon at $10.4B, Dish at $10B and T-Mobile at $1.8B*, FIERCEWIRELESS (Jan. 30, 2015), http://www.fiercewireless.com/story/aws-3-auction-results-att-leads-182b-verizon-104b-dish-10b-and-t-mobile-18b/2015-01-30.

[27] Catherine Haslam, *Ofcom Reports 230% Spectral Efficiency Savings with 4G*, FIERCEWIRELESSEUR. (May 13, 2011), http://www.fiercewireless.com/europe/story/ofcom-reports-230-spectral-efficiency-savings-4g/2011-05-13.

* *Reduced latency*. Shortening the delay for data to transit the network enhances the user experience when browsing the web and using applications that require rapid and frequent back-and-forth communications;

* *Improved service quality and reliability*. New technologies reduce blocked and dropped calls, data loss and retransmission;

* *Enhanced services*. For example, Voice over LTE (VoLTE) can support High-Definition Voice (HD-Voice); and

* *A reduction of network engineering costs*. For example, automatic network configuration can reduce the need for "drive testing," in which engineers drive around extensively to measure radio signal strengths.

C. *Consumers and Implementers Benefit From a Virtuous Circle of Innovation Among Standards-Essential and Other Technologies*

The combined result of many technological innovations in both cellular devices and networks is that the capabilities of the "typical" handset have been totally transformed in less than a decade. Figure 2 illustrates this notion by comparing the features and performance specifications between two market-leading smartphones launched in 2006 and in 2012, respectively—and with a major challenger in 2014. For example, device data speeds have increased more than 100-fold. High-resolution, fast-frame-rate color touch-screens have replaced simple low-resolution displays, making it possible and appealing to watch high-quality streaming video for hours at a time. The range of applications supported by integrated high-speed application and graphics processors, together with GPS and other built-in positioning technologies and sensors since 2012, for example, provide capabilities today that had no equivalent in 2006.

The change for the average consumer worldwide has been even more dramatic. Whereas only a small minority bought smartphones in 2006, with the rest buying basic voice and text phones or feature phones with limited additional capabilities, from 2012, most purchases were smartphones.

Figure 2: Major Smartphone Model Specifications and Prices in 2006, 2012, and 2014

Model	**Nokia N93**[28]	**Samsung Galaxy S III: I747**[29] **and I9305***	**Xiaomi Mi 4 (4G model)^**[30]
Introduced	**April 2006**	**June/September* 2012**	**August 2014**
2G Network	GSM 900/1800/1900	GSM 850/900/1800/1900	GSM 850/900/1800/1900
3G Network	UMTS (WCDMA) 2100	HSDPA 850/900/2100	TD-SCDMA 2010-2025/1880-1920 CDMA 800/1900 and CDMA2000 1x EV-DO (Telecom) HSDPA 850/900/1900/2100 (Unicom)
4G Network	No	LTE 700/2100 or LTE 800/1800/2600*	TD-LTE 2570-2620/1880-1920/2300-2400^
Data Speed	384 kbps (3G)	50 Mbps (LTE)	HSDPA, 42 Mbps; HSUPA; LTE; EVDO Rev A, up to 3.1 Mbps^
Chipset	Nokia/TI baseband processor and Texas Instruments OMAP 2420 Applications Processor	Qualcomm MSM 8960 or Exynos 4412 Quad*	Qualcomm MSM8974AC Snapdragon 801
Central processor	332 MHz Dual ARM 11	Dual core 1.5 GHz or Quad core 1.4 GHz Cortex-A9*	Quad-core 2.5GHz Krait 400
Graphics processor	3D Graphics hardware accelerator	Adreno 225 or Mali-400MP*	Adreno 330
Operating System	Symbian OS 9.1, Series 60 3rd edition UI	Android OS v4.0 (Ice Cream Sandwich) or Android OS v4.1.1 (Jelly Bean)*	Android OS, v4.43 (KitKat)

28 *Nokia N93*, GSMARENA, http://www.gsmarena.com/nokia_n93-1551.php (last visited May 17, 2016).

29 *Samsung Galaxy S III 1747*, GSMARENA, http://www.gsmarena.com/samsung_galaxy_s_iii_i747-4803.php (last visited May 17, 2016); *Samsung I9305 Galaxy S III*, GSMARENA, http://www.gsmarena.com/samsung_i9305_galaxy_s_iii-5001.php (last visited May 17, 2016).

30 *Xiaomi Mi 4*, GSMARENA, http://www.gsmarena.com/xiaomi_mi_4-6518.php (last visited May 17, 2016).

Display	TFT, 256K colours, 240 x 320 pixels, 2.4 inches, 36 x 48mm, 167 pixels per inch	Super AMOLED, 16M colours, 720 x 1,280 pixels, 4.8 inches, 306 pixels per inch	IPS LCD, 16 M colors, 1080x1920 pixels, 5.0 inches , 441 pixels per inch
Touchscreen	No	Capacitive multitouch	Capacitive multitouch
Memory	50MB storage +64 MB RAM +128 MB miniSD Card	16GB storage, 2GB RAM, up to 64 GB microSD	16 GB (64GB at higher price), 3GB RAM
Cameras	3.15 megapixels, VGA @30 fps: secondary CIF videocall camera	8 MP, autofocus, LED flash: secondary 1.9MP, 720p @30 fps	13 MP, autofocus, dual-LED flash. Video includes 2140p@30fps. Secondary 8 MP, 1080p@30fps
Leading Features	SMS, MMS, WAP/xHTML, HTML, Email, IM, polyphonic ringtones, MP3/MP4 and video calling	Simultaneous HD video and image recording, touch focus, geo-tagging, face and smile detection, 1080p @30 fps video, image stabilization. GPS with A-GPS support and GLONASS, accelerometer, gyro, proximity, compass, barometer	Face/smile detection, geotagging, panorama, accelerometer, gyro, proximity, compass, barometer. A-GPS, GLONASS, Beidou. Active noise cancellation with dedicated mic.
Price Without Subsidy	Euro 550 x $1.26 (rate 7/14/2006) = $693[31]	$599-$649[32]	$325-$405[33]

* September introduction for I9305 version. Superseded by the I9500 Galaxy S IV as flagship model in March 2013.
^ Also 3G models with CDMA 800/1900 and CDMA2000 1x EV-DO (Telecom); HSDPA 850/900/1900/2100 (Unicom).

While performance specifications have vastly increased, unsubsidized prices (without adjusting for inflation) have actually somewhat reduced. The price before any carrier subsidy was the equivalent of $693 for the Nokia smartphone in April 2006 and 10 percent lower at around $624 for the Samsung smartphone in June 2012. After adjusting for a 14 percent increase in the U.S. consumer price index over that six-year period, the Samsung device was actually 24 percent cheaper on an inflation-adjusted

31 Press Release, Adobe, Adobe and Nokia Join Forces to Bring Consumers a Complete Video Editing Solution (Apr. 25, 2006), http://www.adobe.com/aboutadobe/pressroom/pressreleases/pdfs/200604/042506Nokia.pdf.

32 Daniel P., *Samsung Galaxy S III to Cost $600 on Verizon at Full Retail Price*, PHONEARENA (June 6, 2012), http://www.phonearena.com/news/Samsung-Galaxy-S-III-to-cost-600-on-Verizon-at-full-retail-price_id30944 - Currency figures are not adjusted for inflation.

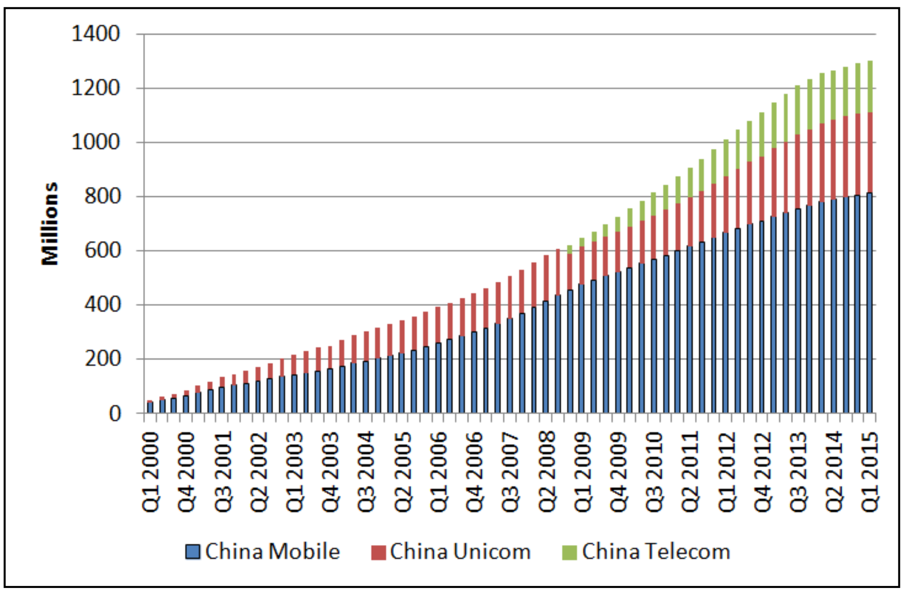
33 Frank Tu, *Out of Stock in 37 Seconds—That's New Xiaomi Mi4*, GIZMOCHINA (Aug. 17, 2014), http://www.gizmochina.com/2014/08/17/out-of-stock-in-37-seconds-thats-new-xiaomi-mi4/. Currency figures are not adjusted for inflation.

basis. Two years later, Chinese Original Equipment Manufacturer ("OEM") Xiaomi (also now named MI) launched its new flagship phone, the Mi4, with similar or better specifications to the Samsung device in several respects, at prices around 40 percent lower, without adjusting for inflation.

D. *China Has Been One of the Most Significant Beneficiaries of the Cellular Revolution*

China has been one of the most significant beneficiaries of this technology revolution in recent years. For example, China has more subscriber connections than any other nation.[34] Manufacturers and consumers have benefitted from competition among different network technologies and operators as indicated in Figure 3.

Figure 3: Cellular Connections in China, 2000- Q1 2015, by Operator[35]



Subscriber connection figures also clearly show there is still a large market opportunity to upgrade 580 million subscriber connections from 2G GSM to 3G and 4G technologies. This change is already well underway.

[34] *Internet Users by Country (2016)*, INTERNET LIVE STATS, http://www.internetlivestats.com/internet-users-by-country/ (last visited May 17, 2016).
[35] *China: Data Dashboard*, GSMA INTELLIGENCE, https://www.gsmaintelligence.com/markets/623/dashboard/ (data available via subscription only).

While handset sales in China until 2011 were predominantly low-performance 2G GSM devices, since then, Chinese consumers have rapidly adopted 3G with WCDMA/HSPA, CDMA2000 EV-DO and TD-SCDMA technologies.[36] The uptake of 4G has been even more rapid with major city commercial launches and 90.1 million LTE devices sold in 2014.[37] The rapid pace of upgrading demonstrates the technical superiority and high consumer demand for the more advanced technologies.

The trends in China are particularly significant because China has become the largest smartphone market in the world.[38] According to market research firm IHS, total domestic handset shipments in China were 423 million in 2014.[39] This represents 23 percent of the 1.86 billion handsets that were sold worldwide that year.[40]

Increased smartphone demand and low barriers to market entry for OEMs have enabled newcomers to grow rapidly. For example, Coolpad, Huawei, Lenovo, Xiaomi, and ZTE, among numerous other Chinese OEMs, have entered the domestic market and rapidly increased their shares of smartphone sales in recent years. According to Fortune magazine, "Almost overnight China's phonemakers came to dominate their own market."[41] Chinese OEMs accounted for 70 percent of handset sales in China during the second half of 2014 and 40 percent of global smartphones shipments that year.[42]

According to Credit Suisse published research, the availability of "reference design" platforms from chipset suppliers Qualcomm, Mediatek, and Spreadtrum for these "emerging customers" has fueled the competition.[43]

---

36 Calum Dewar, *China Approaches 1 Billion Mobile Connections as 3G Services Gain Traction*, GSMA INTELLIGENCE (Jan. 19, 2012), https://gsmaintelligence.com/research/2012/01/china-approaches-1-billion-mobile-connections-as-3g-services-gain-traction/316/.

37 *China Mobile Ends 2014 with a Whopping 90 Million 4G Users*, FORBES (Jan. 21, 2015), http://www.forbes.com/sites/greatspeculations/2015/01/21/china-mobile-ends-2014-with-a-whopping-90-million-4g-users/#10a4691b147f.

38 *Chinese Smartphone Market, World's Largest, Shrinks in Q1—Study*, REUTERS (May 11, 2015), http://www.reuters.com/article/china-handsets-idUSL1N0Y207K20150511.

39 Kevin Wang & Hui He, *Mobile Phones & Electronics Report—China—H2 2014*, IHS TECH. (Jan. 20, 2015), https://technology.ihs.com/458951/mobile-phones-electronics-report-china-h2-2014 (requires subscription).

40 *Gartner, CCS Insight: Smartphone Growth in 2014 Will Be Fueled by Low-Cost Models*, FIERCEWIRELESS (Oct. 14, 2014), http://www.fiercewireless.com/story/gartner-ccs-insight-smartphone-growth-2014-will-be-fueled-low-cost-models/2014-10-15.

41 Scott Cendrowski, *Enter the Dragons*, FORTUNE (Mar. 1, 2015), http://fortune.com/china-smartphone-domination/.

42 Matthew Benson, *Report: Chinese OEMs Accounted for 40% of Phone Sales in 2014*, ANDROID AUTHORITY (Jan. 21, 2015), http://www.androidauthority.com/chinese-oems-phone-sales-in-2014-581495/.

43 CREDIT SUISSE, HANDSET INDUSTRY 2013 OUTLOOK 3 (2013) [hereinafter HANDSET INDUSTRY OUTLOOK], https://research-and-analytics.csfb.com/docView?docid=V0HfWc; *see also* CREDIT SUISSE, CHINA SMARTPHONE SECTOR 16-17 (2014), https://research-and-analytics.csfb.com/docView?docid

The success of those companies is not limited to their home market. Chinese companies are also among the leaders in supplying smartphones and other mobile devices worldwide. By 2011, Huawei and ZTE were among the top-ten smartphone suppliers in the world.[44] A large proportion of these smartphones are exported. Lenovo's acquisition of Google's Motorola Mobility smartphone unit for approximately $2.9 billion in 2014 further demonstrates the potential for Chinese OEMs to expand their exports.[45] China is also the factory for major non-Chinese brands including contract manufacture by Foxconn for most of Apple's highly popular iPhones.

E. *The Cellular Revolution Has Substantially Benefitted Countries Around the World*

In countries around the world, local new market entrants, as well as Chinese OEMs, are also gaining substantial market share. For example, *The Financial Times* reported that in the Philippines domestic brands have almost 60 percent market share for smartphones, and in Vietnam, domestic brands account for nearly a third of all smartphone sales.[46] *The Economist* has revealed that the market share of India's indigenous market leader Micromax, with 22 percent of the Indian market, exceeds that of global market leader Samsung, with only 20 percent share.[47]

=cVdgsP (noting that the growth in share of Chinese brands in the smartphone market is powered "in large part by a Mediatek, Qualcomm or Spreadtrum chipset" along with others). A reference design generally consists of a complete bill of materials and a template or blueprint for building a complex, multi-component device. The purpose of a reference design is to enable less sophisticated manufacturers to quickly introduce products to the market without the need for large in-house engineering resources.

44 *See* Horse Liu, *Huawei Analysis Report—China—2014*, IHS TECH. (Aug. 28, 2014), https://technology.ihs.com/491322/huawei-analysis-report-china-2014; *News—Huawei Releases Full Year 2011 Results*, IHS TECH. (Apr. 23, 2012), https://technology.ihs.com/406105/news-huawei-releases-full-year-2011-results; Kevin Wang & Hui He, *Infrastructure Equipment Report—China—H2 2014*, IHS TECH. (Mar. 22, 2015), https://technology.ihs.com/406105/news-huawei-releases-full-year-2011-results. All reports require subscriptions.

45 Press Release, Lenovo, Lenovo Completes Acquisition of Motorola Mobility from Google (Oct. 13, 2014), http://news.lenovo.com/article_display.cfm?article_id=1860.

46 Simon Mundy, *ASEAN Smartphone Makers Play to Home Market Strengths*, FIN. TIMES (Dec. 30, 2014), http://www.ft.com/intl/cms/s/0/fee4503e-85d1-11e4-b11b-00144feabdc0.html#axzz3bnIZOSNf.

47 *A Guide to Alternative Smatrtphones: Ready to Runcible*, ECONOMIST (May 30, 2015), http://www.economist.com/news/technology-quarterly/21651930-want-be-different-there-are-now-many-handset-brands-choose-besides.

II. THE CELLULAR REVOLUTION HAS BEEN MADE POSSIBLE ONLY BY MASSIVE AND ONGOING INDUSTRY INVESTMENT IN R&D

The technology, industry, and consumer revolution in cellular phones did not happen by chance, and it was not the result of minor, obvious, or inevitable adjustments to existing technologies. Instead, the increased performance provided by each new standard required the invention of many new and complex technologies and systems. These advances would not have been developed without a large and steadily increasing level of R&D investment by the industry.

The entire cellular industry, as well as consumers, benefit from the resulting inventions. This industry is estimated to include global revenues of $22.2 billion for baseband processors, $412 billion for handsets, $55 billion for network equipment, and $1.13 trillion for operators.[48]

A. *Industry R&D Investment as a Whole*

To estimate the total R&D investment that makes all these revenues possible, together with showing trends in R&D growth and in the ratios of R&D to sales, Figure 4 examines the sales revenues and R&D investment figures for twelve large technology companies with a substantial or exclusive focus on mobile communications. The compilation includes Samsung Electronics and LG Electronics, which are quite diversified and do not break out wireless R&D expenditures in public disclosures, so the figures for those companies will include some R&D related to other technologies and product markets. However, the analysis also excludes figures for many companies that also invest in R&D related to cellular products and services such as Alphabet (Google), ARM, Broadcom, Cisco, CommScope, Intel, InterDigital, Juniper, Lenovo, Xiaomi, numerous mobile operators and a plethora of smaller and specialized companies. Consequently, these totals provide a fair, yet approximate, representation of R&D investments by the mobile technology industry as a whole.[49]

---

48 *See* CREDIT SUISSE, https://research-and-analytics.csfb.com (last visited May 17, 2016) (network equipment, 2012); GSMA INTELLIGENCE, https://www.gsmaintelligence.com/data/ (last visited May 17, 2016) (operator revenues, 2013); IDC, http://www.idc.com/ (last visited May 17, 2016) (handsets, 2014); STRATEGY ANALYTICS, https://www.strategyanalytics.com/ (last visited May 17, 2016) (basebands, 2014).

49 For example, if the R&D figures for Samsung Electronics and LG Electronics were prorated on the basis of each company's mobile sales in comparison to its total sales—which would be very conservative because mobile tends to be much more R&D intensive per Won or dollar of product sales than R&D for TVs, washing machines, and other consumer electronics that contribute significantly to total revenues—my total R&D figure would reduce by only $8.5 billion for 2015. This would be more than offset by R&D spending on mobile technologies by other companies that do not publicly report R&D on mobile, and which were not included. Indeed, this estimate is conservative when compared with a Janu-

Figure 4: Total R&D Investments by Major Cellular Industry Participants, in Dollars & as a Percentage of Sales Revenues[50]

	Total Sales (billions)	Total R&D (billions)	R&D/Sales
2008	$400	$28.0	7.0%
2009	$354	$27.9	7.9%
2010	$402	$30.8	7.7%
2011	$511	$37.9	7.4%
2012	$559	$40.0	7.1%
2013	$582	$42.0	7.2%
2014	$614	$48.4	7.9%
Growth From 2008-2014	54%	73%	

B. *Qualcomm Has Made Uniquely High R&D Investments for Many Years*

Qualcomm, which focuses on wireless technology, has for many years invested a larger proportion of sales in R&D than other major wireless industry participants and technology companies generally. Qualcomm spends more than 20 percent of its revenues on R&D and has maintained that high level of investment in innovation for many years, even while its revenues have grown dramatically. As of September 2014, Qualcomm had cumulatively spent more than $38 billion on R&D since 1985.[51]

---

ary 2015 report by the Boston Consulting Group, which estimated that R&D investments in mobile technologies had reached almost $100 billion annually, and were continuing to grow. *See* Bezerra et al., *supra* note 23; *accord The Mobile Revolution: How Mobile Technologies Drive a Trillion-Dollar Impact*, BCG PERSP., https://www.bcgperspectives.com/content/articles/telecommunications_technology_business_transformation_mobile_revolution/?chapter=6 (last visited May 17, 2016).

50 Keith Mallinson, *Busting Smartphone Patent Licensing Myths*, CPIP POL'Y BRIEFS & ISSUE PAPERS (Ctr. Protection Intell. Prop., Arlington, Va.), Sept. 2015, at 6 fig.1 [hereinafter Mallinson, *Busting Myths*], http://cpip.gmu.edu/wp-content/uploads/2015/10/Mallinson-Busting-Smartphone-Patent-Licensing-Myths.pdf. This data is drawn from *Stocks*, REUTERS, http://www.reuters.com/finance/stocks/ (last visited May 17, 2016), or directly from company annual reports if not available therein. Figures included in totals are for Alcatel-Lucent, Apple, BlackBerry, Ericsson, Huawei, LG Electronics, MediaTek, Nokia, Qualcomm, Samsung, Electronics and ZTE.

51 *How to Empower the Inventors Who Will Make IoT a Reality*, QUALCOMM (Feb. 11, 2016), https://www.qualcomm.com/news/onq/2016/02/11/how-empower-inventors-who-will-make-iot-reality.

These large R&D investments could not be made based on profits from Qualcomm's chip component sales alone. In 2014, Qualcomm reported earnings before taxes of approximately $3.8 billion from its chip business, while investing nearly $5.5 billion in R&D.[52] Thus, Qualcomm's continued investments in R&D at anywhere near recent levels are made possible only by Qualcomm licensing its inventions and improvements that include some of the fundamental discoveries enabling high data-rate wireless communications today.

The cellular handset sector, including in particular the many different handset manufacturers, has benefitted from this R&D. Handset operating profits since 2007 tripled to $51 billion on $326 billion revenues in 2013, according to Credit Suisse.[53] These financial results, the approximately $55 billion in cellular network equipment revenues, and the $1.13 trillion in mobile operator service revenues are substantially dependent upon the industry's total R&D developments in standard-essential technologies including Qualcomm's innovations.

C. *Innovators Around the World, Particularly Those in China, Are Rapidly Increasing Their Investments in Cellular R&D*

Chinese companies are now significantly contributing to the global development ecosystem in mobile communications technologies and receiving patents for technologies used in new communications standards. Sales and R&D figures for leading mobile technology vendors Huawei and ZTE show that growth has been particularly strong in recent years.[54] In comparison to the global totals presented in Part II.A above, these two companies together accounted for 9.7 percent of sales and 16.6 percent of R&D in 2014, up substantially from 6.2 percent of sales and 7.5 percent of R&D in 2008.

However, the timing of major performance enhancements in the CDMA2000, UMTS, and LTE standards until most recently (i.e., for CDMA2000, the EV-DO Rev. B release in 2006; for UMTS, Release 7, 8, and 9 in 2007, 2008, and 2009, respectively; and for LTE, also in Release 8 and 9)—and years of prior R&D investments upon which these are based—

---

52 QUALCOMM INC., 2014 ANNUAL REPORT OF FORM 10-K, at 37, 39 (2014).

53 CREDIT SUISSE, THE WIRELESS VIEW 2014: SMARTPHONES—A SLOWING DISRUPTIVE FORCE 7, 16 (Jan. 6, 2014) [hereinafter THE WIRELESS VIEW], https://doc.research-and-analytics.csfb.com/docView?language=ENG&source=emfromsendlink&format=PDF&document_id=805847640&extdo-cid=805847640_1_eng_pdf&serialid=VKIqPfyGKvPXILC6%2bF%2bpFCXU1PjBAqhenh6L1lN6AVE%3d.

54 *See Huawei Boosts 2014 Profit by 33% Thanks to Sales of LTE Gear and Smartphones*, FIERCEWIRELESS (Mar. 31, 2015), http://www.fiercewireless.com/story/huawei-boosts-2014-profit-33-thanks-sales-lte-gear-and-smartphones/2015-03-31.

significantly predates the recent strong growth in R&D investment by Chinese companies.

D. *Essential Cellular Technologies Are Integral to the Value Provided By Other Technologies Now Present in Smartphones and Other Cellular Devices*

Cellular communication technologies are vital to much of the utility and value that consumers derive from even the non-cellular-specific technologies in their mobile devices. As discussed above, smartphones incorporate other technologies in addition to the core cellular communications technologies that enable them to transmit and receive data in conjunction with a cellular network. However, it is clear that much of the meaningful functionality of these other technologies is enabled by, and reliant upon, the fast, high-capacity mobile data communication capabilities.

For example, built-in cameras would be worth much less to the user without the ability to immediately share photographs (whether via email, text, or social media) with friends, or transmit live video to participate in video calls. GPS capability would be worth much less without the ability to rapidly download maps and other location-dependent data. High-resolution color screens would be worth much less to the user without the capability to receive downloads or data streams adequate to fill those screens with photographs or video. Smartphone software applications now widely used globally by large numbers of consumers include those from U.S. companies, such as Google, YouTube, Facebook, Twitter, Instagram, and Snapchat, and popular Chinese examples including Baidu, Youku Todou, Sina Weibo, and TenCent's WeChat. These applications would be far less useful, if useful at all, without high-data-rate cellular connections that provide a wide-range of immediate, on-the-go communication and content options, particularly as compared to devices that have only Wi-Fi connectivity, or no wireless connectivity at all. A reliable, fast, cellular-data connection is necessary to enable the full functionality that consumers demand, and now take for granted.

The central role of cellular communications technology to the whole value package provided by a modern smartphone is strongly confirmed by the very different prices consumers are willing to pay for otherwise comparable devices, with and without a cellular connection, and by the total sales for each. As noted in an earlier paper available at the Center for the Protection of Intellectual Property:

> A particularly clear example is found in a comparison of Apple's 3G HSPA or 4G LTE iPhones against its iPod Touch. These two different products have similar components and capabilities (processor, screen, memory, video and music capabilities, and camera), but the iPod Touch provides only a WiFi connection, while the HSPA or LTE iPhone also provides a high-speed cellular data connection. The iPhone 5c 8GB models sell for $450 (unsubsidized, as sold without service contract), while the iPod Touch 5th Generation model similar

in terms of non-cellular capabilities but with 16GB of memory sells for $199. In other words, adding the high-speed cellular connection increases the value to consumers of this device by over 125%, even though the additional manufacturing costs with necessary cellular chips and antenna are relatively small. Additional utility, appeal and value to consumers is also most strongly illustrated by the fact that Apple's sales revenues for all iPhone models ($102 billion) exceeded sales for all iPod models ($2.3 billion) by a factor of 46 in 2014.[55]

III. LICENSING UNDER EXISTING SSO RULES AND INDUSTRY PRACTICES HAS RESULTED IN INTENSELY COMPETITIVE AND RAPIDLY CHANGING MARKETS IN MOBILE PHONES AND CHIPS

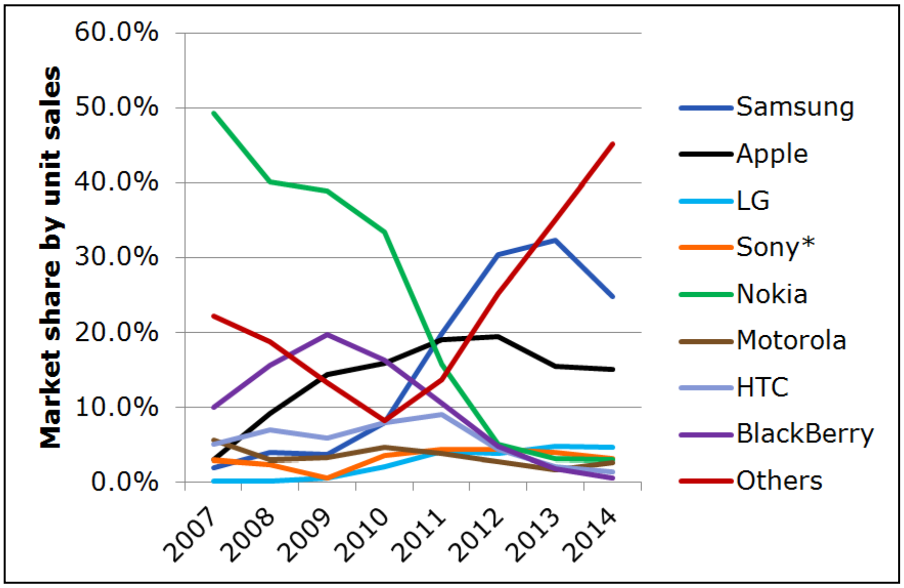
The markets for mobile phones and "baseband" communications processor chips that implement the cellular communications standards are intensely competitive and have been characterized by continual change. Notwithstanding the high level of patented technology incorporated in mobile communication devices, existing SSO licensing policies and voluntary FRAND commitments have ensured widespread access to the required intellectual property, with the result that ever-increasing numbers of device manufacturers are competing globally.

---

55 Mallinson, *Busting Myths*, *supra* note 50, at 5 (footnotes omitted). For more technical information about the Apple products mentioned here, see Neil Hughes, *New iPod Touch vs. iPhone 5s: Apple's latest iPod Packs Surprising Power*, APPLEINSIDER (July 15, 2015), http://appleinsider.com/articles/15/07/15/new-ipod-touch-vs-iphone-5s-apples-latest-ipod-packs-surprising-power.

A. *Mobile Device Markets Are Highly Competitive and Fluid*

Figure 5: Global Shares of Leading Smartphone Industry Participants 2007 – 2014[56]



* Sony Ericsson until 2011

As Figure 5 shows, the share of sales for leading smartphone suppliers shifted significantly every year between 2008 and 2014. This time period includes several well-known examples of new entry and rapid expansion. HTC grew quickly to become a major smartphone supplier from the mid-2000s. Since around that time, Huawei and ZTE rapidly established global leadership in the supply of data dongles (plug-in cellular modems) and have advanced significantly in mobile phones. Apple was a new cellular market entrant in 2007 with little or nothing in the way of cellular standard-essential patents ("SEPs"), and yet it has achieved stellar growth and strong profit margins. Meanwhile, previous market leaders in smartphones such as Research in Motion ("RIM"), renamed BlackBerry, and Nokia have seen their large market shares plunge; and in recent years, a rapidly increasing share of sales has been captured by a large number of smaller manufacturers, including many Chinese manufacturers and others such as Micromax from India (significantly among Figure 5's "Others").

56 Mallinson, Smartphone Market Success, *supra* note 11, at 12. For original source data, see STRATEGY ANALYTICS, https://www.strategyanalytics.com/ (last visited May 17, 2016).

At the global level, sales of both smartphones and cell phones more generally have become increasingly unconcentrated, a trend that began with the decline of Nokia's share since 2007. This important fact can be quantified by reference to the Herfindahl-Hirschman Index, a widely accepted measure of market concentration in competition analysis.[57] The HHI is calculated by summing the squared market shares of all firms in any given market.[58] U.S. antitrust authorities generally classify markets into three types:

- Unconcentrated Markets: HHI below 1500
- Moderately Concentrated Markets: HHI between 1500 and 2500
- Highly Concentrated Markets: HHI above 2500[59]

Since 2007, market concentration for cellular phone suppliers has reduced from moderately concentrated to unconcentrated. This is in part because there are an ever-increasing number of smartphone manufacturers. Smartphones were first marketed as such by Nokia from around 2002.[60] With Nokia and RIM predominating until the market entry of Apple and others in 2007 and 2008, sales of smartphones were "Highly Concentrated," but quickly dropped into the "Moderately Concentrated" and then "Unconcentrated" range, where they have remained, or very nearly so, as other manufacturers entered—shown in Figure 6, below.

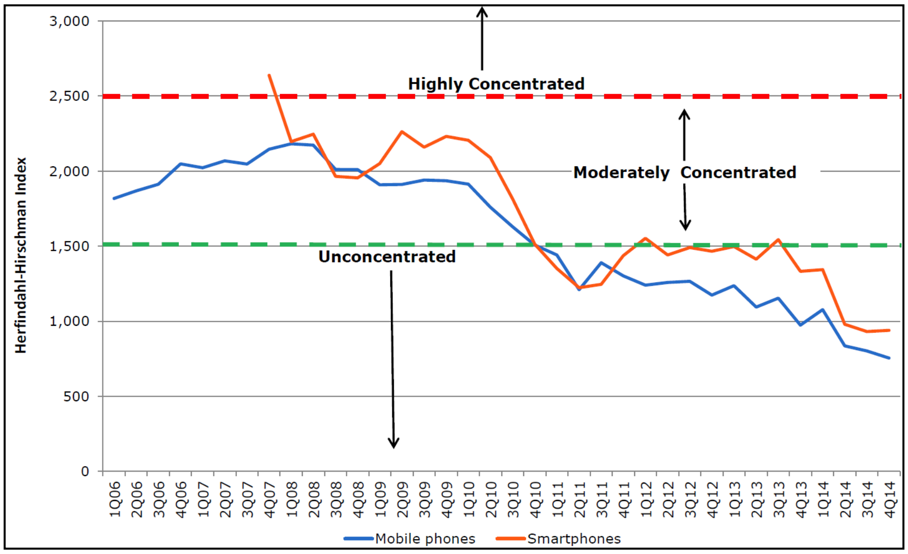
57 U.S. DEP'T OF JUSTICE & FED. TRADE COMM'N, HORIZONTAL MERGER GUIDELINES § 5.3 (2010), *reprinted in* 4 Trade Reg. Rep. (CCH) ¶ 13,104, *available at* https://www.justice.gov/atr/horizontal-merger-guidelines-08192010.

58 *Id.* § 5.3 n.9.

59 *Id.* § 5.3.

60 Rafe Blandford, *Nokia 3650 Specifications*, ALL ABOUT SYMBIAN, http://www.allaboutsymbian.com/devices/item/Nokia_3650.php (last visited May 17, 2016).

Figure 6: Market Concentration of Global Cellular Phone and Smartphone Markets, 2006-2014[61]



Smartphone supply is even less concentrated if one considers China alone. The HHI for supply in China was less than 800 in the first six months of 2013.[62]

B. *As a Result of Existing FRAND Licensing Practices, Companies Without Significant Cellular Patent Portfolios Have Been Able to Enter the Cellular Device Market and Succeed*

As a matter of historical fact, the royalty burdens experienced by companies without strong cellular patent portfolios of their own have not inhibited such companies from entering the cellular phone market, competing fiercely, and succeeding. Companies that have entered the cellular devices market and achieved major success before making R&D investments in basic or standards-essential cellular communications technology have included RIM, HTC, Apple, and others. RIM's first cellular device, the BlackBerry 6210, was introduced in 2003—long after 2G GSM standardization and the standardization of 3G WCDMA in 1999—and transformed the market for mobile communications by introducing email and other ap-

---

61 Mallinson, Smartphone Market Success, *supra* note 11, at 15. Prepared by WiseHarbor based on data from Strategy Analytics.

62 HHI figures calculated by WiseHarbor using Strategy Analytics market share figures.

plications.[63] Despite owning no SEPs for cellular standards at the time, BlackBerry rose to become the *most* successful smartphone vendor in North America (and other nations) in the mid-to-late 2000s.[64] In 2008, it commanded more than 50 percent of smartphone market share in North America and its global market share reached 20 percent the following year.[65] BlackBerry's profit margins were stellar for a few years.[66]

HTC is another example of market entry and significant growth. Following its success as a contract manufacturer of mobile phones, HTC launched itself as a branded manufacturer of smartphones. HTC's global smartphone market share grew to 9 percent in 2011, although it has lost share to competition since then.[67] Like RIM, HTC achieved its success while owning little or nothing in the way of SEPs.[68]

Apple's iPhones (from 2007) have also been wildly successful. By 2011, Apple's North American and global smartphone market shares reached 29 percent and 19 percent respectively.[69] It achieved all this while at the time owning little or nothing in the way of cellular technology SEPs for 2G or 3G standards.[70]

Similarly, Chinese companies in particular, including Coolpad, Huawei, Lenovo, Xiaomi, ZTE and many others, have also been very successful. For example, Huawei and ZTE together took 66 percent global market share in dongles in 2009, following the launch of mobile broadband services with HSDPA and CDMA2000 EV-DO Rev A in the mid 2000s.[71] More recently, Huawei advanced to third position in smartphone market share globally before being overtaken by Lenovo following the latter's acquisition of Motorola Mobility,[72] despite the fact that Huawei was not a

---

63 Roberto Baldwin, *The 12 Cellphones That Changed Our World Forever*, WIRED (Apr. 3, 2013), http://www.wired.com/2013/04/influential-cellphones/.

64 *See* Allen Tsai, *The True Story Behind the Rise and Fall of BlackBerry*, 2MACHINES, http://2machines.com/184127/ (last visited May 17, 2016).

65 BEN PARHAR ET AL., RIM IN A SMARTPHONE MARKET (Oct. 22, 2009), http://zenportfolios.com/chriswong/files/2009/11/Marketing-Case-1.pdf.

66 *See* RESEARCH IN MOTION, 2008 ANNUAL REPORT 18-19 (2008).

67 Leo Sun, *HTC Returns to Tablets with Google's Nexus 9*, MOTLEY FOOL (Sept. 24 2014), http://www.fool.com/investing/general/2014/09/24/htc-returns-to-tablets-with-googles-nexus-9.aspx.

68 For relevant data related to HTC and RIM requiring subscription, see STRATEGY ANALYTICS, https://www.strategyanalytics.com/ (last visited May 17, 2016).

69 Erica Ogg, *IDC: Apple Sold Most Smartphones in Q4, but Samsung Wins 2011*, GIGAOM (Feb. 7 2012), https://gigaom.com/2012/02/07/npd-apple-sold-most-smartphones-in-q4-but-samsung-wins-2011/.

70 For relevant data related to Apple requiring subscription, see STRATEGY ANALYTICS, https://www.strategyanalytics.com/ (last visited May 17, 2016).

71 *USB Dongle Sales Could Reach 46 Million This Year*, BROADBAND ANALYST (Sept. 22, 2009), http://www.broadbandanalyst.co.uk/mobile-broadband/usb-dongles-sales-reach-46-million-year/.

72 Dan Graziano, *Huawei Is Now the World's Third Largest Smartphone Vendor, but Still Far Behind Samsung and Apple*, BGR (Jan. 25, 2013), http://bgr.com/2013/01/25/smartphone-market-share-

major participant in the R&D investments that created 3G technologies. Hundreds of other mobile phone manufacturers have flourished by also being able to exploit the readily available mobile communications standards, and to obtain needed licenses to the underlying patented technology upon which they are based. In many cases, technology innovators—including Qualcomm, MediaTek, and Spreadtrum—have provided the additional assistance of "reference designs." In addition, contract manufacturers, such as Foxconn and Pegatron, which supply most of Apple's iPhones, have been able to flourish without owning SEPs.[73]

Thus, the notable successes of several recent market entrants that had virtually no SEPs for the cellular communication standards currently in use demonstrate that the royalties charged for use of cellular communications SEPs do not inhibit market entry. On the contrary, new companies have shown the ability to grow and thrive, and have done so in a very short time by being able to license and implement those technologies.

C. *Consumers Have Extensive Choice of Handset Suppliers and Device Models, Including in Secondary Markets*

Consumers have enormous choice in handset suppliers and device models. By August 2012 there were 3,847 HSPA and 442 HSPA+ device models available worldwide, according to the GSA.[74] Similarly, by November 2015, around 339 suppliers had launched 3,745 different LTE-enabled user devices, a 69 percent increase in one year.[75] Among handset devices, there are numerous variations from which consumers can choose. Cellular capabilities aside, product differences include form factors (e.g., "candy bar," flip, and classic smartphone), operating systems, display sizes, display definition (i.e., number of pixels per inch), text entry method, applications and graphics processing power (e.g., number of cores), memory size, number of cameras, number of megapixels per camera, inclusion of WiFi, Bluetooth, GPS, compass, accelerometer, and so on.

Major manufacturers each launch and retire dozens of device models every year and many consumers like to carry the latest models. However, as with cars, there is also a vibrant secondary market for cellular phones and smartphones that can extend their operational life well beyond the conventional two-year, service-contract cycle. For example, in May 2013, Mazuma

q4-2012-306399/; *Smartphone Vendor Market Share, 2015 Q2*, IDC, http://www.idc.com/prodserv/smartphone-market-share.jsp (last visited May 17, 2016).

73 *See* Dave Smith, *Apple's Controversial Supplier Pegatron Will Reportedly Control Half of the iPhone 6 Orders*, BUS. INSIDER (Aug. 14, 2014), http://www.businessinsider.com/pegatron-will-control-half-of-all-apple-iphone-6-orders-2014-8?IR=T.

74 *HSPA Device Survey: Key Findings*, GSM/3G MARKET/TECH. UPDATE (Global mobile Suppliers Ass'n, Sawbridgeworth, U.K.), Aug. 19, 2012.

75 GLOBAL MOBILE SUPPLIERS ASS'N, REPORT: STATUS OF LTE ECOSYSTEM (Nov. 2, 2015).

Mobile.com and others in the UK would pay up to £270 ($415) in cash for used, high-end devices such as the iPhone 5 64GB.[76] These devices are refurbished and resold globally, adding further competition against new models.

D. *The Mobile Chipset Market Is Highly Competitive and Fluid*

As is true with smartphones and other cellular devices, many different suppliers compete vigorously in the global markets for components used in these products, including communications and applications processor chips. As in handsets, market entry and success has been possible in the market for communications baseband processors since the mid 2000s as evidenced by companies such as MediaTek and Spreadtrum that acquired market share despite having little or nothing in the way of cellular SEPs. Mobile handset processor chip market shares are well dispersed, and positions of individual chipset component suppliers have changed dramatically over time. Credit Suisse has found that MediaTek is "consistently profitable" in smartphones with gross profit margin at 45 percent and operating margin at 20 percent.[77]

While chipset markets are global with intense competition among vendors and technologies, almost all chips used in cellular devices destined for any country in the world are manufactured in Asia.[78] Chip suppliers vary in competitive strength depending on technology and countries or parts of the world served. For example, MediaTek has built significant chipset sales share, in part because of its strength in GSM/EDGE, while Spreadtrum has grown to a significant position, in part, because of its strength in TD-SCDMA, which is used only by China Mobile, the overwhelmingly market-leading carrier in China.[79] Those companies have increased the range of standards, technologies, and capabilities of the chip products that they produce. According to Strategy Analytics, MediaTek is also the global market leader in WCDMA baseband chips since Q1 2015 with 31 percent market share, and it has entered the market for LTE chips and grown its global LTE baseband processor share to 12 percent.[80]

---

76 *See How Much Is Your Mobile Phone Worth?*, MAZUMA MOBILE, http://www.mazumamobile.com/ (last visited May 17, 2016).

77 THE WIRELESS VIEW, *supra* note 53, at 42.

78 Alan Patterson, *Asian Share of Global Fab Capacity May Top 69% by 2019*, EE TIMES (Mar. 2, 2015), http://www.eetimes.com/document.asp?doc_id=1325877.

79 HANDSET INDUSTRY OUTLOOK, *supra* note 43, at 69.

80 STRATEGY ANALYTICS, https://www.strategyanalytics.com/ (last visited May 17, 2016) (subscription required).

E. *Competition for Sales of Cellular Chipsets Includes Competition Among Standards*

Sales of cellular chipsets are characterized not only by competition among manufacturers, but by competition among chips supporting different cellular standards. Competition is significantly based on the technical performance of the various standards, for example, with consumers trading up from 2G to a choice from among three different 3G standards. Competition also limits prices. Consumers shift to devices operating on a different standard if the combination of performance and price is more appealing (although this may also require a switch to a different carrier).

There are also strong historical examples of this phenomenon. Technological competition began in the United States, Canada, and Latin America during the 1990s, for example, with the introduction of several rival 2G standards including TDMA,[81] cdmaOne and GSM. After the turn of the millennium, competition in 3G technologies and standards initially included WCDMA and CDMA2000 from rival standards groups 3GPP and 3GPP2 respectively. Markets outside the United States have experienced similar competition. For example, the Chinese market has in most recent years supported both the 3GPP and 3GPP2 standards, as well as a third variant of 3G CDMA technology called TD-SCDMA. Technology-share mix in China has changed significantly of late, for example, due to TD-SCDMA rapidly substituting for GSM at China Mobile. The annual growth rates in smartphone shipments of 54 and 26 percent in 2013 and 2014 respectively—according to IHS Technologies—provide further evidence of the dynamic nature of the industry.[82]

Competition among technologies also spurred the rapid development of 4G standards. The IEEE standard-setting organization developed and launched the 802.16 WiMAX technology standard to challenge the then-incumbent 3G technologies, and WiMAX was soon claimed to be the first 4G standard.[83]

This development in turn resulted in the cellular industry pushing for the acceleration of 4G technology developments elsewhere, including the technologies that were standardized soon after by 3GPP as "Long Term Evolution" or LTE. WiMAX was a significant threat for incumbent carriers because it was claimed to be 4G and was being adopted ahead of them by new entrants. However, WiMAX was not being developed to facilitate the

---

81 TDMA (IS-136), also known as Digital AMPS, was approved by the American National Standards Institute (ANSI). It was prevalent throughout the Americas, particularly in the United States and Canada in the late 1990s, before becoming obsolete and being entirely replaced by other technologies in the 2000s.

82 IHS TECH., https://technology.ihs.com/ (last visited May 17, 2016).

83 Sascha Segan, *WiMAX vs. LTE: Should You Switch?*, PC MAG. (May 16, 2012), http://www.pcmag.com/article2/0,2817,2403490,00.asp.

backward compatibility that only incumbents could provide and which was their prospective competitive advantage. For example, as early as 2007, when Vodafone had earned only 10 percent of its revenues from 3G services in the prior year (the remainder still coming from 2G GSM services), at the GSM Association's 3GSM Mobile World Congress in February 2007, Vodafone's then-CEO Arun Sarin issued a "call to arms" to cellular companies to accelerate the development of LTE to compete against new-entrant WiMAX operators.[84] LTE played to the strengths of incumbent mobile operators and their existing suppliers by providing backward compatibility to the established networks with wide 2G and 3G coverage. In contrast, WiMAX was never able to provide the same levels of backward compatibility with existing 3G networks as LTE, which was important to established cellular operators. Following Sarin's comments, Vodafone and its 45-percent-owned CDMA2000 technology-based-partner Verizon Wireless announced they would both pursue LTE as their common next generation technology.[85] A keynote presentation by Verizon Wireless CTO, Dick Lynch, at the 2009 Mobile World Congress in Barcelona, announced the LTE vendor line up and ambitious launch dates.[86]

Competition among different standard technologies is readily visible in other ways as well. For example, in the United States and China, where multiple families of standards are deployed, carriers compete through consumer advertising that praises the performance or pricing advantages of their technologies compared to those with the standards used by rival carriers. Similarly, there is fierce competition between generations of standards, as, for example, carriers or handset suppliers attempt to persuade customers to switch from 2G and 3G devices and services by advertising improved performance available with the newer technologies in 3G and 4G devices and services.[87] Alternatively, some operators emphasize the lower cost of

---

84 *Vodafone CEO: Mobile Biz Must Move Faster*, FIERCEWIRELESSEUR. (Feb. 21, 2007), http://www.fiercewireless.com/europe/story/vodafone-ceo-mobile-biz-must-move-faster.

85 *Vodafone, Verizon Want to Harmonize on 4G*, FIERCEWIRELESSTECH (Sept. 24, 2007), http://www.fiercewireless.com/tech/story/vodafone-verizon-want-harmonize-4g/2007-09-24; Press Release, Verizon, Verizon Selects LTE as 4G Wireless Broadband Direction (Nov. 29, 2007), http://www.verizonwireless.com/news/article/2007/11/pr2007-11-29.html.

86 Sue Marek, *Verizon's Dick Lynch Reveals LTE Equipment Vendors*, FIERCEWIRELESS (Feb. 15, 2009), http://www.fiercewireless.com/story/embargoed-verizons-richard-lynch-reveals-lte-equipment-vendors/2009-02-15.

87 China Unicom capitalized for years on uniquely being able to offer the iPhone with 3G to improve its competitive position. Francis Tan, *iPhone Sales Help China Unicom Reach 140m Subscribers*, NEXT WEB, http://thenextweb.com/asia/2011/01/22/iphone-sales-help-china-unicom-reach-140m-subscribers/#!r7Gm3 (last visited May 17, 2016).

devices and services with their offerings, even if they do not highlight the older technologies employed.[88]

Competition among technologies and generations of technologies at the consumer level represents indirect competition (based on price and performance) between suppliers of various types of cellular chipsets. Consumers choose one carrier over another carrier that might use different cellular technology, or select a handset that uses a particular generation of technology. Such consumer choice drives OEMs' chipset purchasing, particularly in nations such as the United States and China where some different operators use entirely different technology standards.

F. *As a Result of Innovation and Competition, Prices to Consumers for Cellular Devices and Services Continue to Drop Rapidly*

1. Mobile Phone Prices Have Decreased While Quality Has Increased

Global average wholesale phone prices for all categories of phones, (i.e., excluding mobile operator subsidies), declined from $560 to $130 between 1993, when digital 2G technologies were first introduced, and 2010—representing an average 8 percent reduction every year.[89] But these "average" prices do not reflect huge increases in the capabilities and features of many phones over this period. Since the mid-2000s, low-cost, minimum-feature 2G phones—which generally exceed the capabilities of even the best phones that were available in 1993—have wholesaled for prices of $50, and below $30 for ultra-low-cost handsets.[90] That is less than one tenth the price of a decade earlier, even before adjusting for inflation. And, as indicated in the price comparison between leading 2006 and 2012 smartphones in Figure 2, after adjusting for a 14 percent increase in the U.S. consumer price index over that six-year period, the 2012 device was 24 percent cheaper on an inflation-adjusted basis while providing much higher levels of functionality and performance. The figure also shows that by 2014, a smartphone with similar or better capabilities was available for 40 percent less than the 2012 market leader.

---

88 Tracfone in the United States has emphasized voice calling at low prices while mentioning little or nothing about network technologies. *Value Plans*, TRACFONE, https://www.tracfone.com/direct/ValuePlans?app=TRACFONE&lang=en (last visited May 17, 2016).

89 Prices not adjusted for inflation. Adjusting for inflation, the average wholesale phone price for all categories of phones in 2010 would be $86.15 in 1993 dollars.

90 Tatum Anderson, *India Seeks Mobiles for the Masses*, BBC NEWS (Feb. 12, 2007), http://news.bbc.co.uk/1/hi/6339519.stm; Sascha Segan, *How Nokia Made a Beautiful $20 Phone, the Nokia 105*, PC MAG. (Feb. 26, 2013), http://www.pcmag.com/article2/0,2817,2415933,00.asp.

In fact, as reviewed in Part III.C and Figure 2 above, popular phones have become continually more feature rich with higher-performance communications and applications processing. Sales of 2G devices and feature phones have already dropped to a small percentage of sales within the United States, China and in many other nations for lack of consumer demand. Instead, 3G smartphones providing a rich array of features enabled by high-speed data links are widely available. In India, for example, consumers can purchase these phones for less than $100 retail, without subsidies or contracts.[91] This price is very affordable globally, including in lower income nations.

2. Voice Service Charges Are Down to U.S. Cents Per Minute and Data Costs Are Plunging

Also important to consumers, cellular voice and data communications prices have fallen dramatically, and this trend continues. The more efficient use of radio spectrum, higher data speeds and increased network capacity—made possible by successive technological innovations—has driven down network costs. This in combination with competition among carriers and technologies has passed savings on to consumers. Average calling prices have fallen by an order of magnitude over the decades down to U.S. cents or tens of cents per minute in most nations.[92]

Consumer prices for cellular data communication have dropped even more quickly since usage became substantial with introduction of the 3G iPhone and Android devices in 2008.[93] For example, according to the U.S. Federal Communications Commission's sixteenth *Annual Report and Analysis of Competitive Market Conditions with Respect to Mobile Wireless, Including Commercial Mobile Services*, published March 2013, the effective price of data declined from $0.47 per megabyte in the third quarter of 2008 to about $0.05 per megabyte just over two years later (in the fourth quarter of 2010).[94] This total decrease of 89 percent is equivalent to an annual decline of 63 percent.

The price per megabyte of data will continue to reduce dramatically while demand continues to grow exponentially, as device speeds and net-

---

[91] Harichandan Arakali, *Life with a $100 Smartphone: How Low-Cost Phones Are Rapidly Changing Lives in India*, INT'L BUS. TIMES (July 2, 2015), http://www.ibtimes.com/life-100-smartphone-how-low-cost-phones-are-rapidly-changing-lives-india-1948464.

[92] ROGER ENTNER, THE WIRELESS INDUSTRY: THE ESSENTIAL ENGINE OF US ECONOMIC GROWTH 38, 41 (2012), http://reconanalytics.com/wp-content/uploads/2012/04/Wireless-The-Ubiquitous-Engine-by-Recon-Analytics-1.pdf.

[93] FED. COMMC'NS COMM'N, ANNUAL REPORT AND ANALYSIS OF COMPETITIVE MARKET CONDITIONS WITH RESPECT TO MOBILE WIRELESS, INCLUDING COMMERCIAL MOBILE SERVICES 181 (Mar. 21, 2013), https://apps.fcc.gov/edocs_public/attachmatch/FCC-13-34A1.pdf.

[94] *Id.* at 15.

work capacity are increased. In May 2011, WiseHarbor published a forecast predicting that as data traffic grows more than 1,000-fold over a 15-year period, revenue to operators per megabyte transmitted will decline by a factor of at least 100, from $0.10 per megabyte for mobile data in 2010 to $0.001 in 2025 (global averages including postpaid and prepaid service purchasing plans).[95] Trends since 2011 are on track to meet that prediction.

IV. PATENT ROYALTIES ON CELLULAR DEVICES REPRESENT A VERY SMALL PERCENTAGE OF TOTAL COSTS AND A FAIR SHARE OF THE ENORMOUS VALUE THEY PROVIDE

Patent royalties on cellular devices represent an important means by which innovators can recover their risky R&D investments and provide funding for the next cycle of research and innovation that will bring further improvements and lowered costs to OEMs, carriers and consumers. The role of patent royalties greatly affects the overall economics of the cellular industry.

It is the widespread practice within the cellular industry that royalties for substantial patent portfolios are assessed on completed devices, and most commonly based on the average wholesale price ("AWP").[96] This assessment is most significantly because of the value-enabling function of basic cellular technology in devices overall, including many other complementary capabilities as discussed in Part II.D above. When 4G LTE SEP patent-holders publicly announced their "maximum" royalty rates for LTE licenses, all of them announced their rates as a percentage of AWP of handsets (or in a few cases as a flat per-unit royalty).[97] Former Ericsson licensing executive Eric Stasik—who had visibility into cellular licensing in the relevant time period—has confirmed that this licensing practice applied to 2G devices.[98] This practice likely also occurred for 3G licenses.

---

95 WiseHarbor, *Half the World with Mobile Broadband Using Gigabytes Per Month by 2020*, MARKET WIRED (May 17, 2011), http://www.marketwired.com/press-release/half-the-world-with-mobile-broadband-using-gigabytes-per-month-by-2020-1515191.htm.

96 Brief of *Amicus Curiae* Qualcomm Inc. in Support of Affirmance on RAND Issues at 27, Ericsson, Inc. v. D-Link Sys., Inc., 773 F.3d 1201 (Fed. Cir. 2014) (Nos. 2013-1625, 2013-1631, 2013-1632, 2013-1633), http://www.essentialpatentblog.com/wp-content/uploads/sites/64/2014/03/2014.03.12-161.-Qualcomms-Amicus-Brief.pdf.

97 *See, e.g.*, QUALCOMM, LTE/WIMAX PATENT LICENSING STATEMENT (2008), http://www.qualcomm.com/media/documents/ltewimax-patent-licensing-statement; ERIC STASIK, ROYALTY RATES AND LICENSING STRATEGIES FOR ESSENTIAL PATENTS ON LTE (4G) TELECOMMUNICATION STANDARDS (2010), http://www.investorvillage.com/uploads/82827/files/LESI-Royalty-Rates.pdf (discussing royalty rate announcements by various companies for LTE).

98 *See* Expert Report of Eric Stasik ¶ 45, *Nokia Corp. v. Vias De Telecommunicacion Vitelcom, S.L.*, Mercantile Court of Barcelona (report dated Nov. 17, 2004) (stating the royalties were "normally assessed on net sales price as a proxy for profit to avoid invasive accounting"). In 2002, Mr. Stasik was

While it has rarely been possible to know with accuracy the total royalties paid by individual handset OEMs because license agreements are almost always confidential, public disclosures and financial reports of licensors provide an indication of aggregate and average royalties in the industry.

Estimates for royalties initially paid for the SEPs in 2G GSM varied widely. These SEPs were highly concentrated in the hands of Nokia, Ericsson, Motorola, and a few others, who entered into confidential cross-licenses to reduce or eliminate royalty costs among themselves. Cumulative royalties charged for 2G licenses to OEMs that did *not* have any patent rights to trade were estimated to have ranged from 40 percent in the 1990s to low single digits (i.e., less than 5 percent) a decade later.[99]

Actual cumulative royalties on 3G are also rather uncertain, but contrary to early speculation by parties with vested interests in minimizing royalty fees, no evidence suggests that the royalties were higher than the cumulative royalties on 2G devices, despite the much greater number of SEPs, and the far larger R&D investments required to develop 3G technologies. Nokia, which claimed a very large SEP portfolio which likely enabled it to obtain favorable cross-licenses, stated publicly in 2007 that it paid "less than 3 per cent aggregate license fees on [3G] WCDMA handset sales under all its patent license agreements."[100] While CSFB predicted in 2005 that "those vendors without an IPR position to trade off" would face cumulative royalties of 17.3 percent on WCDMA phones, which almost invaria-

---

"director of corporate IPR and licensing for Telefonaktiebolaget LM Ericsson in Stockholm, Sweden as a member of the corporate staff responsible for global patent licensing and patent strategies for the Ericsson concern." *Id.* ¶ 3.

99 Keith Mallinson, *Patent Licensing Fees Modest in Total Cost of Ownership for Cellular*, IP FIN. (June 12, 2011), http://www.ip.finance/2011/06/patent-licensing-fees-modest-in-total.html. As I noted in the *Patent Licensing Fees* article, which was the third in a series for IP Finance, "In 1998, the International Telecommunications Standards User Group [ITSUG] (representing some operators and manufacturers) complained to the European Commission that 'when GSM handsets first appeared on the marketplace cumulative royalties amounted to as much as 35 percent to 40 percent of the ex-works selling price.'" *Id.* It is implausible, however, that such high rates were actually paid while the major SEP owners were paying very little or nothing: much lower rates have prevailed. "Much lower, independent estimates for the cumulative GSM royalty rate paid, by companies that do not have any patents to trade, include 10-13 percent." *Id.* Similarly, a CSFB investment research report also cites ITSUG and with much lower rates: "Indeed, in GSM we note that the royalty rate ranged from anywhere between 8% and 40%, although it has now fallen to low single digits according to telecoms licensing bodies such as the ITSUG." CREDIT SUISSE FIRST BOSTON [CSFB], 3G ECONOMICS, IPR—EXTENDING COMPETITIVE ADVANTAGE 5 (2005), http://www.csfb.com/ir/.

100 Press Release, Nokia, Nokia Has Paid Less Than 3 Per Cent Gross Royalty Rate for WCDMA Handsets (Apr. 12, 2007), http://company.nokia.com/en/news/press-releases/2007/04/12/nokia-has-paid-less-than-3-per-cent-gross-royalty-rate-for-wcdma-handsets.

bly also include GSM technology,[101] ABI Research described WCDMA handset average cumulative royalties of 9.4 percent in 2007.[102]

As reviewed in Part III.E, the scale of investment necessary to develop LTE, and the number of patents necessary to implement the standard, are both larger, yet there is no public evidence that actual cumulative royalties on LTE devices are appreciably higher than has been the case for 3G devices. This Article indicates that a large number of OEMs are selling LTE handsets without claiming that they are paying higher royalty rates on those devices than for 3G devices. Indeed, as indicated in the price comparison between smartphones in Figure 2, feature-packed LTE devices are cheaper now than the top of the line 3G devices were in 2006.

Nevertheless, there is still significant speculation that cumulative royalty rates for LTE technology SEPs amount to tens of percent of wholesale handset prices;[103] yet there is no evidence that rates anywhere near that high are actually being paid.[104] To the contrary, financial reports of total licensing revenues reveal that cumulative royalty rates actually paid for 2G, 3G, and 4G technologies amount to only around 5 percent of wholesale sales revenues for mobile phones.[105] Regardless of the precise cumulative royalty rates OEMs face for 3G or 4G devices, several facts suggest that these royalties are not inappropriate. As discussed below, royalties likely do not prevent market entry or impose excessive costs on consumers. Rather, royalties positively impact the cellular industry by directly enabling market entry, innovation, and market growth.

A. *Intellectual Property Accounts for a High Percentage of the Value in Certain Products*

Intellectual property and other intangibles represent the majority of value in many traditional products and increasingly with those in infor-

---

101 CSFB, *supra* note 99, at 5.

102 *High Handset Royalty Rates Currently Inhibiting Mobile Phone Markets, According to ABI Research*, BUS. WIRE (Jan. 10, 2007), http://www.businesswire.com/news/home/20070110005662/en/High-Handset-Royalty-Rates-Inhibiting-Mobile-Phone#.UsHlXhtFCcw.

103 Intel Vice President and Associate General Counsel Ann Armstrong and WilmerHale's Joseph Mueller and Timothy Syrett argue that aggregate patent licensing fees including SEPs and non-SEPs are excessive at around $120 per $400 smartphone. Ann Armstrong et al., *The Smartphone Royalty Stack: Surveying Royalty Demands for the Components Within Modern Smartphones* 2 (Intel Corp. Working Paper, May 29, 2014), https://www.wilmerhale.com/uploadedFiles/Shared_Content/Editorial/Publications/Documents/The-Smartphone-Royalty-Stack-Armstrong-Mueller-Syrett.pdf

104 Keith Mallinson, *Stacking the Deck in Analysis of Smartphone Patent Licensing Costs*, IP FIN. (Sept. 19, 2014), http://ipfinance.blogspot.co.uk/2014/09/stacking-deck-in-analysis-of-smartphone.html.

105 Keith Mallinson, *Cumulative Mobile-SEP Royalty Payments No More Than Around 5% of Mobile Handset Revenues*, IP FIN. (Aug. 19, 2015), http://ipfinance.blogspot.co.uk/2015/08/cumulative-mobile-sep-royalty-payments.html [hereinafter Mallinson, *Cumulative Mobile-SEP Royalty Payments*].

mation and communication technologies. For example, it is widely accepted that when one pays $25 for a hardcover or $10 for a paperback book, production costs in printing account for but a small proportion of these figures. Royalties to authors, illustrators and agents as well as costs in distribution, marketing and the publisher's profit margin account for the vast majority of these prices. Similarly, other IP-intensive products, such as patented drugs and software, have a very large proportion of costs in IP. For patented drugs, for example, R&D is expensive (and often unsuccessful), while manufacturing, packaging, and other costs are relatively small.[106] Consequently, a large percentage of the ultimate price paid by consumers can be attributed to patented IP.

The value in cellular handsets has significantly shifted from hardware manufacturing costs to intangible intellectual property. The increasing amount of R&D investment required in developing each new generation of cellular technology and the corresponding increase in the number of standard-essential and other applicable patents provide some indication of this. In addition, unlike early cell phones, contemporary smartphones are extremely powerful processing devices, loaded with millions of lines of specialized operating software, as well as many separate software applications. Early on in the smartphone revolution and within six months of the July 2008 launch of the 3G iPhone and the Apple App Store, smartphone users began using many specialized applications, demonstrating a marked trend of increasing value with the intangibles in mobile devices and leading to the value of embedded and aftermarket software coming to predominate over the hardware manufacturing costs.[107] The success of the iPhone including its App Store has proven this point. The iPhone led the smartphone market globally for several years. It has generated stellar gross-profit margins of up to 60 percent and still commands an AWP of approximately $600, although its manufacturing costs are only around $200 per device.[108] Clearly, the majority of the value to consumers with this $400 difference is based on intangibles including various intellectual properties.

Once the critical role of IP in modern smartphones is understood, it becomes clear that it is unreasonable to state without full and robust eco-

---

106 WAYNE WINEGARDEN, THE ECONOMICS OF PHARMACEUTICAL PRICING 5 (2014), https://www.pacificresearch.org/fileadmin/documents/Studies/PDFs/2013-2015/PhamaPricingF.pdf.

107 *See* KEITH MALLINSON, WISEHARBOR, ENSURING COMPETITIVE COSTS AND PRICES FOR LTE HANDSETS 9-10 (2008), http://www.wiseharbor.com/pdfs/WiseHarbor_LTE_handset_11.08.pdf.

108 *See* Paul Boutin, *AT&T's $375 Subsidy Boosts Apples' iPhone Profit Margin to 60 Percent*, VENTURE BEAT (July 29, 2009), http://venturebeat.com/2009/07/29/att-subsidy-of-375-boosts-apples-iphone-profit-margin-to-60-percent/; Press Release, IHS Technology, iPhone 3G S Carries $178.96 BOM and Manufacturing Cost, iSuppli Teardown Reveals (June 24, 2009), http://www.isuppli.com/Teardowns/News/Pages/iPhone-3G-S-Carries-178-96-BOM-and-Manufacturing-Cost-iSuppli-Teardown-Reveals.aspx.

nomic analysis that a cumulative royalty rate on the AWP of cellular devices of, for example, 15 percent, or even 25 percent, is "too high" or inconsistent with the value created by the licensed IP. In the case of a simple household hardware device such as a broom, one would likely expect most of the product value to be created by the manufacturing process. In the case of packaged software, close to 100 percent of the value may be attributable to intellectual property with relatively small costs in CD-ROM production and packaging or in online delivery. In the case of an extremely sophisticated technology device such as a smartphone which makes use of thousands of patented inventions and is loaded with millions of lines of software code, the fair division of value among the various intellectual properties including standard-essential and other patents and copyrighted design and software, versus the more clearly identifiably hardware manufacturing cost, is a complex question.

B. *Device Royalties Are a Small Percentage of Consumers' Overall Cellular Costs*

Patent royalties are commonly assessed on the average wholesale price of handsets, for good reason, as explained above. However, the cost to a consumer of enjoying cellular communications is far more than the handset price. Total consumer expenditures include service fees to carriers (whether paid monthly or per unit of usage, or roaming fees). It is important to realize that the capabilities provided by inventions covered by cellular communications SEPs benefit services and networks, as well as devices. Inventions covered by these SEPs include data transmission techniques used by both handsets and base stations that enable high data rates and reliable reception, voice encoding, encryption, location tracking, and automatic roaming. A handset in isolation from a network cannot make calls or receive data, let alone exploit enhanced capabilities. Thus, while licensing fees are charged on wholesale mobile phone prices, this overlooks the fact that *most* of the ecosystem value provided by cellular technology is realized in operator service revenues—not in handset prices. In fact, handset prices are commonly subsidized by carriers—100 percent in many cases—due to fierce competition among carriers, because innovative new cellular technologies reduce network costs and because carriers anticipate these much larger revenues from *use* of advanced devices.[109] In order to account for this phenomenon, this Article also calculates royalties as a proportion of total consumer costs including handset and service charges.

Figure 7 shows that in North America, Europe, and China, total cellular expenditures during a handset's service life average around three or

---

[109] Don Reisinger, *Analyst: Carriers Are Locked into Those Steep iPhone Subsidies*, CNET (Apr. 24, 2012), http://www.cnet.com/news/analyst-carriers-are-locked-into-those-steep-iphone-subsidies/.

more times the cost of the handset. The average service life for a handset from purchase until retirement is around two years.[110]

Figure 7: Handsets Cost Is a Small Proportion of Total Consumer Cellular Expenses[111]

2014	North America	Europe	China
Average service revenue per subscriber (per month)	$69.03	$23.59	$17.96
Service life (in months)	24	24	24
Total operator services expenditures	$1,657	$566	$431
Average unsubsidized wholesale phone price	$432	$297	$191
Total lifecycle expenditures	$2,089	$863	$622
Handset cost as a percentage of total expenditures	21%	34%	31%

The data and calculations displayed in Figure 7 largely relate to smartphones, given their predominance in these geographies. Higher AWPs for smartphones versus handsets in general would be largely offset by the significantly higher fees being paid for data services on smartphones in comparison to featurephones or basic phones.

The relatively small proportion of total costs in purchasing versus using a handset mean that the effective royalty rate based on total costs is correspondingly much lower. In other words, whatever the handset-based royalty rates are for individual licensors, the corresponding royalty rates as a percentage of total expenditures, including handset and services are only approximately 21, 34, and 31 percent as much in North America, Europe

110 This may vary somewhat among nations, but differences are not significant for the purpose of my overall assessment or national comparisons where service costs predominate over handset costs. In my opinion, measures of national differences in handset service life have only limited accuracy and reliability given issues such as rapid new adoption and multiple device ownership. My service life assumption is conservative given extensive multiple-device ownership, hand-down to family and friends, and second-hand market sales. IDC's 2013 Consumer Smartphone Survey Results for U.S., UK and China are generally and approximately consistent with my assumption of 24 months service life for these three nations.

111 GSMA INTELLIGENCE, https://www.gsmaintelligence.com/ (last visited May 17, 2016) (average revenue per subscriber); IDC, WORLDWIDE MOBILE PHONE TRACKER (2015) (average wholesale price).

and China respectively. For example, if a handset manufacturer pays a patent licensor a 1 percent royalty rate on the AWP of a handset, that payment corresponds to only 0.21 percent of an average North American consumer's total cellular expenditures over the handset's service life.

Cumulative royalty rates on handsets add very little to the consumer's entire cost of cellular communications in comparison to value-added or sales taxes. Estimates of handset-based rates vary from single-digit to double-digit percentages, but with no empirical evidence for the latter.[112] However, for the purposes of illustration and on the same basis with a single licensor above, a 10 percent handset-based aggregate royalty rate would nevertheless correspond only to between 2.1 and 3.4 percent of total expenditures. By way of comparison, consumers in European Union Member States pay Value Add Tax at national rates around five or more times higher varying from 17 to 27 percent on all of their cellular expenditures, including device purchases and service charges.[113] Sales taxes and import tariffs on mobile devices in other regions are commonly at similar levels.

Standard-essential technology development costs are good value for money because consumer usage and carrier revenues are increasingly dependent on new data services. Consumers are voluntarily agreeing to trade-up to smartphones and add data service plans at extra cost to access rich content including Internet and video. Consequently, data revenues have grown enormously. These already exceed or will soon surpass those for voice in most developed nations.[114] More than half of global consumer service revenues are imminently becoming directly attributable to the relatively recent innovations that have enabled high data rates.[115] This revenue growth is only possible with the fast and efficient 3G and 4G technologies introduced commercially in the last decade.

C. *Consumers Voluntarily Pay More IP Royalties for Apps and Music to Play on Their Cellular Devices Than the Royalties Covering All the Standards Essential Cellular Technologies*

A cumulative royalty of 10 percent on the AWPs of smartphones today would range from less than $10 to approximately $50 for the majority of

112 Mallinson, *Cumulative Mobile-SEP Royalty Payments*, *supra* note 105.

113 EUR. COMM'N, VAT RATES APPLIED IN THE MEMBER STATES OF THE EUROPEAN UNION (2016), http://ec.europa.eu/taxation_customs/resources/documents/taxation/vat/how_vat_works/rates/vat_rates_en.pdf.

114 Kevin Fitchard, *Is 2013 the Year Mobile Data Becomes Bigger than Voice?*, GIGAOM (Nov. 14, 2013), http://gigaom.com/2013/11/14/is-2013-the-year-mobile-data-becomes-bigger-than-voice/.

115 GSMA INTELLIGENCE, https://www.gsmaintelligence.com/ (last visited May 17, 2016) (subscription required).

the most expensive high-end devices.[116] This percentage covers all royalties for all the patents covering all the inventions that make cellular communications possible—in particular, technologies providing reliable, fast-data rates.

In considering whether or not royalties are "high," it should also be recognized that consumers are voluntarily spending significant sums for intellectual property rights (most commonly copyright permissions) for music to be played and applications such as games to be used on their smartphones.[117] For example, in North America, where the AWP for all mobile phones was $429, spending on Premium Mobile Content was forecast to be $10.2 billion in 2013.[118] This premium content includes applications and services that users pay for and consume on their handsets. Assuming a two-year phone service life, with 229 million U.S. subscribers,[119] this spending on premium content for use on mobile devices thus represented 20 percent of the AWP, or $87.[120] Paid-for content is becoming increasingly popular with subscriptions to music and video streaming services. The Spotify Premium music service costs $9.99 per month in the United States (and with higher prices of €9.99 in the Euro zone and £9.99 in the UK).[121] A two-year subscription to this service in the United States thus totals $240 or 56 percent of the above device AWP.[122]

D. *The OEM Segment, Which Directly Bears the Royalties, Enjoys High Profitability Overall*

While consumers enjoy major increases in technology performance and rapid declines in per-minute voice and per-megabyte data price rates, royalties charged by the industry's principal R&D investors and innovators are not harming profitability of the OEM sector, which directly pays those

---

116 Holders of SEPs often apply a "cap" to the royalty collected on higher-priced devices.

117 Total smartphone apps revenues increased 70 percent to $20.4 billion globally in 2013 and are projected to continue growing rapidly. PORTIO RESEARCH, MOBILE APPLICATIONS FUTURES 2013-2017 (2013). Spending on copyrighted music and video is in addition. Lance Whitney, *Mobile App Use Surged 115 Percent Last Year—Report*, CNET (Jan. 13, 2014), http://news.cnet.com/8301-1035_3-57617134-94/mobile-app-use-surged-115-percent-last-year-report/.

118 NITESH PATEL, STRATEGY ANALYTICS, GLOBAL MOBILE MEDIA FORECAST (2013); LINDA SUI, STRATEGY ANALYTICS, GLOBAL HANDSET REVENUES, ASPS & PRICE-TIER FORECASTS: 2003 TO 2017 (2013).

119 GSMA INTELLIGENCE, https://www.gsmaintelligence.com/ (last visited May 17, 2016) (subscription required).

120 In addition to these consumer payments, corporate mobile adverting expenditures pay 15 percent of the AWP, or $53, for consumer access to "free" content (e.g., on the mobile Internet).

121 Keith Welch, *Spotify—The New Way To Enjoy Music*, MY REVIEWS, http://my-reviews.co.uk/spotify-the-new-way-to-listen-to-music/ (last visited May 17, 2016).

122 Kim Gilmor, *Comparison of Spotify Subscriptions*, DUMMIES, http://www.dummies.com/how-to/content/comparison-of-spotify-subscriptions.html (last visited May 17, 2016).

royalties. While intense competition among the many OEMs has driven down profit margins for low-end or "commodity" handsets, the OEM segment as a whole is quite profitable overall. For example, while competition has taken its severe toll on the profitability of former smartphone market leaders such as Nokia and BlackBerry, current stars Apple and Samsung have grown very good profit margins at their expense.

Overall profits remain substantial for those who create the products most desired by consumers. Apple posted annual revenue of $183 billion with net income before taxes of $53.5 billion for the year to September 2014, a profit margin of 29 percent.[123] Samsung Electronics has reported revenues of 206 trillion KRW ($204 billion) and net operating income before taxes of 27.9 trillion KRW ($27.6 billion) in the year to December 2014, a profit margin of 13.5 percent.[124]

Even some relative newcomers to the market, including leading Chinese cellular technology companies, have enjoyed healthy profitability. For example, according to its annual report, Huawei saw a net profit of over 27.9 billion RMB ($4.50 billion) on revenue of 288 billion RMB ($46.5 billion) in 2014, a profit margin of 10 percent.[125]

E. *Cellular Carriers Continue To Be Highly Profitable*

While financial performance also varies among carriers, leading players have very large revenues and profits. Any SEP royalty charges passed on to carriers in handset prices are insignificant in comparison. For example, U.S. cellular carrier Verizon Wireless generated an operating income of $26.8 billion on revenues of $87.6 billion in the year to December 31, 2014.[126] This represents a strong operating income margin of 30.5 percent. China Mobile had a pre-tax profit from operations of 117.3 billion RMB ($18.9 billion) on operating revenue of 641.4 billion RMB ($103.4 billion) in the year to December 2014, representing an operating income margin of 18.3 percent.[127] These profit margins greatly exceed the range of 2.1 to 3.4 percent in SEP royalties expressed as a proportion of total carrier revenues including handset sales and service revenues, as estimated in Part IV.B. Whether these costs are absorbed by handset OEMs or passed onto carriers, or passed onto consumers in handset prices, or in service charges when handsets are subsidized, they are small in comparison to the enormous ben-

---

123 APPLE INC., 2014 ANNUAL REPORT 45 (2014).

124 SAMSUNG ELECTRONICS, 2014 ANNUAL REPORT 41 (2014).

125 Liam Tung, *Smartphones Drive Huawei Profits Up 33 Percent for 2014*, ZDNET (Mar. 31, 2015), http://www.zdnet.com/article/smartphones-drive-huawei-profits-up-33-percent-for-2014/.

126 VERIZON COMMC'NS INC., 2014 ANNUAL REPORT 18, 20 (2014).

127 CHINA MOBILE, 2014 ANNUAL REPORT 130 (2014).

efits in network and service performance enhancements and cost reductions that the cellular standards-essential technologies provide.

CONCLUSION

The wireless industry has benefitted from explosive growth in the technologies provided to manufacturers, carriers and consumers over the last few decades. These benefits have resulted from the substantial investment in R&D made by Qualcomm along with others. As carriers and customers shift to 4G technologies, this trend will only continue, and companies all over the world may become important sources as well as users of licensed technology.

The industry has experienced this growth while operating under the existing regime of FRAND patent licensing, including SSO policies and well-established industry practices. The markets for mobile devices and chips are functioning well under these arrangements. These are highly competitive and fluid. Numerous examples show that companies are easily able to enter the markets and in some cases rapidly grow large market shares. They do this by providing improved design, added features, efficient manufacture and thus lower costs. This is all achieved to a large extent by exploiting the advancing technologies upon which cellular communications is based including standardized and openly-available technologies and components.

Consumers have seen the benefits of all this innovation and competition in the form of lower device prices, lower data and voice service rates, and the new availability of attractive high-performance features and functionality. Intellectual property royalties are only a very small percentage of their total costs in purchasing and using their devices; costs that consumers have shown a willingness to pay.

APPENDIX A – GLOSSARY OF ACRONYMS

Acronym	Meaning
1G	First generation analog standard cellular technologies
2G	Second generation digital standard cellular technologies
3G	Third generation digital standard cellular technologies
3GPP	Third Generation Partnership Project
3GPP2	Third Generation Partnership Project 2
4G	Fourth generation digital standard cellular technologies
A-GPS	Assisted Global Positioning System
AMOLED	Active-Matrix Organic Light-Emitting Diode
AWP	Average Wholesale Price
ASP	Average Selling Price
CDMA	Code Division Multiple Access
CDMA2000 EV-DO	CMDA2000 Evolution – Data Optimized
CDMA2000 EV-DO Rev A	CMDA2000 Evolution – Data Optimized, Revision A
CDMA2000 EV-DO Rev B	CMDA2000 Evolution – Data Optimized, Revision B
CEO	Chief Executive Officer
CIF	Common Intermediate Format
CNY	Chinese Yuan
CTO	Chief Technology Officer
EDGE	Enhanced Data rates for GSM Evolution
ETSI	European Telecommunications Standards Institute
fps	Frames per second
FRAND	Fair, Reasonable, and Non-Discriminatory
GB	Gigabyte
GLONASS	Gloablnaya navigatsionnaya sputnikovaya sistema
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSA	Global mobile Suppliers Association
GSM	Global System for Mobile Communications
GSMA	GSM Association
HCST	Handset Country Share Tracker
HHI	Herfindahl-Hirschman Index
HSDPA	High-Speed Downlink Packet Access
HSPA	High-Speed Packet Access
HSPA+	Evolved High-Speed Packet Access

Acronym	Meaning
HSUPA	High-Speed Uplink Packet Access
HTML	HyperText Markup Language
IDC	International Data Corporation
IEEE	Institute of Electrical and Electronics Engineers
IP	Intellectual Property
IPR	Intellectual Property Rights
IPS	In-Plane Switching
LED	Light-Emitting Diode
LTE	Long Term Evolution
MB	Megabyte
Mbps	Megabits per second
MMS	Multimedia Message
OEM	Original Equipment Manufacturer
OS	Operating System
RAM	Random-Access Memory
RMB	Renminbi
SEP	Standard Essential Patent
SMS	Short Message Service
SSO	Standard-Setting Organization
TFT	Thin Film Transistor
TDMA	Time Division Multiple Access
TD-SCDMA	Time Division Synchronous Code Division Multiple Access
UMTS	3G Universal Mobile Telecommunications System
UI	User Interface
USB	Universal Serial Bus
VGA	Video Graphics Array
VoLTE	Voice over LTE
WAP	Wireless Application Protocol
WDS	Wireless Device Strategies
WCDMA	Wide Band Code Division Multiple Access
WiMAX	Worldwide Interoperability for Microwave Access
xHTML	Extensible HyperText Markup Language