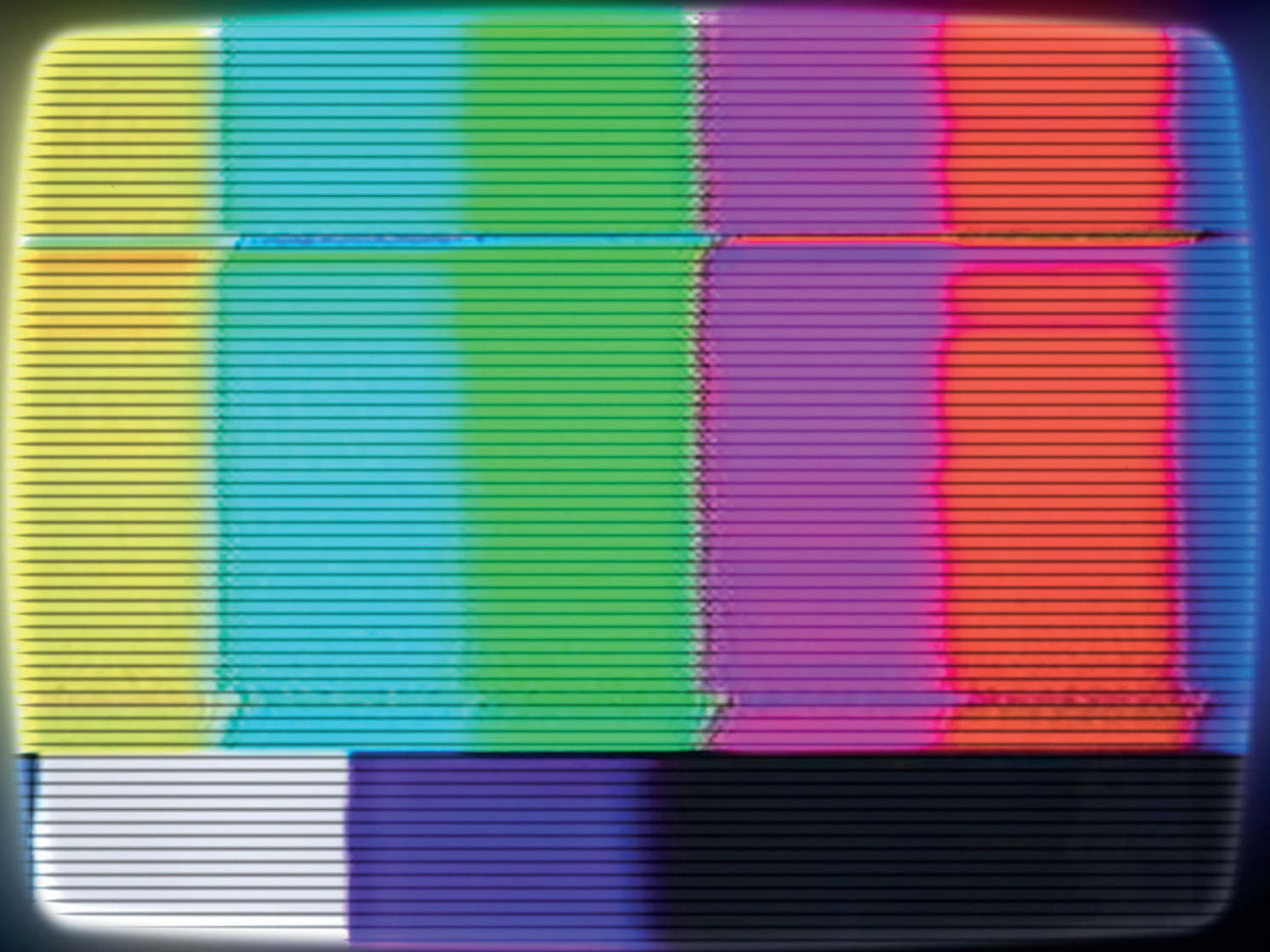


5G AND THE GLOBAL ECONOMY: HOW STATIC COMPETITION POLICY FRAMEWORKS CAN DEFEAT OPEN INNOVATION



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By Kirti Gupta



Understanding “Balance” Requirements for Standards-Development Organizations

By Jorge L. Contreras



The IP Guidelines: Lessons from History

By Willard K. Tom



Stealth Commoditization: The Misuse of Smartphone Antitrust

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Antitrust and Balance of Interests in Standards Development – Lessons from *NSS Labs. v. Symantec*

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I. INTRODUCTION

Wireless telecommunications help knit together the global economy. The efforts of hundreds of thousands of engineers employed by thousands of firms have cooperated and competed to deliver solutions, not just compatible across firms but continually improving across time. This miracle of coordination is due to *Open Innovation*,² a paradigm by which innovating firms use external as well as internal ideas to improve their devices and enhance the consumer experience. This paradigm has helped make mobile telecommunications one of the most, if not the most, innovative engines in the world economy. Today almost two-thirds of the world's population – close to 5 billion subscribers – enjoy the fruits of this technology.

With the advent of 5G, mobile wireless promises to connect everyone and everything all the time with high speed (100x 4G/LTE) and with super-low latency – the time between a command's being issued and its response being received. With 5G, delay is nearly nonexistent, which is central for controlling drones and robots. This technology is both evolutionary and revolutionary, in that it will work with (and draws lessons from) existing 4G/LTE networks, but it is much faster. Before too long, mobile data rates will likely exceed wired network data rates. It will enable a new era of disruptive communication technology and create a digital virtuous cycle. Deployed networks will spur a new generation of applications from remote surgery to autonomous vehicles to drones to virtual reality – and whatever the collective power of the upstream technology community and the applications community can create. More data is consumed as the user experience improves.

With the initial rollout of 5G now occurring, we are in the very early stages of moving beyond person-to-person connectivity. Device-to-device connectivity is the next big wave and it will result in connected homes and connected machines, particularly in the industrial and automotive segments. “We’re talking about smarter motorways, smarter factories, smarter cities,³ smarter homes.”⁴

This paper explains how the mobile wireless open innovation model has been impaired by regulatory interventions and judicial decisions – so much so that the open innovation model, which has been so important in the evolution of the mobile wireless industry to date, could well collapse and be replaced by a vertical integration “stack” model which would be less friendly and beneficial to consumers. In this new reality open dialogue between technology developers, chipset partners, and device manufacturers would become less open, less frequent, and more proprietary.

² See Henry Chesbrough, *Open Innovation: The New Imperative for Creating and Profiting from Technology*, Boston: Harvard Business School Press, 2003.

³ Smart cities should finally flourish with 5G, which will allow real-time data flows about pollution levels, traffic flows, and energy use.

⁴ Rahim Tafazoli, 5G Innovation Centre, University of Surrey, quoted in *Business Life*, June 2019, p. 27.

In the context of mobile wireless, the 3rd Generation Partnership Project (“3GPP”) has united Standards Development Organizations (“SDO”) such as the European Telecommunications Standards Institute (“ETSI”) and others to ensure compatibility and, most importantly, improvement. In the existing Open Innovation paradigm, new wireless technologies must first be ratified in the 3GPP standard, but also must be validated in network equipment. ETSI fosters rapid innovation by “adequately and fairly” rewarding contributors of intellectual property (IP) in order to encourage nonexclusive licensing versus exclusive own-use. The pricing criterion to encourage development, adoption and licensing of upstream mobile wireless technology is fair, reasonable, and nondiscriminatory (“FRAND”) royalty rates. These should be high enough to encourage development but not so high as to discourage adoption. The nonexclusive licensing model enabled by ETSI’s FRAND policy has led to the twin technological triumphs of cooperative development and widespread adoption.

Overzealous – and I would argue myopic – competition authorities and courts have been lured into the belief that FRAND terms implicate antitrust (and not just contractual) issues, due to a hypothetical, narrowly, and wrongly defined fear of “holdup” (opportunism) by patent owners leading to royalty rates that are “too high.” Patent owners, having collectively sunk billions into R&D to support the mobile ecosystem, are themselves deeply exposed to “holdout” (evasion of licensing) by implementers whose investments may not be sunk, and who can take advantage of the fact that patents are not self-enforcing. The SSNIP test inappropriately applied to IP rights takes too narrow a view of the market and has led to some antitrust scholars seeing “monopolies” associated with each standard-essential patent – monopoly power which should be curbed through antitrust intervention.

By siding with device makers – often very large companies like Apple, who have the financial resources to litigate in multiple venues – antitrust agencies and courts have in my view injected antitrust theories based on incorrect assumptions into licensing issues where they don’t belong. In doing so, the authorities have come close – and may succeed – to destroying the highly competitive Open Innovation model that they (ironically, in less contentious forums) recognize as virtuous. Jonathan Barnett recently asked whether academia has led patent law astray.⁵ In a similar spirit, this paper expresses a concern that academia (and in particular antitrust economists wedded to static frameworks) may too have led elements of the U.S. FTC and some judges astray.

To survive, the Open Innovation model must promote sufficient returns to allow a technology market to work. Otherwise the licensing model breaks down and innovation falters, or is confined to vertically integrated firms that fund R&D internally.

In the U.S. the FTC has taken actions which are likely to, at minimum, impair Open Innovation in wireless telecommunications, and possibly destroy it. The consumer, whom those agencies supposedly champion, will be the loser. Clearly that is not the agencies’ goal. But competition authorities and the courts need to look with a wider lens in cases when innovation issues, ecosystems, and international competition are front and center, as they are with 5G.

This wider lens would have sufficient aperture to view the relevant competitive arena, which is the entire mobile wireless innovation ecosystem. It is only by doing so that policy makers have a chance of doing more good than harm. Antitrust economists often start by defining some relevant market, but that lens as commonly employed is too narrow to comprehend the interconnected and complex systems that form the relevant competitive arena in which Open Innovation has thrived.

Indeed, another ambition of this short essay is to stimulate antitrust scholars to question received notions about relevant markets, and in particular, so-called “technology markets,” where each individual standard-essential patent becomes a market. This formulation is *reductio ad absurdum*.

⁵ Jonathan Barnett, “Has the Academy Led Patent Law Astray?,” 32 *Berkeley Technology Law Journal* 1313 (2018).

II. MOBILE WIRELESS TECHNOLOGY AS ENABLING TECHNOLOGY

In my view it is important to recognize that a good many wireless innovations enable other innovations. An *enabling technology* possesses both the capacity for ongoing improvement and the stimulus for complementary innovation in separate, adjacent or downstream “application” sectors.⁶ It naturally stimulates spillovers into those sectors. Because of these spillovers, and because you cannot easily integrate your way around the associated bargaining issues, enabling technology faces serious market failure issues. Legislatures and the courts need to be sensitive to this and not compound the problem with fallacious antitrust theories which end up amplifying the problem.

The essence of enabling technology is that it has spillovers in many complementary or downstream applications, opening up downstream opportunities. For example, 4G allowed networked transport applications like Uber and Lyft to work well. Therefore, incentivizing its creation and improvement is critical to the downstream sector(s). Under-incentivizing enabling technology is not unlike shutting down irrigation in California’s Central Valley. Lack of water would deny many crops the occasion to flourish; from almonds to beans to corn to grapes to oranges to rice to walnuts.

Implementers of enabling technology, like device makers in the case of 5G, build on the upstream innovation. The device maker’s business model to capture value is typically to sell bundles of technology with tangible inputs. This is relatively straightforward and doesn’t require much help from the courts, as the technology sale is embedded in the product sale. The revenue loss due to product theft is less catastrophic to the implementer than widespread patent infringement would be to the patent-owning technology contributor.

Widespread infringement of the upstream enabling technology can lead to royalties being permanently depressed. The weakening of injunctive relief in the U.S. post-*eBay* allows infringement (and the avoidance of royalty payments) to continue for long periods.⁷ The results are hinted at by the global share of smartphone industry profits, which have largely accrued to the two leading device makers, Apple and Samsung.⁸

In short, IP protection for enabling wireless technology – which has very large and positive externalities, or “spillovers” – has become weak and uncertain because courts have allowed antitrust issues to be injected into what is a contractual issue – namely, the appropriate FRAND royalty.⁹ Thus, in addition to the inherent long-standing difficulty of collecting payment for IP, proper reward for IP now suffers from misdirected antitrust intervention animated by empirically unsupported holdup theories, court-created *de facto* royalty caps following the “smallest salable patent-practicing unit” doctrine, and other inimical notions untethered from the basic economics of technological innovation. Addressing this imbalance is a critical policy issue if 5G is to reach its full potential, and if the open innovation model is to stay alive.

6 See David J. Teece, “Profiting from Innovation in the Digital Economy: Enabling Technologies, Standards, and Licensing Models in the Wireless World,” 47 *Research Policy* 1367 (2017); David J. Teece, “Enabling Technology, Social Returns to Innovation, and Antitrust: The Tragedy of Depressed Royalties,” *CPI Antitrust Chronicle* (June 2018); and David J. Teece, “The ‘Tragedy of the Anticommons’ Fallacy: A Law and Economics Analysis of Patent Thickets and FRAND Licensing,” 32:4 *Berkeley Technology Law Journal* 1489 (2017), 1515-1522.

7 Michael P. Akemann, John A. Blair & David J. Teece, Patent Enforcement in an Uncertain World: Widespread Infringement and the Paradox of Value for Patented Technologies, 1 *Criterion J. on Innovation* 861 (2016).

8 ZDNet, “Apple, Samsung capture all of industry’s smartphone profits,” August 22, 2016, citing Canaccord Genuity finding Apple earned 91 percent of total 2015 industry profit; Samsung 14 percent; Microsoft, Sony, others posted losses. <https://www.zdnet.com/article/apple-samsung-capture-all-of-industrys-smartphone-profits/>.

9 A sitting FTC commissioner put it this way: “Judicial alchemy also converted a contractual obligation into an antitrust one.” Christine Wilson, “A Court’s Dangerous Antitrust Overreach,” *The Wall Street Journal*, May 28, 2019. <https://www.wsj.com/articles/a-courts-dangerous-antitrust-overreach-11559085055>.

III. OPEN INNOVATION AND 5G AS A SOFTWARE TECHNOLOGY

5G wireless is fundamentally a software technology: expensive to create, cheap to copy, and very much in need of strong IP rights. In that regard 5G and mobile wireless are little different from some other industries. With increasing frequency, innovative companies have software as their core asset. Although known for other products – Apple for the iPhone and iPad, Amazon for retailing, Qualcomm for Snapdragon mobile processors – nearly all technology companies have software at their core. With more powerful software, hardware is abstracted away, and combinatorial innovation accelerates. These developments were heralded eight years ago, when Mark Andreessen explained that “software is eating the world.”

Markets for technology don't function well without strong IP rights.¹⁰ Technology may still get developed without IP protection, but it will be confined in vertically integrated organizational structures, to be embedded in, and priced into, goods and services supplied via a vertically integrated organization. That's how consumers and producers usually pay for technology. Thus, the proprietary technology to develop drugs is paid for when one buys the product.¹¹ The same is true for many intermediate products, like automotive parts. It is only in unusual cases that the division of labor between technology developer and product maker is nearly complete, at which point the technology is made available through licensing. 3G, 4G, and (hopefully) 5G wireless telecommunications are cases in point.

Competition policy advocates admire the Open Innovation model.¹² “Consumers benefit from open innovation strategies,” according to the Federal Trade Commission.¹³ Allowing the market for knowhow to flourish – and with it the Open Innovation model – requires that licensing regimes be supported with royalties at levels sufficient to draw forth the investment needed to make the ecosystem robust, and open innovation to succeed.

Unlocking the full potential of 5G will require robust protection for 5G technological contributions to ensure rewards sufficient to induce investment by the developer-owners of open collaborative technologies. Each generation of wireless technology – 3G, 4G, now 5G – has taken more than 5 years (10 years for 5G) to define and many more years to perfect. While initial 5G wireless standards have been set, there will be many updates and improvements – assuming that antitrust authorities and courts don't interfere with the improvement process by, for example, destroying the licensing model that has made the earlier generations' improvement profitable and possible.

The likelihood of error by regulators and courts is high given their limited toolkit for understanding complex innovative environments, and their simplistic penchant to believe that almost any non-zero price for mobile wireless technology embedded in standards is too high... despite the billions that still need to be spent to develop the enabling technology that is required and desired. Antitrust policy that fixates on licensor market power (weak at best), while remaining oblivious to implementers' free-riding on standards technology developed by others, threatens the development of a dynamic 5G market and myriad other innovations that dynamic markets can enable.

The wireless technology market designed and supported by ETSI/3GPP is the linchpin of the Open Innovation model. Without it the “closed innovation” of proprietary stack-to-stack oligopolistic competition would prevail. The oligopolistic stacks would admit no (or only limited) licensing of wireless technologies outside each stack. Entry barriers – the price of admission to for new entrants to each stack – would be much higher, especially for device makers. Hence, it may well be that the major incumbent device makers would prefer to see the Open Innovation licensing model collapse. They seem to have coopted the U.S. FTC (perhaps unknowingly) into that strategy.

10 See David J. Teece, “Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy,” 15 *Research Policy* 285 (1986).

11 See David J. Teece, “Business Models, Business Strategy and Innovation,” 43 *Long Range Planning* 172 (2010).

12 Open Innovation is defined by Henry Chesbrough as the use of purposeful inflows and outflows of knowledge to accelerate internal innovation, and expand the market for external use of innovations. See Henry Chesbrough, *Open Innovation*, *supra* note 2. FRAND licensing is an open innovation business model enabled by ETSI/3GPP.

13 Federal Trade Commission, *The Evolving IP Marketplace: Aligning Patent Notice and Remedies with Competition*, March 2011, p. 7. <https://www.ftc.gov/sites/default/files/documents/reports/evolving-ip-marketplace-aligning-patent-notice-and-remedies-competition-report-federal-trade/110307patentreport.pdf>.

IV. STRUCTURAL IMPLICATIONS OF COMPETITION POLICY RUN AMOK

Qualcomm, the American standard bearer for 5G, has been ordered by Judge Koh in San Jose to, in effect, dismantle the licensing model that has funded its past innovation. The decision is being appealed, and interestingly the US DOJ has filed an amicus brief with the Ninth Circuit seeking to overturn Judge Koh's unfortunate (for competition and innovation) decision.¹⁴

The only other global leader in 5G is the Chinese standard bearer, Huawei, a robust innovator that does not rely on judicial royalty-rate determinations for its success. The effect of the recent federal court decision against Qualcomm's business model will be to cede global leadership in 5G to Huawei. As licensing regimes falter, so does the whole 3GPP Open Innovation ecosystem.

A. The Death of Open Innovation and the Re-emergence of the Oligopolistic Integrated "Stack" Model?

For antitrust economists, the courts, and policy makers to comprehend the full impact of their myopic theories, perhaps it is necessary to map out what might happen if rewards for investing in 5G mobile wireless technology are in fact set too low. The likely consequence is that: (1) R&D on mobile wireless is reduced and invention that relies on the licensing model slows. 5G updates occur less frequently, if at all. (2) Device makers and application developers suffer slowing, even declining, sales. There is little reason to buy new phones and other devices if the new ones don't do much more than the old ones as technology obsolescence is what causes most customers to upgrade their devices. (3) To combat declining upstream innovation, device makers like Apple facing eroded sales may for the first time start to contemplate subsidizing upstream R&D. But this will be difficult because, in the shadow of *FTC v. Qualcomm*, the upstream wireless technology developers must provide FRAND licenses to all, subsidizer and free rider alike, at "nondiscriminatory" rates.¹⁵ Device makers subsidizing upstream technology developers is a strategy likely to fail, as individual device makers that consider subsidizing upstream R&D will have to compete with other free riding device makers. (4) Because such efforts to patch up open innovation are likely to fail, the large players (e.g. Apple, Google, Samsung, Huawei) are likely to begin to build their own proprietary technology stacks, causing the ETSI/3GPP open innovation model to collapse further. The integrated players will no longer wish to tender their technology to ETSI and be exposed to the FRAND commitment. The open innovation FRAND model will then no longer support sufficient technological development. This might not in the end trouble the big players like Samsung, Apple, and Huawei who can bring the technology in-house and not license it to the other usually smaller players. However, innovation will slow, and concentration in the downstream device markets would likely increase dramatically.

The irony would be that the same antitrust policy makers that might take pride from the breakup of the vertically integrated Bell System ("AT&T"), would have in fact stimulated the emergence of a vertically integrated model in mobile wireless, one that would likely suffocate a good deal of follow-on innovation and squeeze out downstream players. New entry into the device market would be much, much harder. The highly competitive model we have now, with scores if not hundreds of players, would collapse to a few players with proprietary software stacks. Perhaps these stacks would cooperate to achieve some amount of compatibility. Oligopoly would replace the vigorous competition we see today. Lower innovation is a likely corollary.

There is not much in this scenario that is appealing from a competition policy perspective. Should this scenario play out, antitrust zealots in the US and the EU should then have on their tombstone the inscription that they "helped destroy the greatest model of technological cooperation and innovation in the history of human civilization" – all because they used too narrow an analytical lens. The poorest members of global society, who have benefited enormously from mobile technology, are likely to suffer disproportionately.

14 See David J. Teece, "FTC v. Qualcomm Should Be Viewed Through A Wider Lens," Law360, May 21, 2019, <https://www.law360.com/articles/1160642/ftc-v-qualcomm-should-be-viewed-through-a-wider-lens>; and David J. Teece, "FTC's Antitrust Win Against Qualcomm Should Not Stand," July 29, 2019, <https://www.law360.com/articles/1182240/ftc-s-antitrust-win-against-qualcomm-should-not-stand>.

15 Presumably, Apple might argue that it had paid the upfront contract R&D courts and ought to take this as a deduct from its FRAND royalty in order for the FRAND rate others are getting to be fair to it. However, given the propensity of courts to make errors around complex economic issues, it would have no such immediate assurances.

B. Early Indicator

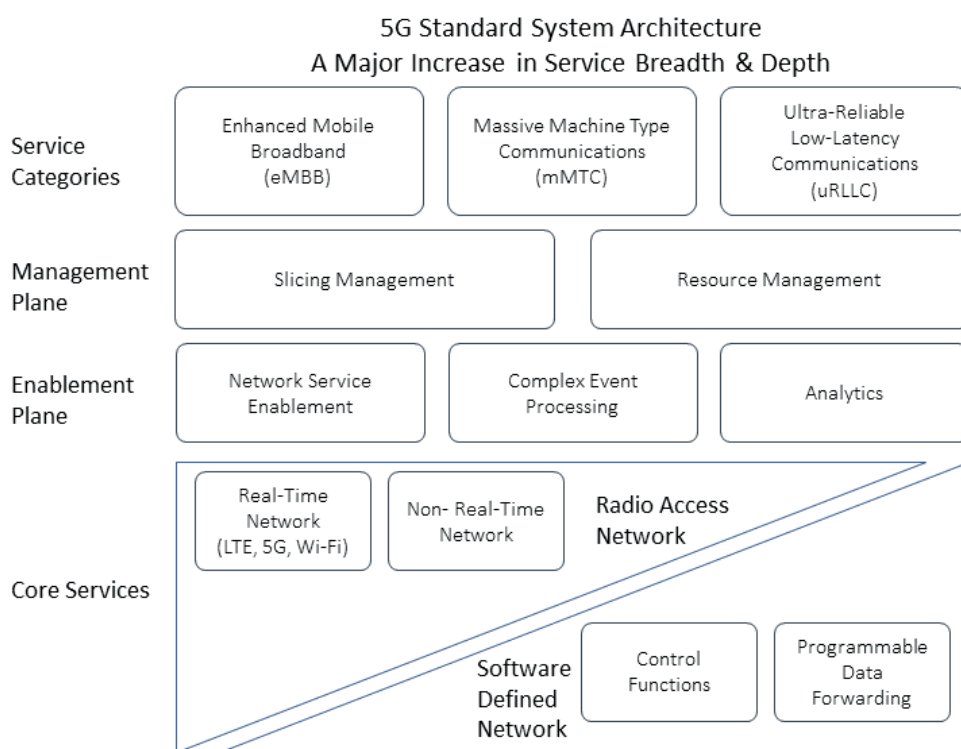
The sale of Intel's modem business to Apple is an early indicator of the demise of the open innovation model. On July 25, 2019, Apple announced its acquisition of the majority of Intel's smartphone modem business.¹⁶ Apple's senior vice president for hardware technologies took note that the acquisition would "allow Apple to further differentiate moving forward." The Apple stack could well separate more completely from rival stacks in the future. It is still early days, and key judicial outcomes are still in the balance.

C. Why the Open Innovation Model is Better for the World than the Closed or Semi-closed Stack Model.

As discussed, the likely collateral damage of antitrust interference with the Open Innovation model is that licensing-based financial support for upstream wireless innovation collapses. A possible downstream response would have device makers (e.g. Apple, Samsung, Huawei) subsidize upstream innovation, but free riding – a likely consequence of FRAND licensing in the shadow of *FTC v. Qualcomm* – would likely doom that business model.¹⁷ The device makers might then be forced to become stack sponsors, possibly doing more wireless innovation inside their stack but not licensing to rival stacks, or licensing only among themselves (the oligopoly model). Mobile wireless research still happens, but its diffusion across stacks would be limited. One version of this might be that Apple or Samsung acquire Qualcomm or Ericsson. (The purchase of Qualcomm by Huawei would likely be blocked by CFIUS).

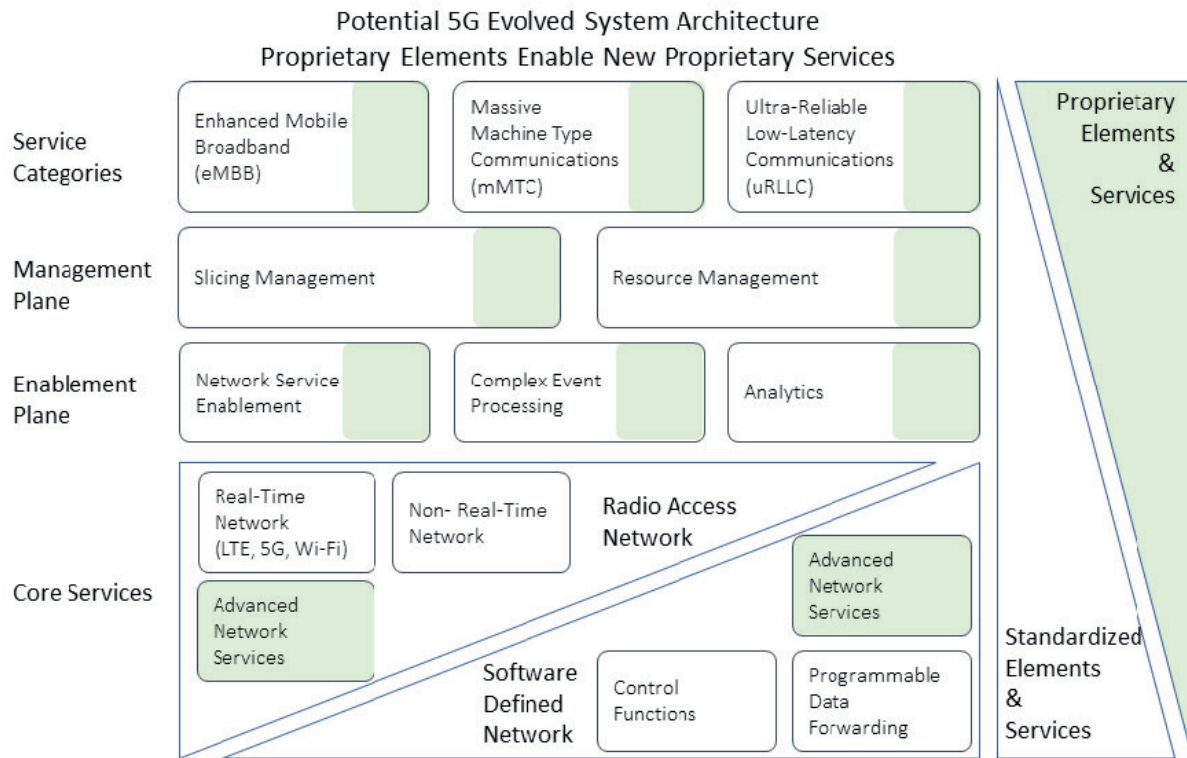
From a global consumer welfare perspective, one might ask whether the situation is markedly different. Not only does oligopoly seem less attractive on its face than the highly competitive model that currently exists on pure static (efficiency) grounds. It's likely worse on dynamic grounds.

Consider the "standard" system architecture enabled by 5G, as depicted in the upper panel below. 5G is likely to enhance mobile broadband (make it more ubiquitous, faster); enable massive Machine Type Communications (the "Internet of Things"); and promote ultra-reliable low-latency communications (e.g. "the self-driving car").



¹⁶ Apple Inc., "Apple to acquire the majority of Intel's smartphone modem business," July 25, 2019 press release. <https://www.apple.com/newsroom/2019/07/apple-to-acquire-the-majority-of-intels-smartphone-modem-business/>.

¹⁷ This decision has been appealed to the Ninth Circuit. The Department of Justice has weighed in with the United States' statement of interest for issuance of a stay, "The court's remedy is intended to deprive, and risks depriving, Qualcomm of substantial licensing revenue that could otherwise fund time-sensitive R&D..." *Federal Trade Commission v. Qualcomm Inc.*, United States' Statement of Interest Concerning Qualcomm's Motion for Partial Stay of Injunction Pending Appeal (9th Cir. Case No. 19-16122), July 16, 2019, at 12.



The lower panel depicts an “evolved” 5G system architecture in which each “stack” contains a “proprietary” element in the shaded regions of every architectural object. A mundane example, even today, would be the Apple iOS-exclusive FaceTime service that is not, and cannot, be supported by the rival Android “stack.” The proprietary nature of the evolved-5G would be FaceTime writ large.

The fundamental reason consumer welfare would likely be worse is because, as discussed, 5G and future generations are precious “enabling technologies.” As noted above, such technologies benefit from engagement with downstream players who deliver a myriad of further applications. The “stack” or “oligopoly” model contains less incentive to license such technologies – IP owners can keep it to themselves and limit competition downstream. This not only denies consumers lower prices, but shuts down a good deal of device innovation. The existing Open Innovation licensing-dependent framework does not suffer this fate.

Former DOJ chief economists Fiona Scott Morton and Carl Shapiro have criticized this position: “Defendants sometimes point to these market improvements (cheaper and faster products) as evidence that no exclusionary conduct has taken place. However, the correct question is whether the improvement in speed and reductions in price would have been even larger absent the exclusionary conduct.”¹⁸ The former chief economists set themselves a very low bar indeed if they need not pay attention to the performance of the actual market that an accused defendant has succeeded in, and the actual consumer benefit that defendant has delivered. This low bar likely extends to whatever counterfactual they eventually settle on, for which hints and whispers of some hypothetically superior but unoffered product are deemed sufficient evidence to condemn the actual technology that enabled actual innovation to please actual consumers. As one commentator has asked, “By what standard of proof should one judge the plausibility of the supposedly brighter world that never was?”¹⁹

It is apparent to me that antitrust economists must use a wider lens if they are to do more good than harm. They have confused “assertive” antitrust policy with *wise* antitrust policy.

18 Giulio Federico, Fiona M. Scott Morton & Carl Shapiro, “Antitrust and Innovation: Welcoming and Protecting Disruption,” NBER Working Paper No. 26005, May 24, 2019, p. 25. <https://www.nber.org/papers/w26005>.

19 J. Gregory Sidak, “Is Patent Holdup a Hoax?” 3 *The Criterion Journal on Innovation* 447 (2018). See also Harold Demsetz, “Information and Efficiency: Another Viewpoint,” 12 *Journal of Law and Economics* 1 (April 1969) (“In practice, those who adopt the nirvana viewpoint seek to discover discrepancies between the ideal and the real and if discrepancies are found, they deduce that the real is inefficient.”)

V. CONCLUSION

Too many antitrust economists and their legal brethren have a trained incapacity for strategy and strategic thinking, coupled with an unwillingness to study and understand innovation at the enterprise level.²⁰

The recent drift of antitrust enforcement, exemplified by the U.S. district court decision in *FTC v. Qualcomm*,²¹ has narrowed its focus upon the shortest-run considerations, such as contract negotiations between technology creator and technology implementer, to the exclusion of providing for fair and adequate incentives for innovative technology creation. This too-narrow focus has led to a judicial order²² requiring the business model that has to date delivered very substantial telecommunications improvements be enjoined (discontinued).

Discontinuation of that business model means that it will likely be replaced by another business model – one that is inferior in terms of the innovation it is likely to deliver, and the degree to which it is competitive. Because wireless technology is expensive to create, but prospectively will be rendered less remunerative in the shadow of *FTC v. Qualcomm*, either that technology will be underprovided or, if created, may migrate from today's Open Innovation standards development organizations such as ETSI into the proprietary stacks of a few sponsors (such as Apple, Huawei, Samsung, or Google/Alphabet).

The zeal and litigation success of a section of the FTC will likely, but paradoxically, lead to greater market concentration because of the collapse of today's Open Innovation marketplace for technology into proprietary stacks. By crippling the business model of one successful technology creator (Qualcomm), the short-run effect will make existing technology, such as the current version of 5G established over the past decade, cheaper for implementers. But in the medium run 5G's improvement path will be less innovative than before, due to less remunerative licensing – including the very real possibility of continued widespread patent infringement by implementers.

But in the long run implementers dependent upon 5G improvements to serve their own business models may end up being forced to sponsor those improvements themselves. The precarious state of Open Innovation licensing due to the current hostility to reasonable royalties will favor bundled technology and product sales, making sponsoring implementers less likely to share those improvements with rivals. This new world is not demonstrably more “competitive,” let alone better for consumers. It is a degradation from the world we have now. Advocates for our entering this new world should provide a far larger quantum of proof for its superiority before conclusively destroying the existing highly innovative Open Innovation model that has served global society – and especially the poor in the developing world – so well.²³

20 Even solid surveys by mainstream economists seem remarkably wooden. See Nicholas Bloom, John Van Reenen, and Heidi Williams, “A Toolkit of Policies to Promote Innovation,” 33:3 *Journal of Economic Perspectives* 163-184 (Summer 2019). Innovation scholar Richard Nelson in private correspondence to this author commented as follows: “The authors cover a lot of material, and draw from a number of empirical studies. There are only a few things I found foolish in it but nothing particularly insightful. In my view the basic problem with the paper is the authors’ lack of familiarity with the significant empirical literature on how technology actually evolves, the roles of different kinds of institutions in the process, various changes that occur as the technology matures, and the very major differences across technologies and industries. The fact that there is no reference to Rosenberg is indicative.” (correspondence with R.R. Nelson, August 10, 2019)

21 *Federal Trade Commission v. Qualcomm Inc.*, Findings of Fact and Conclusions of Law, Case No. 17-CV-00220-LHK (N.D. Cal. May 21, 2019).

22 *FTC v. Qualcomm*, Findings of Fact and Conclusions of Law, May 21, 2019, pp. 227-233.

23 J. Gregory Sidak, “The Morality of Innovation,” working paper, 2019.

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