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Prospects for Gigabit Broadband: Examining whether Google's fiber strategy portends a new round of investment and competition in local access networks

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Prospects for Gigabit Broadband

*Examining whether Google's fiber strategy
portends a new round of investment and
competition in local access networks*

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Prospects for Gigabit Broadband

Abstract

This paper examines the question of whether the local access network environment stands on the cusp of significant change, one characterized by investment in new Gigabit broadband networks operated by a new breed of service providers. The high-profile Google Fiber project first deployed in the Kansas City metro area in 2012, soon followed by the more limited progress of the project in 2016, poses the strategic question of whether Google has “cracked the code” to identify and develop a viable business model for overbuilding local access networks. Based on a “top-down” estimate of the potential costs of deployment, this analysis finds that four business-model innovations pursued by Google, and now other players, can improve the economics of new network deployment to a significant degree under some realistic conditions, and, lacking any response from incumbents, therefore would improve the prospects for new entry of service providers in some areas. Incumbent broadband providers, however, are forming competitive responses that are substantially boosting the speed of their own broadband services in areas where Google Fiber is being deployed. The key takeaway from this analysis is that whether deployed by new entrants or incumbents, the “prove-in” point for Gigabit broadband networks is becoming lower, with the result that this technology will likely be deployed on an increasing basis in those areas where residential broadband consumers demonstrate a strong demand for the Gigabit service. One of the key policy issues raised by this outcome is the degree to which policy makers are comfortable with the resulting patchwork of fiber network deployment throughout a geographic region.

Introduction

It was only 2 years ago that many considered the local access network environment to be standing on the cusp of significant change, one characterized by investment in new Gigabit broadband networks operated by a new breed of service providers. The high-profile Google Fiber project posed the strategic question of whether Google had “cracked the code” to identify and develop a viable business model for overbuilding and the establishment of competitive local access networks in the presence of incumbent broadband providers. Many more cities breathlessly applied and waited to be selected in the next wave of Gigabit deployment to achieve the broadband utopia necessary to provide unparalleled economic development opportunities.

The Google Fiber project had attracted significant attention due to the Gigabit broadband speeds offered for residential broadband service as first deployed in the Kansas City metro area of the United States.¹ While apparently achieving some degree of success based on early reports, the fundamental question of interest to technologists, economists and policy makers was whether Google’s approach would be viable in the long run, particularly given the dismal economics of overbuilding that have traditionally existed.²

The question of viability in the Google Gigabit sweepstakes in the United States was lost in the hype of the competition among municipalities to be selected by Google for deployment in their cities. Google itself admitted that the initial objective of their fiber access program was to “influence” the U.S. broadband market by demonstrating demand for higher speed residential broadband service, not to establish a new overbuilding strategy. Beginning in 2009, this was to be accomplished by designing a

¹ See Medin, M. (2011, March 30). Google blogpost. Ultra High-Speed Broadband is coming to Kansas City, Kansas. Retrieved on May 18, 2018, accessed at: <https://googleblog.blogspot.com/2011/03/ultra-high-speed-broadband-is-coming-to.html>. Over 1100 municipalities competed to be selected by Google for the Gigabit network deployment. As stated, the goal was to find a location where Google “could build efficiently, make an impact on the community and develop relationships with local government and community organizations”.

² For a detailed early study of the economics of fiber-to-the-home networks, see David P. Reed. *Residential Fiber Optic Networks: An Engineering and Public Policy Analysis*, Artech House, Boston 1991.

fiber network to deliver Gigabit broadband as an “experiment, not a product” that was “optimized for political/research goals”.³

Yet the new innovations that Google put into practice, and the apparently significant demand they reported in their fiber trials, led Google to conduct more serious evaluations of the business opportunity presented by the deployment of local access networks delivering Gigabit per second broadband speeds to residential customers. Presumably as an outcome of early positive results to this evaluation, Google increased the number of cities it planned to build an all-fiber network. In April of 2013, Google announced plans to build fiber networks in Austin, Texas and Provo, Utah.⁴ Even further, in February of 2014, Google announced it was in early discussions with 34 more cities in 9 metro areas around the United States “to explore what it would take to bring a new fiber-optic network to their community”.⁵

And then, in October 2016, Google Fiber announced it was “pausing” the project and shifting its approach to wireless technology.⁶ This pause was followed by some activity in 2017 it launched in three new cities: Huntsville, Alabama; Louisville, Kentucky; and San Antonio, Texas.⁷ Nevertheless, numerous skeptics remain regarding the future prospects for the service following the 2016 announcement and subsequent reorganization of personnel away from the project.

What happened in the roughly 5 years of the Google Fiber experiment that led to the reversal and apparent abandonment or review of the fiber-based, Gigabit network strategy? The research question of this paper is to identify the reasons for Google’s change in strategy to pursue the deployment of Gigabit networks to residential users in competitive environments, and the implications for others continuing to develop Gigabit

³ See Medin, M. (2013, February 13). *The Road to a Gigabit*. Retrieved July 1, 2013, from IEEE Communications Society, Santa Clara Valley Chapter: accessed at <http://www.ewh.ieee.org/r6/scv/comsoc/02132013MiloMedin.pdf>.

⁴ See Gaar, B., Hawkins, L., & Ladendorf, K. (2013, April 9). High-speed celebration: Austin lands super-fast Google Fiber network. *Austin American-Statesman*; see also, Horiuchi, V. (2013, April 18). Provo will be 3rd U.S. metro area to get speedy Google Fiber. *The Salt Lake Tribune*.

⁵ See Google Fiber. (2013, April 9). *Google Fiber Blog*. Retrieved March 2, 2014, accessed at: http://googlefiberblog.blogspot.com/2013_04_01_archive.html.

⁶ See Bodkin, J. (2016, October 25). Google Fiber division cuts staff by 9%, “pauses” fiber plans in 11 cities. *ArsTechnica*.

⁷ See Krauth, O. (2017, December 112). How Google Fiber turned 2017 into its comeback year. *TechRepublic*.

network plans such as municipalities or other countries through their national broadband plans. Google Fiber aggressively targeted deployments in U.S. cities that already had two existing broadband providers representing the legacy telephone and cable television companies. These were not areas that were underserved or unserved with Internet access service, though they were underserved in the sense that 1 Gbps broadband service was unavailable.

This paper examines the question of how the approach implemented by Google Fiber, as documented in public sources, held promise as a viable overbuilding strategy that was thought to portend a new round of investment and deployment of local access networks, and the recent changes in circumstances that has apparently led to a revised strategy. For the past two decades, it has been generally accepted that the economics in the local loop – and in particular the high cost of residential fiber optic networks – are not favorable for new entrants to overbuild or incumbents to upgrade with fiber-to-the-home networks.⁸ Another interesting question is why the innovations introduced (or packaged together) in the Google Fiber project apparently failed to tip the economic equation in favor of a new entrant in local access markets. There are four main innovations used by Google that we focus upon in this paper to answer this question:

- Demand aggregation for a 1 Gbps service
- Cooperation with municipalities
- Supply chain optimization
- Reduced deployment costs due to technology innovations

To measure or estimate the impact of these factors, we have constructed a simple “top-down” business model using representative numbers for capital and operating expenses that allows us to estimate the magnitude of the financial impact of these business innovations.⁹ This model is based on high-level, publicly available sources that have not been validated through a more rigorous, detailed “bottoms-up” engineering

⁸ See *supra* note 2

⁹ Each assumption for the “top-down” business model is made in aggregate form based upon the best available sources (e.g., cost of a fiber network is several hundred dollars per home passed). In contrast, “bottom-up” business models are built using detailed estimates of model parameters (e.g., estimating the cost of a fiber network based upon the cost of fiber per meter, cost of installation per meter, cost of specific network equipment, etc.). The benefit of top-down models is the speed at which they can be developed, though often at the expense of the accuracy of results and knowledge of the more detailed engineering-economic tradeoffs usually inherent in technology-based businesses such as building residential fiber networks to offer broadband services.

cost model. The intent of this financial model is to generate results that are good estimates, but not highly precise given the significant uncertainty associated with a large number of model inputs.

Business Innovations

This section describes three general business innovations that appear to have been pursued by the Google Fiber project, and our estimates of their financial impact on the overall business model for deploying a new residential fiber network to provide broadband services. This analysis is only based upon information drawn from public press reports and presentations from Google. There is some speculation from the author on different aspects of these innovations which may, or may not, be correct.

The four business innovations analyzed in this paper section are demand aggregation for a 1 Gbps service, cooperation with municipalities and supply chain optimization for an “all-IP” network and reduced deployment costs by utilizing new technology to build optical networks.

At the outset it is worth noting that, contrary to the business models for building all-fiber networks that were considered in the 1990s, modern business models for local access networks can take advantage of “triple-play” economics as consumers are now well accustomed to purchasing their voice, broadband and video services in a single communications service bundle for a single price. The revenue “bump” from this development is not insignificant as cable operators and telephone companies have seen their average revenue per user (ARPU) grow significantly over the decade from 2003 - 2013 due in large part to the emergence of the triple-play service bundle, though it has plateaued in the remaining 5 years in the range of \$110 - \$160 per bundle subscriber.¹⁰ The business case for building an all-fiber network, then, has seen significant improvement *for any entity* due to this significant increase in ARPU.

¹⁰ For example, Comcast ARPU grew 366% over the past decade from \$41.33 in 2003 to \$151.49 in 2013. See Comcast Web Page. Retrieved May 18, 2018, accessed at: <http://www.cmcsa.com/releasedetail.cfm?ReleaseID=394946>; Malik, O. (2014, February 12). Comcast and Time Warner Cable: Forget TV, It Is All about Broadband. *Gigaom*. Comcast ARPU has remained at \$150.49 in 2017. See Frankel, M. (2018, March 1). The top 7 cable, satellite and telco pay TV operators in Q4 2017. *FierceCable*. Note that a significant part of the ARPU from video services is a straight pass-through of the cost

Google Fiber currently offers a residential broadband service of 1 Gbps in 12 cities for between \$55 (in San Antonio) to \$70 per month, or a service bundle of broadband and video for \$130 per month (premium video services such as HBO are additional charges). Customers may also sign up for Google Fiber Phone service with unlimited nationwide calling for \$10 per month. Since 2016 Google no longer offers a “free-after-installation” basic Internet service of 5 Mbps, but now offers with a 100 Mbps service for \$50 per month that also includes a \$300 installation fee.¹¹

Demand Aggregation for a 1 Gbps Service

From a practical usability as well as marketing perspective, when Google Fiber was first launched the sheer increase in speed of the broadband service to 1 Gbps for \$70 per month, or 5 Mbps for no monthly fee at all, provided a significant differentiation from the existing broadband service providers. Even after the service had been launched for over a year in Kansas City, the download speeds and prices for broadband services (as listed on web sites) from incumbent providers Time Warner Cable and AT&T were only between 15 – 25 Mbps for \$35 - \$55 per month, and 3 – 18 Mbps for \$15 - \$20 per month (for 1-year commitment), respectively. But this sluggish competitive response on the part of incumbents was not long lived. Both the incumbent cable operator and telephone company in Austin, Texas, for example, announced sharply higher speeds in their broadband services with the announcement by Google Fiber’s intent to launch broadband services in mid 2014.¹² AT&T then further announced plans to start talks

for content charged to them by content providers, which has seen significant increases over 2003 - 2013. Over a 5-year span during this time frame, programming costs were reported to have increased 9% annually, which equates to an increase of 236% over a span of 10 years. See James, M. (2011, December 8) Cable TV Networks Feel Pressure of Programming Costs. *Los Angeles Times*. In 2018 58.8% of Comcast’s video ARPU of \$84.7 per subscriber went directly to programmers for program license fees. See OTT Multiscreen media analysis. *NScreenMedia*. Retrieved on May 18, 2018, accessed at: <http://www.nscreenmedia.com/comcast/>.

¹¹ See McGee, J. (2016, April 11). Google Fiber move signals higher prices for basic plan. *Tennessean*. Since this offer made Internet service more affordable for low-income families, existing customers with low Internet usage were held to a cost increase of \$15 a month for 25 Mbps service. The ConnectHome initiative run by the U.S. Department of Housing and Urban Development will still include free Gigabit Internet to subsidized housing units where Google Fiber access is available.

¹² Time Warner Cable announced a new 300 Mbps tier and plans to increase existing broadband speed tiers to 50 – 200 Mbps (up from 15 - 30 Mbps) for the same costs of

with 21 other cities to offer Gigabit broadband, and this list included Kansas City along with 9 other metro areas targeted by Google.¹³ By 2015 AT&T had dropped its broadband service prices for its “GigaPower” fiber services to match Google fiber at \$70 per month for broadband and \$120 per month for television and broadband.¹⁴ In addition, both telephone and cable providers started announcing plans to deploy fiber networks in the same markets as Google Fiber.¹⁵

Thus, the establishment of the unprecedented benchmark speed of 1 Gbps for residential broadband appears to have brought to fruition in many cities one of the intended outcomes of the original Google Fiber experiment: to significantly increase the broadband speeds of incumbent provider’s broadband services. On the surface, it appears the “Gig” speed benchmark has gained sufficient market traction with broadband consumers to generate an increasingly potent competitive reaction from incumbent providers. For example, 1) AT&T will be deploying Gigabit broadband to 12.5 million homes in the 67 metro areas by mid-2019, 2) Charter will deploy Gigabit-speed cable to 40 million homes by end of 2018 for \$105 - \$125 per month, and 3) Comcast has its Gigabit-cable service deployed to 90% of its 50-million household service area.¹⁶ Notably, Comcast also says that 75% of its residential broadband customers now subscribe to packages offering speeds of 100 Mbit/s or higher.¹⁷

Coupled with the 1 Gbps speed benchmark, Google incorporated a demand aggregation process into its business model for building the fiber network. Demand aggregation in this context is the effort of the service provider to pre-subscribe

\$35 - \$55 per month. AT&T announced plans to build an all-fiber network to provide customers a symmetric 1 Gbps broadband service by mid 2014 as well. See Baumgartner, J. (2014, February 20). TWC Tees Up 300-Meg Broadband Service For Austin. *Multichannel News*.

¹³ See Jones, D. (2014, April 21). AT&T Turns up Gig Heat in 21 New Metros. *LightReading*. AT&T said it could deploy Gigabit broadband in up to 100 cities.

¹⁴ See McGee, J. (2015, September 29). AT&T drops fiber prices to Google Fiber levels. *Tennessean*.

¹⁵ *Ibid*.

¹⁶ See AT&T press release (2017, February 13). Retrieved on May 18, 2018, accessed at:

http://about.att.com/newsroom/att_fiber_coming_to_over_50_metros_by_end_of_february.html; Brodtkin, J. (2018, February 6). Charter’s gigabit cable-starting at \$105-is coming to over 40 million homes. *arsTechnica*; and Breznick, A. (2018, April 25). Comcast sees lots of Runway for broadband growth. *Broadband World News*.

¹⁷ *Ibid*, Breznick.

customers to its network services as a condition for the service provider building out the network in their area. The notion of demand aggregation is not a new concept and has been a topic of frequent analysis and discussion in the telecommunications arena. For example, the United States' National Broadband Plan recommended federal and state policies to facilitate demand aggregation as a means to improve broadband availability.¹⁸

The demand aggregation approach implemented by Google utilizes a self-described “rally” approach that requires certain threshold demand targets to be met before the network is built in the specific “fiberhood” area. This approach assures that capital for network build-out is only spent in areas where demand has been verified through presubscription. In addition, this approach allows Google to install users in waves instead of a single subscriber at a time.

From an economic perspective, demand aggregation addresses a key limitation of past overbuilding business models that suffered from low penetration rates of services in the early years of deployment. If the service provider grows service penetration at 5% per year, for example, it takes 5 years to reach 25% service penetration rate, even though a large network investment typically has been made to pass 100% of the homes in an area. Through demand aggregation, however, if a network builder can “jump” to 20% or 40% service penetration rates at the time of deployment, the overall returns of the network investment are vastly improved.

As one would expect, early reports from Google claimed that its demand aggregation efforts were very successful. Google reported that 33,000 homes in Kansas City, more than 20% of homes in their initial build area, signed up for service in 6 weeks.¹⁹ Some of the fiberhood areas had signup rates in excess of 50% of homes. Another source cited a 350-home survey in Kansas City by Bernstein Research that found up to 75% of homes in higher-income areas and 30% of homes in lower-income areas subscribing to

¹⁸ Recommendation 20 from Chapter 8 of the National Broadband Plan states: “Federal and state policies should facilitate demand aggregation and use of state, regional and local networks when that is the most cost-efficient solution for anchor institutions to meet their connectivity needs.” See Federal Communications Commission. (2009). *National Broadband Plan*. Retrieved July accessed at: 6, 2013, <http://www.broadband.gov>.

¹⁹ *Supra*, note 1.

Google Fiber.²⁰ Given this, our model will examine the financial impact of demand aggregation achieving presubscription levels between 20% - 40% of homes in a targeted neighborhood.

Finally, we also assume the ability to install the network in one fiberhood segment at a time reduces the labor cost of installation by 10% - 20% for the variable costs associated with the initial set of first-year subscribers. Presubscription allows for better deployment planning as Google Fiber can pass and connect houses in the same area at the same time without having to make trips back for each new initial subscriber.

Cooperation with Municipality

One of more noteworthy aspects of the Google Fiber project has been the cooperation that was forged with the municipalities regulating the building of local access networks. Rather than the contentious relationships commonplace between municipalities and the telephone and cable companies they regulate, Google works to forge partnerships with municipalities eager for the deployment of Gigabit broadband networks in their cities. Indeed, Google had over 1100 cities respond to the Request For Information it issued in February 2010 to ascertain interest in municipalities in serving as the host city for building its Gigabit network. From the list of responders, Google selected Kansas City as the site of its first Gigabit network deployment.

One of the key reasons given for this selection was the close partnership that Google thought it would be able to establish with the local Kansas City government to reduce the costs of network deployment. At a high level, Google says this means it works with the city to streamline processes that reduce construction and support costs such as:²¹

- City provides dedicated inspectors,
- Colocation of Google staff with the permitting office, and

²⁰ See Reardon, M. (2014, May 6). Is Google Fiber on Track to Become Major Broadband Competitor? *c/net*. Also noted 10% - 15% taking the free basic Internet service offered by Google Fiber.

²¹ See Medin, *supra*, note 1. See also Google Fiber website, retrieved on May 18, 2018, accessed at <https://fiber.google.com/newcities/>. The site discusses next steps for the next cities that may be built out:

“We’ll provide a checklist of things for these cities to complete to help make their area ready for fiber. We’re asking cities to provide us with information that can speed up planning and construction (e.g. maps of poles, conduit, existing water, gas, and electricity lines). We also ask that they streamline processes (e.g. permitting procedures and access to local infrastructure) to make it easier for a construction process of this scale to move quickly.”

- Reusing city rights-of-way and real estate to speed site selection of network nodes.

Google – Kansas City Agreement

Given the importance of municipal cooperation in the business model of Google Fiber, it is worth taking a closer look at the details of the agreement between Google Fiber and the City of Kansas City, the first deployment site of Google Fiber.²²

Under this agreement Google and the City of Kansas City describe the terms under which they will “cooperate in the design, planning, construction, and operation” of the fiber network. Google’s major requirements under the agreement are:

1. Google will decide the locations where and when demand for services support the building of the fiber network
2. Google will design, build, maintain, and operate a fiber network, using commercially reasonable efforts to achieve a service speed up to 1 Gbps
3. Google will offer customer support for end-users
4. Google will provide basic Internet service (without support) free of charge for up to three hundred locations chosen by Kansas City
5. Google will comply with all requirements of Kansas City for permit and use applications

Table 1 summarizes the major elements of the agreement that Kansas City is required to do in support of the Google Fiber deployment, organized by the following categories: infrastructure, coordination and communication, expedited inspections and permit review, publicity and marketing, and contract term.²³ The agreement elements with the most material impact upon the cost to deploy a new fiber network fall under the infrastructure, coordination and communication, and expedited inspections and permit review categories.

The upshot of this agreement is that Google can deploy the fiber network in the specific locations of its choice, and bears all operating and deployment costs, while Kansas City provides without cost office and equipment space, power, expedited permits and inspections, and right-of-way easements.

²² See *Development Agreement, Final Execution Version 5*. (2011). Retrieved March 2, 2014, accessed at <http://www.netcompetition.org/wp-content/uploads/Google-Kansas-Agreement1.pdf>.

²³ The author appreciates the assistance of Doug Brake, Research Assistant, Silicon Flatirons Center, University of Colorado Boulder in compiling this information.

Category	Agreement Terms
Infrastructure	
Space and Power	<ul style="list-style-type: none"> • KC will provide access to assets and infrastructure without any charge. • KC will provide space in city facilities for installation of GF Central Office equipment and network facilities. • KC will provide the electricity to power GF equipment. • GF will have 24/7 access to the network in city facilities, and city facilities must have reasonable security measures, including locked doors and alarms.
Poles and Rights of Way	<ul style="list-style-type: none"> • KC will allow GF to attach fiber on city poles and also cooperate in GF efforts to gain access to poles and rights-of-way owned by third parties. • GF will have access to necessary rights-of-way on property owned by KC. This access includes permission to perform construction work on city property, including city streets. GF will have access to these rights-of-way during regular business hours for non-emergency work and 24/7 for emergency work. • KC will provide GF with GIS data and location information of available city infrastructure and rights-of-way, and, if possible, those of third parties. • Location of the build will be determined based on demand, within the geographic boundaries of KC.
Interconnection	<ul style="list-style-type: none"> • KC will provide settlement-free interconnection with anchor institutions in KC that have existing network connections.
Coordination and Communication	
Point of contact	<ul style="list-style-type: none"> • KC will provide a senior level Executive Sponsor for interaction between GF and the City Council. • KC will provide GF a single point of contact responsible for giving coordination across departments and serving as communications/troubleshooting resource for GF. This point of contact will ensure full cooperation of all city departments.
City project team	<ul style="list-style-type: none"> • KC will create a City Project team and hold regular meetings to coordinate all matters related to the project. • City Project team will provide consulting assistance to GF. • KC will provide space in city office locations for the City Project team and GF employees to work side-by-side.
Expedited Inspections and Permit Review	
<ul style="list-style-type: none"> • KC's City Project team will coordinate with GF and provide expedited inspections, response to permit applications, and on-the-spot exceptions. 	
<ul style="list-style-type: none"> • GF will manage all traffic control using KC's permitting system. KC will not impose any permit or inspection fees. GF will use standardized permits for encroachments, excavations, and traffic control. 	
Publicity and Marketing	
<ul style="list-style-type: none"> • KC will cooperate with GF on all publicity for the project. KC must obtain GF approval for any of the city's public statements or announcements related to the fiber project. 	
<ul style="list-style-type: none"> • KC will develop and implement a city-managed marketing/education program for local residents with respect to the Project, in consultation with GF. Such program would include items as direct mailings, community meetings, and others to be decided on jointly by GF and KC. 	
Term	
<ul style="list-style-type: none"> • Contract remains in effect unless GF terminates with notice at the end of an initial ten-year term or at the end of a five-year renewal term. 	
<ul style="list-style-type: none"> • Google has the right to terminate for convenience up to after 2 years from the start of construction. 	

Table 1: Elements of Google Fiber (GF)/Kansas City (KC) Agreement

The strategic impact that this agreement had as a stimulus for deploying new fiber-to-the-home networks was significant. The demand aggregation approach is viewed by broadband providers as a very powerful incentive for broadband deployment, though as we shall see in our discussion of policy implications, this approach generates concerns because it allows service providers to “cherry pick” areas for network deployment. Nevertheless, broadband providers and municipalities alike replicated the cooperative intent and partnership reflected in the agreement to launch further deployment of fiber networks. For example, c-spire launched a program very similar to Google Fiber – complete with fiberhoods, homeowner pre-registrations, and competitive applications from cities in Mississippi wanting to build the “first” fiber network.²⁴ AT&T subsequently emphasized the need for municipal cooperation similar to the Google Fiber agreement as well in any city that it eventually plans to extend fiber to the home.²⁵ Moreover, in more than just a coincidence, past FCC Chairman Julius Genachowski issued a “Gigabit City Challenge” effort that included establishment of an online clearinghouse of best practices such as those included in the agreement.²⁶

With its roots in the Kansas City agreement, Google published a “Google Fiber City Checklist” that summarized and explained the steps that new cities must undertake in order for Google to consider deploying a fiber network in their community.²⁷ The checklist described the information required from Google regarding the location of existing infrastructure, rules for accessing the infrastructure, and necessary permitting and construction processes.

How much can this cooperation reduce the costs of deployment? Clearly, some of the requirements in the Google Fiber/Kansas City agreement could have a significant bearing on the cost of building and operating the fiber network. Google has not reported this figure (nor did it have any experience deploying a residential fiber network with a prior baseline experience). The Infrastructure section (Chapter 6) of the National Broadband Plan does note the following:

²⁴ See c-spire web site at <https://www.cspire.com/home-services/cities/>. A c-spire blog post, no longer available on the web site, from September 9, 2013 stated: “we need the cooperation of citizens and their municipal leadership”.

²⁵ See Buckley, S. (2014, March 7) AT&T’s Stephenson Names Dallas as Next FTTH Stop. *FierceTelecom*. AT&T CEO Randall Stephenson is quoted as saying “In fact, we’re so encouraged that we want to begin taking this to other communities. What we’re doing in cities and municipalities where we can get the terms and conditions we got in Austin we’re redirecting ... investment to fiber to the home deployment.”

²⁶ See FCC Press Release (2013, January 18). Retrieved at <http://www.fcc.gov/document/fcc-chairman-genachowski-issues-gigabit-city-challenge>.

²⁷ See Google Fiber City Checklist. Updated February 2014. Retrieved at DSLReports website on May 18, 2018, accessed at: <http://www.dslreports.com/r0/download/2153849~db99a635734f6be41c0b95abbc219369/googlefibercitychecklist2-24-14.pdf>.

*"The cost of deploying a broadband network depends significantly on the costs that service providers incur to access conduits, ducts, poles and rights-of-way on public and private lands. Collectively, the expense of obtaining permits and leasing pole attachments and rights-of-way can amount to 20% of the cost of fiber optic deployment."*²⁸

More specifically, the permitting and inspection processes that have developed over time between network providers and municipalities can be costly due to the resources required to complete the permits, as well as manage any delays in network construction while awaiting inspections.²⁹ The ability to deploy in certain areas will also serve to reduce the overall cost of deployment by avoiding areas that have particularly high deployment costs due to circumstances specific to the area.

It is reasonable that the expected cost reductions through streamlined processes will vary considerably based on individual municipal experiences. A definitive estimate of potential savings through better cooperation has not been published, though this 20% figure provides some unsubstantiated guidance. Consequently, because the overall cost impact is not known (at least publicly), we will assume this practice can achieve a 10% - 20% reduction in the fixed costs associated with fiber deployment (which does not include the customer premise equipment and its installation).

We do not assume any significant reduction in operating expenses due to municipal cooperation.

Supply Chain Optimization

The previous two business model innovations are generally the efforts noted by Google and others to drive down the costs of Gigabit network deployment. A third effort, not publicly recognized by the press and Google, that may also have served as a significant driver of benefits to Google are improvements to the supply chain for providing broadband services on a vertically integrated basis.

²⁸ See Connecting America: The National Broadband Plan, Chapter 6, at 109 (available online at <http://download.broadband.gov/plan/national-broadband-plan.pdf>).

²⁹ See Reardon, M. (2014, April 30). Google's Fiber Effect: Fuel for a Broadband Explosion. *c/net*. Quoting AT&T's VP of Broadband Planning: "In the past, certain permitting processes cost us millions of dollars. But now the city is interested in working with us to reduce those expenses." The Google/Kansas City agreement commits Kansas City to review and respond to permits within 5 working days.

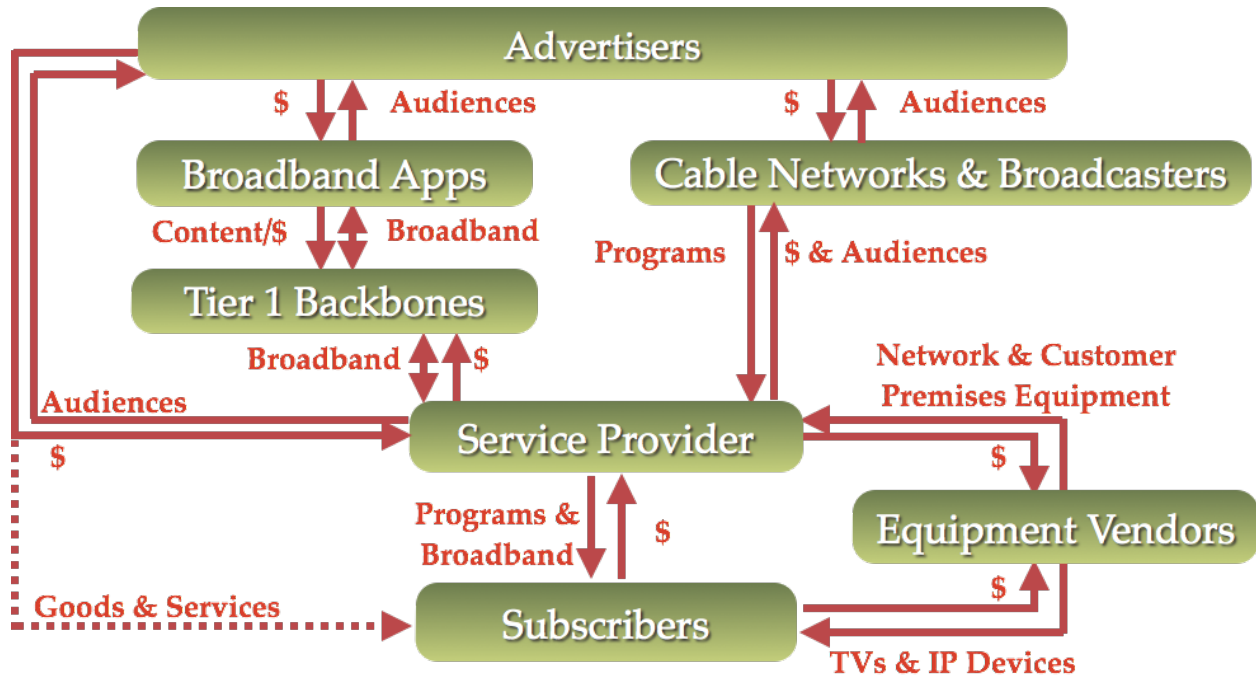


Figure 1: General Supply Chain for Residential Video and Broadband Services³⁰

Figure 1 shows a simplified “supply chain” for a service provider to deliver residential video and Internet services. The supply chains for video and broadband vary as depicted in the chart. The supply chain for broadband includes Tier 1 backbones and Content Distribution Networks (CDNs) for access to the Internet and broadband application providers for content. The supply chain for video includes cable networks and broadcasters for video content. Both include advertisers because they rely upon an ad-supported business model, as well as equipment vendors for gear in the network and the customer premises.

Given this description of the supply chain one, approach employed by Google with the potential to substantially lower the costs for supplying broadband services was to establish an end-to-end transport chain using equipment based upon Internet Protocol (IP) technology. Google’s ability to accomplish this may be more a function of timing given the maturation of IP technologies over the past decade than an innovation itself. Nevertheless, Google was one of the early service providers to adopt an “all IP” approach for providing video and Internet services to residential customers at Gigabit transport speeds in 2010. Many telephone companies deployed video and Internet services using IP, though this was typically done using twisted copper pairs to the home using much lower-speed digital subscriber line (DSL) technology. Verizon did deploy fiber-to-the-home early to offer roughly 50 Mbps broadband but the video service used

³⁰ Sources for the supply chain include the author, and Owen, B. (1999). *The Internet Challenge to Television*. Harvard University Press.

IP only for broadcast video, not for video on demand. Cable operators likewise were in transition to an all-IP solution during this time but have yet to fully achieve this even today due to the need to support legacy set-top boxes.³¹

The maturation of the layered Internet architecture and accompanying evolution of web services that it facilitates provides an opportunity for service providers to be much more independent in the design and manufacture of devices for use in the network and at the customer premises. The ability to “plug and play” major elements of the Internet architecture with established, interoperable software solutions (some of which are open source) facilitates the ability of carriers to specify the design of their own equipment with non-proprietary low-cost components. In addition, the emergence of original equipment manufacturers (OEMs) that can build sophisticated network devices at low cost with profit margins much lower than traditional equipment vendors is another key enabler. Thus, Google has been building its own routing and switching in its core network since 2004.³² Similar reports have emerged that Google designs most of the equipment for Google Fiber in the home as well.³³ This includes optical termination, a storage device that acts as a DVR, a TV box to provide channels, and a residential gateway to provide Wi-Fi throughout the home.

How much savings might be attributed to a “build your own” approach? Again, Google has not shared any figures. The cost savings could be significant, trading the slim 10% or lower margins of OEMs against full-service equipment vendors that previously marked up equipment prices by as much as 50% above cost. Moreover, service and maintenance contracts, which on software-based network devices can cost between 10% - 20% of device cost on an annual basis, also can be avoided and internalized.

Another potential advantage to Google derived from supply chain management possibilities arises from their effort over the past several years to build a large national and international backbone network as part of a CDN strategy to develop and support the Google applications such as search and others.³⁴ For Google Fiber this CDN allows them to lower transport costs by minimizing transit payments to the Tier 1 Internet

³¹ See Sibley, M. (2015, October 14). Comcast: All-IP Video Target Is Q1. *Light Reading*; and Sibley, M. (2017, March 29). Comcast May Go All IP by End of Year – Rumor. *Light Reading*.

³² See Metz, C. (2013, March 26). Revealed: The Secret Gear Connecting Google’s Online Empire. *Wired*. Describing how Google designs its own networking gear in the same way it designs its own servers, storage gear, and data centers.

³³ Higginbotham, S. (2012, July 26). The economics of Google Fiber and what it means for U.S. broadband. *Gigaoam*.

³⁴ See Fitzgerald, D. and Ante, S. (2013, December 16) Tech Firms Push to Control Web’s Pipes. *Wall Street Journal*. Noting that Google has spent years piecing together a network of private fiber-optic cables and now controls more than 100,000 miles of routes around the world.

providers, as well as to improve video or other Google Fiber application performance by insuring enough capacity is available to support the growing traffic demands of their applications. This means Google Fiber project locations will be able to utilize the Google backbone to avoid Internet transit fees. Given the large bandwidth delivered on a per subscriber basis, this might appear to be a significant savings despite the fact that transit prices are estimated to have fallen to \$0.27 per Mbps in 2014.³⁵ To be clear, the amount in transit required per subscriber is only a fraction of actual usage associated with the peak service rate of 1 Gbps. Instead, broadband providers take advantage of statistical multiplexing to significantly reduce the transit required on a per subscriber basis.³⁶ Given this, the actual savings realized by Google in operating its own CDN for broadband service is probably quite modest even when consideration for video services are included in the calculation.³⁷ For this reason, our model does not include any material reduction in costs for the use of the CDN to serve Google Fiber markets.

A final advantage could stem from the “vertical integration” in the supply chain for the flow of consumer usage data. Operation of the Internet access service will provide Google with direct access to additional usage data of Google Fiber customers. The privacy notice of Google Fiber states that overall privacy policy for all Google services applies to its services and also describes how additional information collected mainly through the service install or billing may be used.³⁸ The general Google Privacy Notice describes the data collected in terms of device characteristics, activities and locations.³⁹ While an in-depth review of Google’s Privacy Notice is beyond the scope of this paper, what these notices do communicate is that the same data tracking and acquisition actions taken by customers of Google services are applied to Google Fiber customers

³⁵ See <http://drpeering.net/white-papers/Internet-Transit-Pricing-Historical-And-Projected.php>. This source provides a historical record of transit prices between 1998 – 2015. The estimate for transit pricing provided above conservatively assumes annual decreases of 25% for 2016-2018.

³⁶ A presentation by Time Warner Cable to the FCC shows that the peak bandwidth allocated per broadband user is 276 Kbps for a group of users, over two-thirds of which receive a 15 Mbps broadband service or above. See Leddy, K., Time Warner Cable presentation to FCC Workshop on Gigabit Community Broadband Networks, March 27, 2013. Retrieved on May 20, 2014 at <http://transition.fcc.gov/presentations/03272013/Kevin-Leddy.pdf>.

³⁷ Assuming use of video compression to 5 Mbps per high-definition video stream, a 150+ channel television service probably consists of about 135 national channels requiring a connection of less than 1 Gbps to transport the required 675 Mbps. In comparison, core networking interfaces of 10 - 100 Gbps are commonplace.

³⁸ See Google Fiber Privacy Notice. Retrieved on May 18, 2018, accessed at: <https://fiber.google.com/legal/privacy/>.

³⁹ See Google Privacy Notice. Retrieved on May 18, 2018, accessed at <https://policies.google.com/privacy/update>.

as well, and their does not appear to be additional efforts to collect and monetize customer data based upon the network provider relationship.

Other network providers have provided a market example of the monetization value of data that can be collected by network providers regarding the usage characteristics of their customers. For example, AT&T originally set its GigaPower prices at \$120 per month if customers were willing to share their data for targeted advertising through an Internet Preferences program, and \$149 per month if they were not.⁴⁰ Customers participating in the Internet Preferences program would provide consent to AT&T to analyze search terms and the type, visit frequency, and time spent on websites accessed by users.⁴¹ Through the Internet Preferences program AT&T clearly values this information to be at least \$29 per month, for a not-insignificant sum of roughly \$350 per year.

There is no evidence, however, to support the notion that Google Fiber allows Google search to extract such an incremental additional value from its subscribers. In contrast to AT&T, Google already has the top-ranked tracking infrastructure with tracking mechanisms such as cookies on 92 of the top 100 most popular websites and on 923 of the top 1,000 websites.⁴² In short, it may be that pre-existing tracking infrastructure means that the amount of information available to Google Fiber as the network provider is incrementally much less in value. Thus, while the Google Fiber customer relationship is likely to improve the data provided to other Google broadband applications such as search, the lack of any guidance data on the value of this incremental improvement, particularly when noting the substantial tracking infrastructure already available to Google, leads us to not include any contribution of material value to the business model.

Technology Innovations

A final innovation that Google has discussed publicly is the use of shallow trenching or “microtrenching” to deploy the optical fiber networks. This is not an innovation available only to Google Fiber as other network providers have also expressed an interest and have used this technology.

It is well known that a significant portion of the cost of deploying residential fiber networks is due to the labor required to lay the network cable throughout a city area. Traditional options for deploying the cable are to string the fiber aerially using telephone

⁴⁰ *Supra*, note 13.

⁴¹ See Brodtkin, J. (March 27, 2017) AT&T’s plan to watch your Web browsing – and what you can do about it. *ArsTechnica*.

⁴² See Altaweel I, Good N, Hoofnagle C. (December 15, 2015). Web Privacy Census. *Technology Science*. 2015121502.. <https://techscience.org/a/2015121502>.

poles or to run the cable underground in conduit or as buried cable. Depending upon the circumstances the labor of network installation can exceed two-thirds of the total cost of the outside plant installation. One idea to reduce the installation costs that was developed roughly a decade ago was to use shallow trenches, only a few inches deep, to bury the small optical fiber cable throughout the network service area. This approach takes advantage of the small physical size of fiber relative to copper wire pair or coaxial cables. The shallow trenching method of laying cables is to cut a small groove in the street or sidewalk, lay the fiber in that groove, and backfill it with a special epoxy. This way is much faster and cheaper than traditional methods.⁴³

Again, the actual savings with shallow trenching will vary significantly depending upon local circumstances such as the amount of aerial versus underground infrastructure and population density. We assume the savings due to this technology may range from 10% to 20% of the fixed network costs, with no change to the variable cost component as most network providers typically already use a shallow trenching technique for drop cable if the plant is not aerial. There can also be concerns raised regarding how streets and sidewalks are maintained as the normal maintenance of this infrastructure can now have a more significant impact on the shallow-trenched network. The model does not increase long-run operating costs due to this concern though this might be a future change to the business model as more experience is gained with shallow-trenched networks.

Model Assumption Summary

The financial model provides an estimate of the expected costs and revenues associated with building an all-fiber network to provide 1 Gigabit broadband service in a residential fiberhood of 1000 homes. To simplify the reporting of results, we define three scenarios of increasing impact to the business model innovations described above:

1. *Status Quo*. This scenario assumes status quo approach to fiber deployment without any benefit to the business model innovations described in the paper.
2. *Base*. This scenario assumes a moderate base case of assumptions for the business model innovations.
3. *Optimistic*. This scenario assumes an optimistic set of assumptions for the business model innovations.

⁴³ See Coren, M. (2017, March 21). Want blinding fast internet? Let Google dig a tiny trench outside your house. *Quartz*.

Table 2 summarizes the set of assumptions associated with these three scenarios for the model innovations.

Innovation	Status Quo	Base Case	Optimistic
Demand Aggregation	10% penetration in first year	20% presubscription, 10% savings in first year variable costs	40% presubscription, 20% savings in first year variable costs
Municipal Cooperation	No change	10% savings in fixed costs of network	20% savings in fixed costs of network
Supply Chain Optimization	No change	25% savings in home equipment costs	50% savings in home equipment costs
Technology Innovation	No change	10% savings in fixed costs of network	20% savings in fixed costs of network

Table 2: Model Scenarios and Related Assumptions

Table 3 provides a list of the other basic assumptions inherent to the financial model.

The fixed and variable costs for building a fiber-to-the-home network are critical assumptions for the model. As a beginning, we assume numbers that were widely reported by Verizon in their large deployment of fiber networks as listed in Table 3. These cost estimates of \$700 per home passed and variable costs of \$650 per customer are provided with the caveat that fiber network costs do vary widely with particular sensitivity to the degree of aerial versus underground or buried plant and the cost of labor for network installation. For example, a municipality received estimated costs of \$1500 per home passed to build a new all-fiber network in its city (a relatively high figure due to the need for fully underground installation) and a variable cost of \$2500 per subscriber at 35% penetration for core network electronics, drop cable and installation, and customer premises equipment.⁴⁴ Again this variable cost is relatively high with almost 50% accountable to the cost of underground drop installation. The important point here is to recognize that fiber network costs will vary significantly depending upon local circumstances. Thus, a sensitivity analysis of these parameters is conducted in the discussion of model results.

⁴⁴ See ctc technology and energy. Cost Estimates for FTTP Network Construction. Prepared for City of Santa Cruz, California. May 2015. Retrieved on May 18, 2018 at https://www.tellusventure.com/downloads/santacruz/ctc_santa_cruz_ftth_estimate_may_2015.pdf.

Item	Amount	Comment
Capital cost per home passed of fiber network	\$700 per home passed	Fixed cost of fiber deployment. Based on estimated cost of deployment by Verizon FIOS. ⁴⁵ Assumed to represent outside plant costs.
Capital cost per incremental home	\$650	Variable cost of fiber deployment. Based on estimated cost of deployment by Verizon FIOS. ⁴⁶ Assumed to represent drop network, customer premises equipment, and network electronics.
Annual operating expenses	\$20 per home passed for network + 25% of revenues	Network expenses for fiber network. ⁴⁷ Assume General & Administrative account for 10% of revenues. Selling and Marketing (13%) and Bad Debt (2%) account for remaining expenses. ⁴⁸
Broadband service price	\$70 per month (\$300 construction fee for low-cost Internet, waived for others)	Monthly price of Gigabit broadband for Google varies between \$55-\$70. Video not included in model as cost of programming assumed to be roughly equal to additional \$60 monthly revenue of video service. Phone service of \$10 per month also not considered for same reason. Model assumes 15% of customers opt for low-cost Internet service for \$50 per month.
Fiberhood size	1000 homes	

Table 3: Financial Model Basic Assumptions

The variable network cost component consists of the fiber drop network segment, optical network termination device, network router and other assorted network devices in the home, and the cost of labor for installation. Out of this \$650 cost, a reasonable estimate would be that labor costs would run \$250, fiber drop materials \$75, and network termination and customer premises equipment of \$325.⁴⁹ For our model calculations, we assume a cost savings of 25% - 50% in these equipment costs for

⁴⁵ See Calix. (2010). *Why Are You Not Getting Fiber?* Retrieved July 2013, from <http://www.natoa.org/events/NATOAPresentationCalix.pdf>.

⁴⁶ *ibid.*

⁴⁷ Kulkarni, P., et al. (2008). *FTTH Network Economics: Key Parameters Impacting Technology Decisions*. Retrieved July 2013, from http://www.networks2008.org/data/upload/file/Technical/A2_2_Kulkarni_EI-Syaed_Polonsky_Gagen.pdf.

⁴⁸ CostQuest Associates. (2012, September). *DAF2 Model Overview*. Retrieved July 2013, from http://transition.fcc.gov/wcb/tapd/universal_service/caf/CAF2-Part2.pdf.

⁴⁹ The equipment needed for broadband service is a fiber jack (optical network terminal) and a network box (router). A TV box (set-top box) and a storage box (DVR) are needed for television service.

networking and customer premises equipment.⁵⁰ Recall that we also assume a further 10% - 20% savings in the labor for network installation by concentrating on signing up subscribers in one neighborhood at a time. Given these assumptions, the total variable cost component falls by 22.5% - 45% to about \$360 - \$500 per initial first-year subscriber due to these efforts.

Model Results

This section of the paper describes the model results given the set of assumptions described above.

With the assumptions described in the previous section the results of our financial model indicates that this set of business model innovations can have a significant economic positive impact on the viability of the fiber network, whereas the economic viability of the overbuild in the status quo approach is less attractive (see Table 4).⁵¹ As described above, the model considers three demand scenarios: a “status quo” scenario where subscriber penetration is assumed to start at zero, along with “Base” and “Optimistic” scenarios where first-year service penetration starts at 20% and 40% of pre-subscribed households, respectively. All scenarios otherwise add 5% new subscribers per year until achieving 50%, after which growth moderates to 2% per year thereafter assuming a 10-year study lifetime.⁵² The model assumes 15% of all

⁵⁰ It should be emphasized once again that Google’s use of low-margin OEMs to build devices it has designed is not unique to the service provider industry at this point in time. Other telephone companies and cable operators have adopted similar strategies to lower capital expenses of equipment over the past several years. Given our initial cost estimates are based upon Verizon’s cost structure, which did not utilize OEMs (Verizon selected Motorola as its set-top box vendor), it is appropriate to discount the cost of equipment to reflect this approach.

⁵¹ To measure financial impact, we use Internal Rate of Return (IRR) and Net Present Value (NPV). IRR is a standard financial metric that reflects the discount rate needed to make the net present value of the cash flow of an investment equal to zero. The higher the IRR value, the more desirable it is to undertake the investment. NPV is also a standard financial metric that reflects the magnitude profitability of a projected investment based upon future returns.

⁵² As a comparison, Verizon reported that it achieved a 50% penetration of its broadband service in Dallas, Texas, where it had deployed for over 5 years. See Marek, S. (2014, May 14). Verizon’s FiOS has 50% penetration in Dallas. *FierceCable*.

subscribers always opt for the “low-cost Internet” option that provides a one-time revenue event of \$300 construction fee upfront, and \$50 thereafter.

In general, if the IRR of a project exceeds the cost of capital to the firm, and the magnitude of the returns are sufficient as reflected by the NPV, then it would be profitable to undertake the project. An IRR guidance roughly in the range of 20% or more for returns of an acceptable magnitude is a reasonable rule of thumb in corporate guidance.

	Status Quo	Base	Optimistic
Internal Rate of Return	12%	29%	79%
Net Present Value (10% cost of capital)	\$88K	\$554K	\$1.2M

Table 4: Model Results as Internal Rate of Return

In looking at these results, it needs to be stressed that these numbers are not meant to accurately estimate the exact business model of Google. Instead, they are meant to demonstrate directionally the trends in the business model for building Gigabit networks in the local loop, and to be representative of the rough magnitude of impact of the recent innovations in the overbuilding business model.

It is not surprising that the results for the status quo scenario does not exceed the 20% IRR threshold, and does not generate a very significant NPV as well. This is consistent with the traditional view of overbuilding economics that it is difficult to generate sufficient demand in the early years of deployment to generate significant returns (recall in this scenario the initial year adoption was 10% and 5% growth annually thereafter). The Base and Optimistic scenarios do provide acceptable returns of 23% and 79%, respectively.

IRR and NPV are very sensitive to the price of broadband service. Figures 2 and 3 below illustrate this sensitivity and provides additional interesting results. It shows that the Status Quo scenario is not attractive even for broadband revenues up to about \$85 per month without the benefit of the business model innovations. The Base and Optimistic scenarios appear to be acceptable all the way down to \$55 per month. The main reason for the attractive returns of these scenarios is that the penetration rate starts at 20% to 40% of homes in the service area.

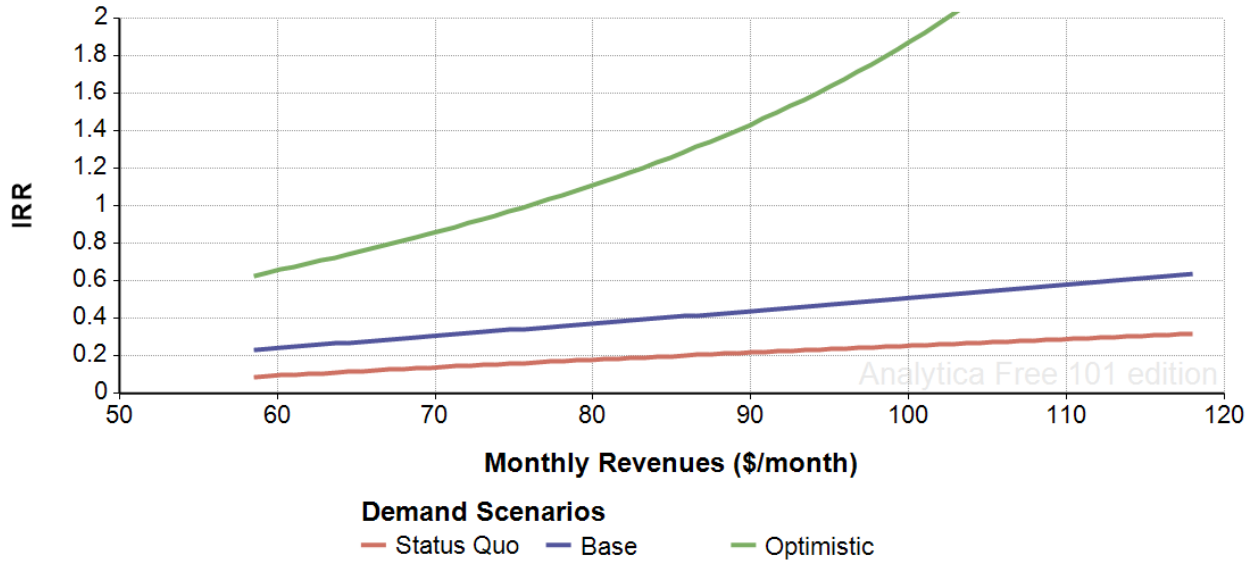


Figure 2: Internal Rate of Return of Demand Scenarios

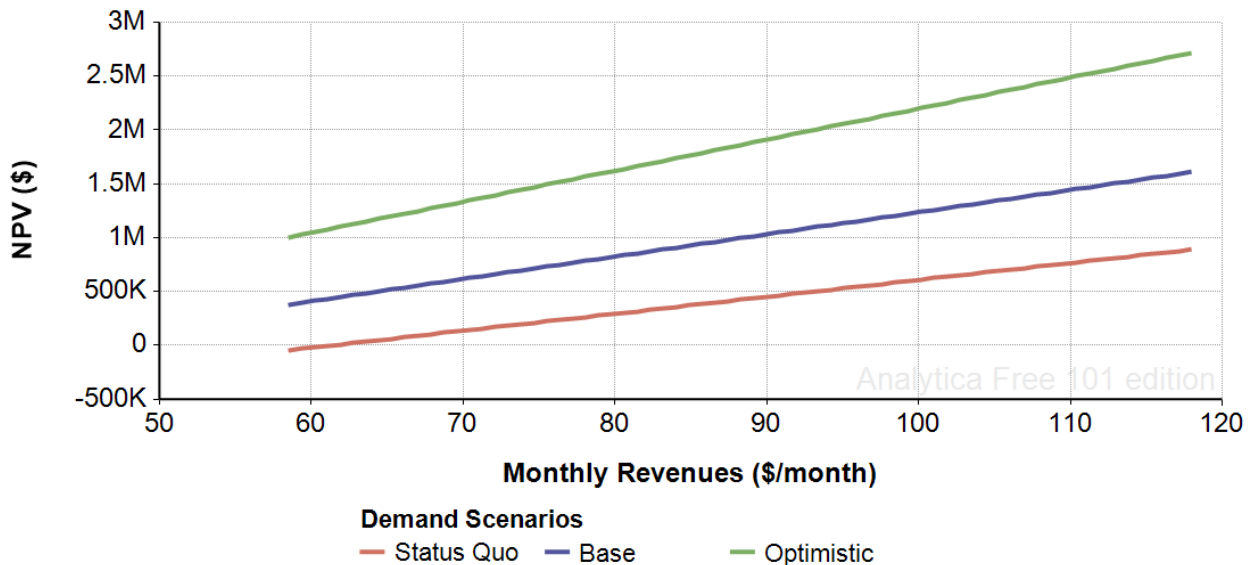


Figure 3: Net Present Value of Demand Scenarios

Both financial metrics are also sensitive to the network cost. Figures 4 and 5 show this sensitivity of IRR and NPV, respectively, against a network multiplier factor to the base case assumptions of \$700 per home passed plus \$650 per subscriber (shown when the multiplier is equal to 1). The price of broadband service in both figures is \$70 per month. These results show that the status quo scenario reaches the 20% IRR benchmark with a 0.75 network cost multiplier (\$525 per home passed plus \$470 per subscriber). The

base scenario reaches the 20% IRR benchmark with a 1.2 network cost multiplier (\$840 per home passed plus \$780 per subscriber) and the optimistic scenario always remains above the 20% IRR mark even with a 2.0 multiplier (\$1400 per home passed plus \$1300 per subscriber).

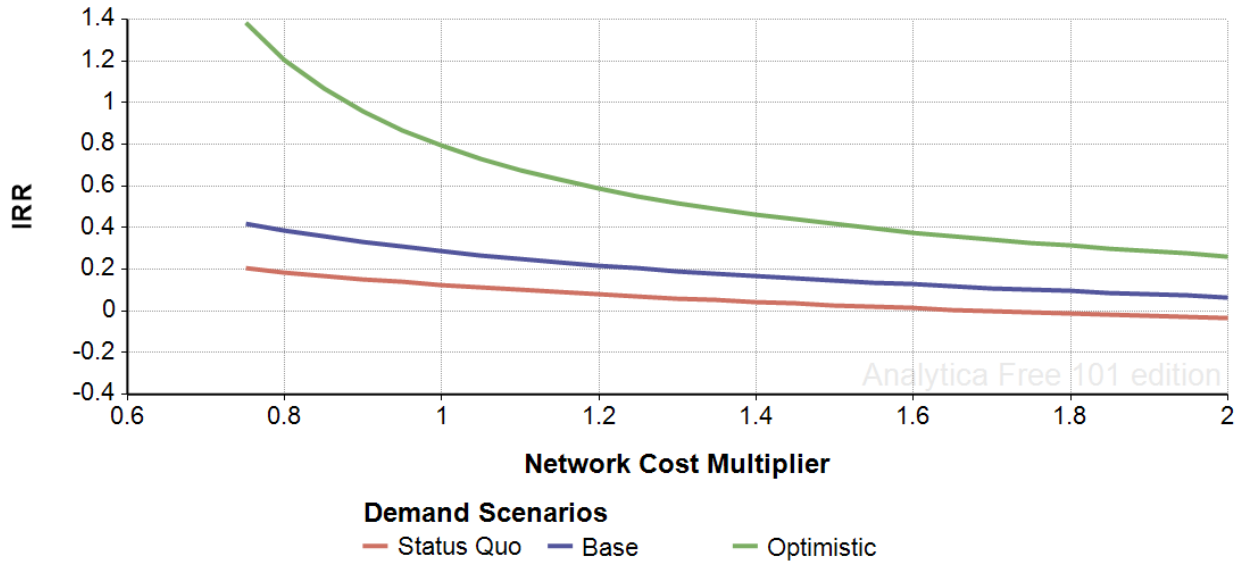


Figure 4: Sensitivity of IRR to Variations in Network Cost

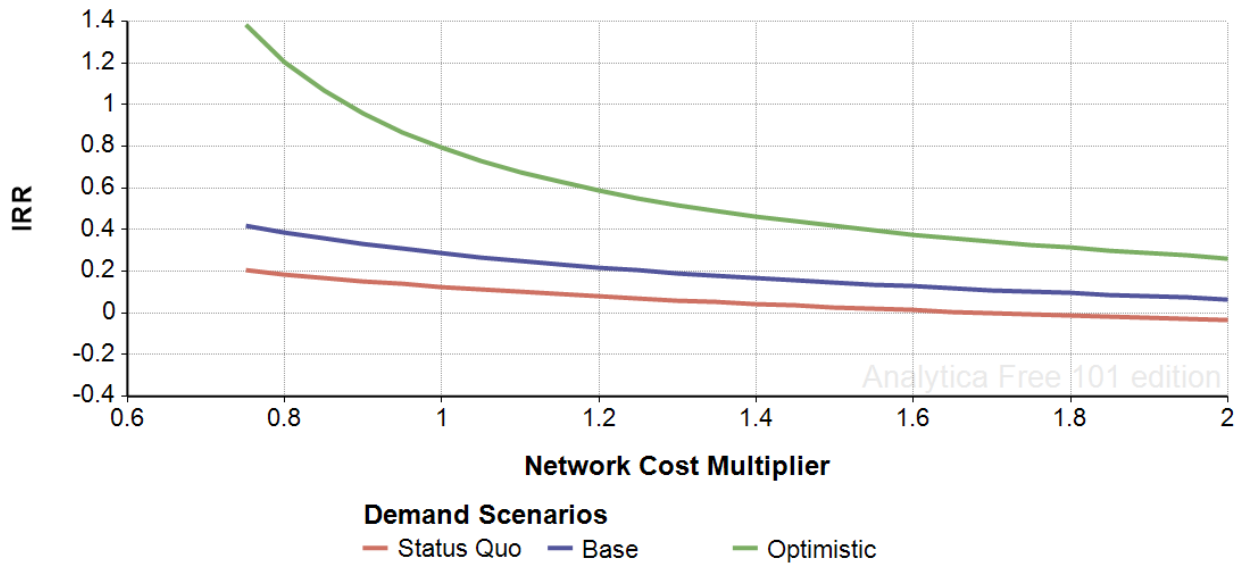


Figure 5: Sensitivity of NPV to Variations in Network Cost

Strategic Implications

The research question of this working paper is whether the prospects for new investment and competition in the local access market are improving. Based on the analysis presented here, it would appear the answer to this question is that the prospects for new investment to build Gigabit capacity are improved due to falling cost. Yet the analysis is inconclusive as to whether these innovations will result in additional competition from a new entrant. The limitations of the model prevent making an accurate forecast of the scope of anticipated new investment and new entry on the near horizon. Yet the model makes clear that directionally, new innovations are lowering the entry barriers for construction of Gigabit networks for residential subscribers. Practically speaking, this means that some areas, either urban or suburban, that were previously not feasible for deployment of all-fiber networks may now provide a viable location for the construction and operation of these networks to offer broadband services at Gigabit speeds. Yet the analysis suggests that new entrants or incumbents alike can capture these innovations. If accurate, the model results indicate that an aggressive incumbent response, particularly one that depresses the effectiveness of the demand aggregation effort, make the economic equation much more difficult for an overbuilder.

Some of the strategic implications of this finding, broken out along technology, economic, and policy dimensions, are discussed in this section.

Technology

There are two important strategic implications as related to technology.

First, the cost of building Gigabit broadband networks is decreasing. As the cost of optical networks has declined, its adoption has advanced from long haul to metropolitan networks, and now an increasing portion in the last mile of the network. Shallow trench is but the latest significant innovation that can significantly decrease the cost of building these networks. Over time cost reductions in network and customer premise equipment will move the prove-in point for fully fiber optic networks to areas with increasingly lower housing densities. All of the technical advances and benefits are available to both new entrant and incumbent network providers. The tradeoffs for incumbent providers are more complex, however, as they must weigh the benefits of incremental advances in augmenting their current networks versus the conversion cost to a fully fiber optic network. What seems clear at this point, barring an unexpected development on the

wireless front, is that the lowest cost per bit technology in the loop will be provided by fully fiber optic networks for the foreseeable future. As the market for broadband access speeds approaches a Gigabit per second, this will be an increasing advantage to this platform over the long run.

Second, the emergence of an all-IP supply chain for broadband services will be a critical imperative of all broadband providers. Without access to and utilization of IP-based standards and web services, service providers will be at a significant cost disadvantage to players that aggressively integrate elements of the supply chain. For example, the analysis discussed how direct interconnection to Internet national backbones is increasingly important to meet growing traffic requirements. With the CDN that Google has established in support of YouTube, Google acknowledges the advantages this extensive network infrastructure provides in support of its local access broadband service.⁵³

Economics

The analysis identifies three strategic implications as related to the economics of local access networks.

First, the business model for overbuilding still poses challenges, and is most viable with the business model innovations examined in the paper. The status quo model is marginally cash-flow positive assuming the network can generate an annual customer growth of 5%. The business model innovations examined in this study, however, show that success can be achieved with successful execution, particularly in the implementation of a demand aggregation plan.

Second, a demand aggregation strategy attacks what was one of the weakest elements of the business case for overbuilding – the length of time needed to generate sufficient cash flow to offset significant upfront capital expenditures. Moreover, it permits capital to be spent in areas where demand has been verified. In our model, the benefits of demand aggregation accounted for roughly two-thirds to three-quarters of the total benefits from the business model innovations included in this study.

Third, this result implies that any provider that cannot enter the market without a notable amount of demand aggregated at the outset of deployment could face a difficult market

⁵³ See Medin, *op cit.*

that increases the probability of failure. Note that incumbents, with their set of existing subscribers, have an advantage of having already aggregated potential large segments of customers in their existing service areas.

The other business model innovations – cooperation with the municipality and supply chain optimization – provide a material, but less significant lift to the business model.

Policy

The policy implications of these results fall generally under two categories: broadband competition policy and municipal demand for broadband.

Broadband Competition Policy

The results of this analysis indicate that new innovations are lowering entry barriers to building local access networks. This should be welcome news to policy makers who generally favor more competition rather than less. As noted above, however, it is unclear to the overall degree that additional competition may emerge or whether it is enough to foster a significant amount of new competition if incumbent broadband providers mount a competitive response that features its own Gigabit service.

Nevertheless, federal, state, and municipal policy makers should anticipate the development of innovative new business models for deploying Gigabit networks in the local loop. Barring request for government subsidization, policy makers should strive to remove policies that can serve to hamper the construction of new networks. While this paper has characterized municipal cooperation as an innovation to the business model for building new local access networks, the flip side of the coin is to question how municipal regulation and bureaucracy may have grown to the point of being such a significant barrier for deployment or large cost of regulation.

While forecasting the prospects for overbuilding is difficult, it intuitively would appear that this is a zero-sum game – any subscribers obtained by a new network built by a new entrant or incumbent will be largely lost by an incumbent provider. Our financial model seemed to generate positive cash-flow results when the service penetration exceeded between 30% to 50%. This means the number of facilities-based subscribers that can be supported in an area may be limited to 2 or 3, particularly as wireless options become more popular and entice households to “cut the cord”. Policy makers need to recognize that an incumbent slow to respond to changing circumstances or new

entrants failing to gain enough traction with consumers may come out as market losers in some areas.

Finally, the demand aggregation strategy has policy implications associated with the policy objectives of regulators or policy makers for universal service or the consistent provision of broadband services throughout a geographic area. Such “red-lining” or “cherry-picking” may raise equity and fairness issues for regulators as advanced networks get built in some areas but not others depending upon the demand of residents. Google attempted to counter this perception by offering a free Internet service to help fill in the digital divide gaps though financial pressures apparently forced it to eliminate this offer with a \$50 per month replacement.

Municipal Demand for Broadband

The Google approach has tapped into significant demand for broadband on the part of municipalities. As witnessed by the 1100 cities that responded to the initial Google RFP – an overwhelming response to be sure – there are a large number of cities that would like to upgrade the broadband infrastructure in their communities to be among the most advanced anywhere in the United States. The reason that cities seek better broadband infrastructure is due to the large benefits they perceive can be realized through more efficient government operations, relocation and retention of employers in the area, and more efficient communications infrastructure for their residents.⁵⁴

The primary reason for municipal demand for broadband is to establish their communities among the top echelon of municipal alternatives in terms of broadband speed and availability. Said differently, if the speed and availability of broadband in the municipality is not among the highest available, the “selling point” for the advanced broadband network is diluted or totally eliminated. Figure 6 shows a hypothetical distribution of broadband download speeds by municipality.⁵⁵ Those cities that rank in the top 1%, or at most 10%, of municipal alternatives are able to effectively compete with new business incubators and other claims for technical supremacy in the broadband ecosystem.

⁵⁴ As an example of the benefits described by cities with all-fiber networks, see the video produced by the city of Chattanooga at <http://us-ignite.org/>.

⁵⁵ Imagine that the results of a broadband speed tester were sorted by municipality, rather than by country or individual. The average download speed of each city would create a distribution, from lower speeds to the highest speeds. To the author’s best knowledge, such a distribution of broadband access speeds has not been created. For an example of speed tester results by country, see Ookla Net Index at <http://www.netindex.com/download/allcountries/>.

Hypothetical Distribution of Municipal Ranking in Speed

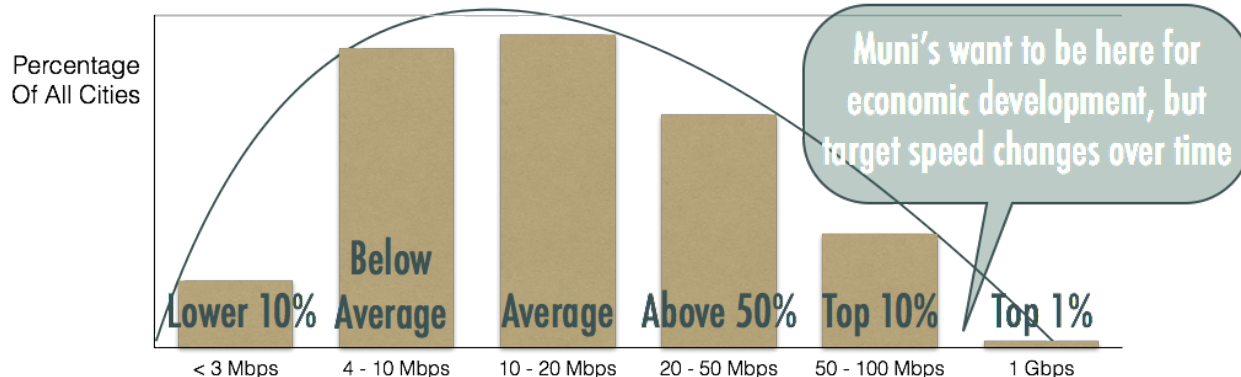


Figure 6: Hypothetical Distribution of Broadband Speed by Municipality

As technology advances, of course, the target broadband platform changes in terms of speed (or other capabilities). Today, the top speeds are 1 Gbps, but already there are reports indicating that 10 Gbps is the next top speed benchmark.⁵⁶ To their credit, municipalities at the top today recognize the target is moving and have incorporated programs that attempt to maintain their leadership over time. Kansas City, for example, released a “playbook for capitalizing upon ultra-high-speed fiber in Kansas City” and Chattanooga has created the “Gig-Tank” to incubate new broadband applications using the fiber network.⁵⁷

The important policy implication to be drawn from Google’s efforts is that significant demand exists between municipalities to leapfrog into a leadership position on broadband network infrastructure. Right or wrong, this leadership position is viewed as delivering important benefits to the community in attractive new high-tech employers improving municipal services and retention of tech-savvy citizens. Given this, municipalities are willing to cooperate with new entrants to spur investment in leading-edge broadband infrastructure in ways that reduce the cost and time-to-market. Note, however, that there only can be a limited number of cities that occupy the top at any given time. As 1 Gbps technology is deployed more widely, the advantage to cities with this technology is diluted unless they are able to be early adopters of 10 Gbps technology.

⁵⁶ See Barr, A. (2014, February 12). Google Working on 10 Gigabit Internet Speeds. *USA Today*

⁵⁷ See Mayors' Bi-State Innovation Team. (2012). *Playing to Win in America's Digital Crossroads: Version 1.0*; see also *GiG-Tank*. (n.d.). Retrieved March 2, 2014, from <http://www.thegigcity.com/gigtank/>.

Policy makers need to recognize this limitation given the inevitable calls for standardization of the municipal terms given to Google or the establishment of uniform “broadband best practices”.⁵⁸ Once all or most cities have 1 Gbps networks, or even something approaching 500 Mbps, then the benefits of recruiting new companies to the city are severely diluted. Transparency to the best practices that enable new networks is surely a useful thing, but uniform imposition of the best practices will take away some of the early-adopter advantages currently enjoyed by cities with 1 Gbps networks.

More important to policy makers is that cities are able to strongly “compete” to maintain or advance into a leadership position in broadband infrastructure. Policies targeting broadband best practices could have unintended consequences or be used by incumbents as opportunities to slow down the deployment of new broadband infrastructure. This analysis, for example, demonstrates the major impact that demand aggregation strategies have upon the business case for fiber networks. New regulations that place constraints on the ability of new entrants to use this approach could significantly undercut the viability of new fiber networks.

⁵⁸ For example, see Kessler, A. (2014, February 23). Why Super-Fast Internet Is Coming Super Slowly. *The Wall Street Journal* .