Recommendations for Expanding Internet Access and Supporting Net Neutrality

A report to Mayor Joseph A. Curtatone of the Somerville Internet Access Task Force

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1. Executive Summary

The Somerville Internet Access Task Force was assembled in the spring of 2018, at the request of Mayor Joseph A. Curtatone, to consider the challenges and opportunities to improve broadband connectivity for residents and businesses throughout the City[1]. Over the past year the Task Force has met regularly to discuss and research the existing market context, unmet social and economic objectives, existing and emerging technologies, relevant policies and regulations, and case studies and best practices. The Task Force also corresponded with and hosted broadband subject matter experts and entrepreneurs to address member questions and test the viability of various options for improved internet access throughout Somerville.

In 2019 there is little disagreement about the critical role internet access plays in the lives of most people of all ages and backgrounds, for education, employment, entertainment, civic and community participation, communication, creativity, research, innovation, and collaboration. Thus cities and towns across the U.S. and around the world increasingly view ubiquitous and affordable broadband service as an essential service not unlike electricity, water, and other core utilities.

When it comes to improving internet access however, opinions vary both on the nature of the problem and the framework for a solution. Internet access in the U.S. is typically provided by private telephone and cable TV service providers, through a mix of legacy and new technologies and federal, state, and local government rules and regulations. As a result, suboptimal internet access can be understood as a market failure due to insufficient competition, a regulatory failure due to out of date policies and laws, or some combination of the two. Similarly solutions to address poor service can range from waiting for market and technology improvements, intervening to foster greater competition, establishing a publicly financed and managed service, or some combination or hybrid of these approaches.

In 2019 other internet policy concerns, beyond fast, equitable, and affordable broadband service, are also shaping public opinion about internet access. Hacking, identity theft, commercialization of personal information, and the filtering, throttling, and favoring of internet content by private companies are contributing to these concerns. Recent FCC regulatory changes to eliminate or minimize net neutrality are driving state and municipal government efforts to better address these principles where possible. In this context people and communities are increasingly interested in internet access that protects user privacy, makes clear any commercial use of personally identifiable information, and avoids or makes clear any filtering, favoring, or throttling of select internet traffic or content.

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[1] https://www.somervillema.gov/news/somerville-seeks-members-and-advisors-internet-task-force

The City of Somerville has a history of broadband leadership and innovation. In 1997, Somerville was the first municipality in Massachusetts to establish greater competition in cable TV and internet services when RCN became the second provider in the City. Today many communities still have only one cable provider, and not all telephone service providers offer high speed internet access[2]. In 2017, there were parts of Somerville where 25% of households lacked home internet[3]. But over 20 years later competition between two cable providers is not sufficient to significantly improve broadband services. Following years of corporate consolidation and acquisitions, many cable and telephone providers are viewed as de facto duopolies with little incentive for innovation and price reduction. Some of the most innovative broadband projects in the U.S. are in rural communities that established municipal electrical cooperatives over 100 years ago since private providers found insufficient profit potential. Today facing similar challenges with broadband access, many rural communities are building their own fiber networks which are owned and operated by the same electrical coops.

But establishing publicly owned and operated broadband networks in an urban environment is more challenging. Cities do not have the advantage of an existing municipal or cooperative organization that controls poles, owns bucket trucks, and bills customers for a similar service. And while urban communities may suffer from unsatisfactory internet access they likely to have private providers resistant to competition from a municipal network operator and will incur higher construction costs given density and complexity. And in the context of Somerville, ongoing major investments including a new Somerville High School, new water and sewer infrastructure, and MBTA Green Line construction, make funding a public fiber network untenable.

However the Task Force believes that Somerville can once again demonstrate broadband leadership by welcoming new technologies and emerging business models to spark innovation with little to no investment of taxpayer funds. The Task Force's key recommendations include a slate of best practice actions to foster an environment more conducive to broadband initiatives in the future and a fast track effort to partner with disruptive broadband service providers to consider Somerville as the first and best place to roll out next generation technologies.

In the following pages the Task Force seeks to summarize problems to be addressed, a vision for the future, key principles and goals, the process undertaken to date, broadband terms and definitions, a range of service options and policy interventions, and recommended actions for the City to take given anticipated resources, regulatory context, demographics, and the physical landscape of Somerville.

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[2] https://broadbandmap.fcc.gov/#/location-summary?version=jun2017&lat=42.388987&lon=-71.102199&tech=acfosw&speed=25_3&vlat=42.40090870558885&vlon=-71.10309745462058&vzoom=12.529431479032137

[3] https://www.digitalinclusion.org/home-internet-maps/

2. Problem Statement

1. There is a broadband market failure that has led to insufficient internet speed, quality of service, equity, affordability, and innovation in our City.
2. There is a government policy and regulatory failure that has led to insufficient consumer protection, user privacy, innovation, and competition in our City.

THEREFORE - We should consider establishing policies that treat internet access as a public utility and not as a nice-to-have service.

Additionally, the City should consider establishing infrastructure policies that promote future innovation, broadband distribution, and equality of access.

3. Vision

In developing a vision for internet access in Somerville we decided it would be helpful to describe both minimalist and ambitious approaches to better convey the range of opportunities and appetite for innovation. Thus here are definitions of both narrow and audacious visions.

Narrow: We envision a city where upload and download internet access is convenient, accessible, and reliable for every person and company. This access shall preserve the privacy and security of each participant. Each packet is treated equally.

Audacious: We envision a city with internet access treated as public utility with fast, open,and innovative solutions that are available to all residents; where upload and download internet access is convenient, accessible, and reliable for every person and company. This access shall preserve the privacy and security of each participant, and each packet is treated equally.

4. Principles and Goals

Underlying the Task Force's vision for better broadband in Somerville are a number of key principles and goals that we believe should guide any and all broadband initiatives and supporting policies and processes:

- Affordable, ubiquitous, and reliable internet accessible to all residents and businesses
- Reasonably balanced download and upload speeds (approaching symmetry) to enable digital creativity as well as consumption
- Adherence to net neutrality principles to ensure all internet content and traffic is treated equitably without bias or throttling
- Clear and accessible data privacy and security policies that favor opt in (not opt out) sharing of personally identifiable information (PII) and metadata

- Support for affordable, equitable, and innovative provision of municipal services

5. Process

The Internet Access Task Force is comprised of nine Somerville community members. Along the way, several additional community members contributed their expertise and talents to group discussions. This document was authored by the following Somerville residents. Professional affiliations are included for transparency, however the recommendations and views of this report represent individual perspectives and do not represent the views of the organizations with which they are affiliated:

Marlee Chong, Infor
Tayeb Al Karim, Google
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Kyle Rose, Akamai and IETF
Hilary Ross
Kate Zebrose

The Task Force met monthly from April 2018 to May 2019. The Task Force hosted presenters and spoke to outside experts, including:

David Talbot
Joanne Hovis
Jim Hanley
Next Century Cities staff

The Task Force was staffed by Meghann Ackermann, Public Information Officer, and Cortni Desir, SomerStat Principal Analyst.

6. Definitions

Broadband - High speed internet access that is always available. The FCC 2019 benchmark for broadband is 25Mbps upload and 3Mbps download[4]. These speed requirements are expected to increase with new service innovations.

Dark fiber - Fiber optic cables that are not currently being used to transmit data, but are available for future use.

Download speed - Speed of internet traffic from a web server to a user measured in megabits bits per second. Typical example include web browsing, streaming video, and gaming.[5] Many ISP provide websites that can measure a users download speed. Netflix also provides such a service, Fast.com, that can be compared to the providers service.

Equity - Insuring that all community members have access to internet services. Requiring providers to service the entire city and not allowing them to cherry pick the areas most easily serviced due to geography and/or subscriber incomes will help achieve this goal.

Innovation - New ideas, creative thoughts, new imaginations in the form of device or method.[6] Microtrenching is an innovative idea enabling greater fiber deployment with less disruption.

Internet - A world wide network of computers interconnected with the Internet Protocol(IP) and using addresses assigned by the Internet Assigned Number Authority (IANA).[7]

Internet access - The ability to gain electronic access to the internet and use services such as email, web browsing, video streaming, file transfer, and many more. Internet access requires an electronic device with a communication port that support IP. This could be a phone, computers or perhaps you car. The device also needs to have the ability to support the desired service.

ISP - Internet Service Provider - An organization that provides access to internet services. These services include browsing web pages, streaming video, performing on-line banking, and IP phone services.

Last mile - The connection between the user and the ISP's consolidation equipment where the data can be carried less expensively on a higher speed link. This is the most expensive part of a

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[4] FCC-18-10A1.pdf '2018 BROADBAND DEPLOYMENT REPORT' [15] pg 6 https://www.fcc.gov/reports-research/reports/broadband-progress-reports/2018-broadband-deployment-report

[5] https://broadbandnow.com/guides/how-much-internet-speed-do-i-need

[6] *Merriam-webster.com*. Merriam-Webster. Retrieved 14 March 2016.

[7] https://www.iana.org

telecommunications network, representing 80% of the cost, as it is dedicated to a single user.[8] The term is figurative and in Somerville is likely less than a mile, often from the middle of the street to a residence or business.

Latency - Delay, measured in microseconds, in transmission from a user to a server and back. Latency greater than 35 microseconds in voice requires echo cancellation. Latency for cutting edge robotics can be more stringent. Latency is less important for video streaming or web browsing. Fiber optic and 5G are expected to have lower latency.

Mesh network - Connection of networking equipment in a peer to peer configuration without hierarchy. Nodes must have the ability to determine a route with a cooperative algorithm. MassMesh is a local organization promoting the use of mesh networks.[9]

Microtrenching - Also known at slot-cutting, a method of laying fiber optic cable with a small trench, typically 6-16 inches deep and 1.25 inches across.[10] This method has been used successfully in Toronto, Canada by Connectivitywerx and in Austin, Texas by Google Fiber.

Nanotrenching - A method of laying fiber optic cable with a very small trench, typically only two inches deep and less than an inch wide.[11] This is the method Google Fiber used in Louisville, Kentucky, which has been discredited.[12] While the cabling did not work, the Louisville experiment shows what a positive effect having a third competitor has on a market.

Net Neutrality - A network should treat packets between endpoints in the same way. That is to say though a network operator is allowed to manage their network to maintain network health, by say, throttling video to allow better voice quality, they should not do so by discriminating against specific endpoints, for example, dropping video packets from only a specific service. They should instead randomly drop video packets from all video services. As the FCC order detailed in 2015 *"... three specific practices invariably harm the open Internet—Blocking, Throttling, and Paid Prioritization—this Order bans each of them, applying the same rules to both fixed and mobile broadband internet access service."*[13]

Privacy - In the context of internet access, privacy means data privacy and the expectation that providers of internet infrastructure will not use a subscribers data except as needed to provide

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[8] http://www.thefoa.org/tech/ref/appln/FTTH.html
[9] https://massmesh.org/
[10] http://www.thefoa.org/tech/ref/install/Microtrenching/index.html
[11] https://www.techrepublic.com/article/google-fiber-is-using-a-secret-weapon-to-outpace-at-t-and-other-gigabit-competitors/
[12] https://www.courier-journal.com/story/news/2019/02/07/google-fiber-louisville-internet-service-leaving-city/2802763002/
[13] FCC Open Internet Order, Section: II-A-1 (Clear, Bright-Line Rules) https://transition.fcc.gov/Daily_Releases/Daily_Business/2015/db0312/FCC-15-24A1.pdf

services. The federal Information Infrastructure Task Force defined information privacy as "an individual's claim to control the terms under which personal information - information identifiable to the individual - is acquired, disclosed, and used."

Security - In the context of internet access, security refers to services, such as cryptography, that allow users to know who they are communicating with and that their communication will be kept private. Not only should an ISP not misuse access to a subscriber's information, but it also need to insure the information is not available to others who might misuse it.

Shallow fiber - Any installation of fiber optic cable at a depth well above sewer, water, gas, and other existing buried assets.

Small cell - A mobile phone cell that is smaller in size and range than is typical. The FCC defines such cells as having an antenna of not more than 3 cubic feet and being supported by equipment not more than 28 cubic feet. Many small cells are using millimeter frequency bands which require line of sight access. This means many of these small cells are required for effective coverage.[14]

Take rate - The percentage of potential subscribers who are offered service that actually subscribe.[15] Projecting the take rate will be an important part of making a business case for any new service.

Upload speed - Speed of internet traffic travelling from a user to a web server measured in megabits bits per second. Typical examples include uploading video to YouTube, sending documents via email, storing documents or pictures in a 'cloud' server.[16]

[14] https://docs.fcc.gov/public/attachments/DOC-353962A1.pdf
[15] https://muninetworks.org/content/community-ftth-networks-get-high-take-rate
[16] https://broadbandnow.com/guides/how-much-internet-speed-do-i-need

7. Recommendations

For the purposes of **encouraging a competitive marketplace and net neutrality**, this task force recommends that Somerville:

- Facilitate a buildout of a **shallow fiber conduit** city-wide network owned and operated by a **wholesale conduit and dark fiber provider**.
    - This network should have a rollout plan such that 100% of Somerville households and businesses are served once rollout has been completed, and the entire rollout is complete within 2 years. This provider is restricted from selling retail internet services.
    - The completion of this rollout will *not* result in internet access being available to all residents. It will result in all residents being serveable.
- Allow the wholesale network operator to find an anchor retail internet service provider that will provide internet access to residents and businesses and allow a de-facto monopoly for up to 3 years, subject to negotiation with the provider.
- In 3 years, subject to negotiation, stipulate that any business that wants to provide retail internet services may do so using the wholesale conduit operator's network.
- Design a **Request for Information** to implement the above, and follow up with a proposed permitting plan and a **Request For Proposals** to discover a wholesale shallow conduit / dark fiber provider.

Please refer to the section entitled, *Privately Owned Network, Conditions set by Municipality*, for further discussion.

There are various other technologies and policies that we believe are **complementary** to the above solution. Many of these would be inexpensive, short-term, and incomplete solutions, but would still be valuable in expanding internet access.

To **increase access** and to **assist in technical literacy**, this task force proposes that Somerville:

- Encourage continued research into **mesh networks**.
- Research and implement a **signed-in publicly wireless network**, accessible near Somerville municipal facilities (libraries, offices, public parks, etc).
- Provide more funding for **device / hot spot lending in libraries**.
- **Publish a one-pager** with a list of resources (known good contacts, websites, community efforts) that:
    - Communicates information about federal programs to get access to subsidized internet / phones
    - Provide pointers or resources for obtaining cheap alternatives to communications technology (for example: VoIP phones, etc)

- Encourage competition by working with companies that may be interested in providing internet access at city-regulated large buildings via **building-hosted services**.

Somerville can implement the following policies / fund roles with the following responsibilities

- **Advocate** for pro-net-neutrality legislation in the MA Legislature.
- Write a **statement of values**, describing what Somerville wishes to support in terms of net neutrality.
- Explore writing a **preferred purchase policy** that describes preferential treatment on city projects for networks that exhibit the characteristics and values described by the statement of values. This is a ranking mechanism, not a requirement.
- Appoint a **point-person to be in charge of policies/communication** for regional and municipal collaborations around net neutrality
- Research and implement a **dig once policy**. This may range from future-forward looking efforts (build a city-owned conduit incrementally whenever a road is opened for maintenance) to ensuring that all interested parties are notified when there is road work being done so that they may install conduit without having to open the road again.
- **Ensure that all existing conduit are correctly mapped and tracked as assets**. Ensure these assets are available to city planners

Finally, to show potential retail internet service providers that Somerville residents are interested in net neutrality

- Sponsor or encourage a **survey that asked if residents would be willing to pay more to support net neutrality** [similar to green energy]

8. Last Mile Access Technologies

There are three types of last mile access technologies: Copper cables, Fiber optic cables and WiFi mesh networks. These technologies can be used separately or together to provide internet access to Somerville.

Data speeds via fiber cables currently far exceed that of copper cable and mesh networking. Additionally, fiber will provide greater speed and capacity as technology improves and fiber cables are likely to last for many decades. Fiber represents the best choice for high speed internet access and availability.

A fiber network could be setup to provide access to multiple ISPs with the provider acting as a utility to maintain the fiber cables as a common-access resource for a reasonable cost. Such a utility, which could be city owned or owned by a private utility, would need to have a policy of reasonably priced open access to all companies utilizing the fiber network. Since Somerville does not own the telephone or electricity poles in our city nor have a dedicated conduit network, installing fiber would require the use of shallow trenching techniques. As a result, the cost of bringing fiber to the city is likely to cost many tens of millions of dollars.

WiFi Mesh networks use a set of wireless access points around a city or neighborhood to provide redundant internet access. Residents' computers would gain access to the network by connecting with one or more access points within line of sight. Some nodes in the mesh network would connect to the internet via higher speed connections, either point-to-point mesh connections or via fiber cables.

8.1. Copper Cable

Cable internet is usually provided via copper cables, with a current maximum speed of ~1 Gbps (with the latest DOCSIS 3.1 standard), with research suggesting a max rate of ~10 Gbps in the future[17]. Electric signals are modulated through the cable to provide a data stream to the home. Note that copper cable needs to be insulated from electric fields and, in most cases, the bandwidth is shared within a population of users.

Cable loses signal quickly, necessitating more facilities within a given service region based on density. Because of this, most implementations of cable networks are built on top of fiber backbone networks.

[17] https://spectrum.ieee.org/tech-talk/telecom/internet/bell-labs-sets-new-record-for-internet-over-copper

8.2. Fiber Optic Cable

Fiber optic cables are flexible glass cables used to carry modulated light signals representing data streams, as distinguished from current-carrying technologies such as coaxial cable (as employed by cable internet providers) or CAT6 (commonly used within offices and dwellings for local area networks). As a last-mile delivery technology, fiber is currently the gold standard for performance and extensibility:

- Fiber can support much higher data rates on a single strand than on a single run of coax.
- Many fiber optic strands can fit into the same physical space as a single coaxial cable or CAT6 cable.
- The capacity of an individual strand frequently can be increased simply by replacing the signaling equipment at each end.
- Signal loss per mile (especially for single mode fiber) is much lower than for current-carrying technologies subject to resistance loss and inductive signal interference, allowing for longer uninterrupted runs between equipment such as repeaters.
- Fiber capacity is allocated entirely to the two endpoints: there are not multiple nodes competing for capacity on the same strand (except insofar as the endpoints may represent multiple machines), nor any need to perform collision detection and avoidance at the link layer. This is in comparison to various cable technologies (like DSL).
- Given the rapid growth in adoption of cable internet and the demand for bandwidth driven by on-demand streaming video delivery, even cable providers now themselves use fiber for data transmission to all but the final several hundred or thousand feet from customer presence equipment (CPE).
- Most wireless-based broadband technologies, such as small cell mobile/5G and community WiFi networks, employ fiber as a backhaul between wireless distribution nodes and the rest of the internet. Mesh networks do not, but they are not best-in-class from the perspective of performance (latency and effective bandwidth) or reliability (loss/drop rates), and mesh networks by their very nature share bandwidth among users.
- Fiber is endpoint-agnostic: being a point-to-point link between two devices instead of a shared resource means that individual strands can be connected to entirely different infrastructures, and also that a strand can be repurposed simply by replacing the equipment at each end, without any need for explicit cooperation or coordination between different providers.

The downsides of fiber mostly come down to the cost of physical deployment and maintenance:

- Somerville does not own its telephone poles, effectively precluding deployment above ground.

- The cost of universal deployment using traditional trenching techniques is high for a dense city with significant existing ground infrastructure that would need to be carefully protected during the deployment process.
- The number of city streets with existing available deep conduit suitable for fiber deployment is insignificant compared to the overall mileage that would need to be covered.
- Buried fiber can be disrupted by road or infrastructure construction (known in the business as “backhoeing a cable”), with not insignificant repair costs.

Additionally, experience from other municipalities suggests that the city-owned and -operated fiber network model is not typically successful, a problem that will be covered in more depth in a later section: briefly, given the existing alternatives of Comcast and RCN, Somerville simply cannot guarantee a level or rate of uptake among residents to justify the cost of a full buildout using city-financed debt instruments.

8.2.1. Shallow Fiber

To address some of the cost issues, techniques have been developed for deploying fiber either on the road surface cased in a high-strength protective material or in shallow trenches (between 12 and 18 inches below the road surface). This design avoids major existing buried infrastructure (gas, water, sewer) while protecting the fiber from road maintenance, such as road resurfacing, and from minor damage to the road surface caused by construction equipment or heavy vehicles. This design has the potential to bring the cost of deploying a city-wide fiber network to a point at which either Somerville or a third-party could justify the capital expenditure.

8.2.2. Case Study: Netly

- Shallow fiber build out in a city in California, slated to start in Q1 2019
- Deployment occurs in two phases:
    - In the first, every street in the city is fitted with one or two lengths of preformed, high-impact plastic conduit that can accommodate several bundles of fiber each. These conduits terminate at one or more central drop locations (data centers with termination equipment, transit links, and possibly other infrastructure such as CDN caches), but will initially themselves be empty. The conduits are installed by a process called micro-trenching, which involves a machine that digs up a thin trench of the road and roadbed near the curb, lays the conduit, and fills and patches the road surface, also installing access ports (small manhole covers) periodically.
    - The second phase is to run a fiber bundle through the conduit from the central drop location to the desired service location, and then to terminate the fiber at both the provider and customer. Termination at the customer avoids further disruption of the road surface by making use of the pre-installed access ports to enable straightforward tunneling of the fiber under the sidewalk.

8.2.3. Case Study: TRAXyL

- Gluing Fiber to the Ground in Stillwater, Okla., and Fauquier County, Va.
- “When you think of broadband, the fiber optic cables are usually up in the air or they’re buried underground,” said Meagan Kascsak, communications coordinator for the city of Stillwater. “This is kind of in between, it’s on a hard surface like a street or a parking lot in this case.”[18]
- The city’s pilot project, which began in May 2017, is one of the first for a startup based in the greater Washington, D.C., area called Traxyl (stylized as TRAXyL). The company has patented methods to adhere fiber cables to hard surfaces using substances that should protect them from basically anything, from weather to 50-ton excavators.

8.2.4. Case Study: Google Fiber in Louisville, KY

- Nano-fiber deployment was abandoned in an incomplete state because of technical issues.
- “In Louisville, Google Fiber reportedly was burying cables in ‘nano-trenches’ that were just two inches deep.”[19]
- “Google Fiber used a shallow trenching strategy that is quicker than traditional underground fiber deployment and doesn't require digging giant holes. Instead of a foot-wide trench, a micro-trench is generally about an inch wide and four inches deep.”[20]
- This suggests that there is a minimum cost and complexity to install a viable shallow fiber network.

8.3. WiFi Mesh Networks

WiFi Mesh networks connect a set of wireless access points around a city or neighborhood. Some of those access points can be connected to the internet via high speed connections, such as point-to-point wireless mesh connections or fiber optic cables. Each access point is designed to communicate with multiple other access points such that if one or more access point were to fail, network traffic could go through the other access points to get to its destination. Residents’ computers could connect with one of multiple access points within line of sight.

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18 https://www.govtech.com/biz/By-Gluing-Fiber-to-the-Ground-Startup-Thinks-It-Can-Slash-Broadband-Installation-Costs-for-Local-Government.html

19 https://arstechnica.com/information-technology/2019/02/google-fiber-exits-louisville-after-shoddy-installs-left-exposed-wires-in-roads/

20 https://arstechnica.com/information-technology/2019/02/google-fiber-exits-louisville-after-shoddy-installs-left-exposed-wires-in-roads/

Mesh networks provide redundancy and are fairly easy to setup. Access points require power and sometimes a land ethernet or fiber connection. One design that Somerville could adopt, whether by public or private initiative, would be to establish high speed fiber backbones along major roads or at major buildings and build mesh access points along that backbone. Other mesh access points would then be setup at regular intervals fanning out from the backbone to provide access to the city. High speed point to point mesh access points could be used as an alternative to a fiber backbone or to minimize the build out of such a backbone.

Many houses in Somerville are within connection distance of 20 or more WiFi access points. Another approach to building out a mesh network would be to encourage residents to acquire, perhaps at a discount, a standardized mesh network access point that they can use to replace the WiFi access point they purchased themselves or that was provided by their ISP. The mesh access points would be designed to connect to one another and protect users' privacy and to gather only the data they need to maintain proper functioning of the network. Any updates to the mesh access point software would be open to all and its contents transparent so everyone could review it.

The benefits of mesh networks include:

- Setup requires minimal disruption of residents;
- Buildout could be incremental focusing on those areas least serviced by existing commercial ISPs;
- With weather-proof access points costing $100 able to provide decent service to a short street, upfront costs are low;
- Potentially fewer points of failure leads to higher network redundancy;

Drawbacks include:

- Access points are computers and, as such, would need to have their software updated to stay secure. This can be done remotely;
- Access points could fail and would need to be identified and replaced;
- Access point technologies improve and access points would need to be replaced to improve the speed of service;
- Any wireless technology is unlikely to provide the maximum bandwidth or minimum latency of a fiber network;
- Mesh network technology is less mature than other options at the scale we're pursuing

9. Ownership Models for the Access Network

There are a number of possible models for deployment, ownership, and operation of a city-wide access network in addition to the privately-owned model employed by RCN and Comcast today. We outline the major alternatives here, along with benefits and drawbacks encountered where these models have been implemented.

9.1. Municipally-Owned and -Operated Broadband

A municipally-owned broadband network would be fully owned by the City of Somerville. There are almost 500 communities across the United States that own their broadband networks.[21] Many are in low-density (rural) areas where private ISPs would not offer service.

In Massachusetts, there are a few successful examples of municipally owned and operated broadband services. Concord, a town with a hundred year-old municipally-owned electricity utility, recently built out a fiber optic network and began providing residential broadband service. [22] Leverett, a town of 2,000 in Western Massachusetts, also has a municipal fiber optic network. [23] Charlemont, a town of 1,300 in Western Massachusetts, voted in December 2018 to establish their own municipal fiber broadband network to cover all residents and rejected Comcast's proposal to provide a slower service to 96% of residents[24].

Municipally-owned and -operated broadband would allow Somerville to ensure that:

- Users are able to purchase access to high speed broadband service at reasonable rates.
- All traffic of a given class receives equal treatment by the network.
- As little information on users and their traffic as possible is collected, ensuring users' privacy is protected from ISP surveillance.

Drawbacks include:

- Building such a network would be expensive. Cambridge explored building its own municipal broadband provider and concluded that the cost would be upwards of $180 million[25].

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[21] https://muninetworks.org/communitymap

[22] https://www.washingtonpost.com/opinions/saving-net-neutrality-one-house-at-a-time/2018/04/22/a4de8a7e-39af-11e8-8fd2-49fe3c675a89_story.html

[23] https://cyber.harvard.edu/publications/2013/internet_to_leverett

[24] https://arstechnica.com/tech-policy/2018/12/comcast-rejected-by-small-town-residents-vote-for-municipal-fiber-instead/

[25] https://cambridge.wickedlocal.com/news/20180409/high-cost-of-municipal-broadband-in-cambridge-leads-to-lack-of-city-support

- Organizing political support for financing a network buildout, given competing interests for city government attention and financial support.
- Managing a network and providing customer service is difficult. Where municipally-owned broadband efforts have failed, one contributing factor is the complexity of management: lack of knowledge of billing systems, difficulty in selling the product and providing customer support, the challenges of managing a complex, high-availability service, etc.
- Potential legal issues. In many municipalities where private companies have provided broadband service, ISPs fought municipal broadband proposals in court as unfair competition by a municipality.

9.2. Municipally-Owned but Privately-Operated Network

In this model, the city would invest in a dark fiber network spanning the community, making an investment in equipment and operations more attractive to a private partner.

Benefits include:

- The creation of a competitive market for ISPs with low entry costs, resulting in lower retail prices and better quality of service.
- Private entities with relevant staffing and infrastructure would assume responsibility for the complexities of network operations, billing, and customer service.

The primary drawbacks are those related to financing physical deployment of fiber, as discussed in the previous section.

9.2.1. Case Study: UTOPIA Fiber

UTOPIA is a consortium of 16 Utah municipalities formed to build out a fiber network.[26] These cities are prohibited by state law from offering retail service; instead, they build out dark fiber and lease it to private ISPs. UTOPIA has suffered recurrent financial problems resulting primarily from failure to hit uptake targets.

9.3. Public-Private Partnership

In a Public-Private Partnership (PPP) model, the city pays a portion of the cost of physical plant deployment and/or of operating and service costs, resulting in reduced CapEx financing and OpEx outlays, but still retains some measure of influence over access and traffic management policies implemented by tenant ISPs. At its most basic level, PPP involves public and private entities sharing costs and risks. The actual exchange could, however, involve a wide variety of commitments, including private access to and use of city-owned assets such as conduit, buildings, poles, and other components necessary to build out a fiber network.

[26] https://en.wikipedia.org/wiki/Utah_Telecommunication_Open_Infrastructure_Agency

Benefits include those of privately-owned and -operated networks, plus the ability to set contractual conditions for access to city-owned assets not otherwise regulated by state or federal law, such as for purposes of mandating net neutrality, restricting surveillance, providing universal access, or setting reasonable subscriber rates.

As with a municipally-owned network, one major drawback is the assumption of some financial risk by the city of inadequate cost recovery (e.g., through low uptake rates). This would pose challenges similar to those of a city-owned network in building political support for approval of such a project.

9.4. Privately-Owned Network with Conditions Set by Municipality

In this model, the city is responsible neither for deployment nor operation of a fiber buildout; instead, it uses permitting leverage, access to easements and rights-of-way, and administrative support to ease a private entity's deployment while maintaining contractual assurances of important outcomes. Such terms could include mandating net neutrality, requiring city-wide deployment and universal access, and ensuring shared access to the resulting infrastructure by ISPs in a competitive market.

Benefits include those from public-private partnerships, plus:

- Little to no financial risk on the part of the city, as the cost of deployment is fully borne by private entities.
- If competitive access is made a condition of permitting installation, multiple ISPs leveraging this infrastructure would form a competitive marketplace, reducing prices and increasing quality of service.
- Non-discriminatory access to dark fiber could be attractive to legacy cable providers, reducing redundant infrastructure and associated costs.

Drawbacks include:

- Uncertainty related to the immaturity of this business model, especially with respect to receivership and its impact on contractual obligations.
- Private venture funding will come with consideration for investors, such as a temporary monopoly for an anchor residential ISP, which would likely result in higher prices until that limited monopoly period expires.
- The city may need to provide evidence and/or assurances that the community is committed to and interested in an alternative broadband solution, mitigating concerns about take rate.

9.4.1. Case Study: Netly

Netly is planning to build out a privately-owned network with the purpose of creating a competitive ISP market with the fiber buildout being a natural monopoly:

> Netly, LLC proposes to provide high speed fiber to commercial and governmental entities on an “open access” basis. Access will be granted to multiple service providers so they can provide wholesale services to their subscribers in the local access network, without the need for each service provider to install their own fiber access network to the premises.[27]

Netly’s financial model is to provide monopoly residential access for a small number of years to an anchor tenant ISP in exchange for funding the buildout. Once this period ends, other ISPs will be able to lease lines from Netly at the same rate.

Owing to the potential long-term benefits of a high-quality physical asset with contractually-guaranteed RAND access following the anchor tenant period, as well as to the low cost to municipalities, Netly was able to obtain an expedited review process and a detariffed status for buildouts from the state of California, reducing delays and costs associated with regulation and permitting.[28]

[27] http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M221/K847/221847071.docx
[28] http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M221/K847/221847071.docx

10. Policy Options

There are a number of policy options that the City of Somerville could explore to preserve and expand affordable and accessible internet service. These options are outlined below, with pros and cons. They include issuing a statement in support of net neutrality, leveraging purchasing policies, writing local ordinances, working collaboratively with other local governments, and advocating at the state level.

We specifically recommend the following, which are discussed in further detail in the section below:

- Mayor Curtatone **issue a statement of values**, describing what Somerville wishes to support in terms of net neutrality.
- **Appoint a point-person to be in charge of policies/communication** for regional and municipal collaborations around net neutrality and access to the internet.
- **Take steps to create a Digital Equity Fund,** similar to the City of Boston's, to be operated in partnership with local nonprofit organizations.
- **Explore writing a preferred purchase policy** that describes preferential treatment on city projects for networks that exhibit the characteristics and values described by the statement of values. This is a ranking mechanism, not a requirement.
- **Ensure that all existing conduit are correctly mapped and tracked as assets**. Ensure these assets are available to city planners.
- **Research and implement a dig once policy**. This may range from future-forward looking efforts (build a city-owned conduit incrementally whenever a road is opened for maintenance) to ensuring that all interested parties are notified when there is road work being done so that they may install conduit without having to open the road again.
- **Look to collaborate on regional or municipal efforts** to increase internet access in Massachusetts, and ensure the internet is "net neutral." In particular, we suggest joining Next Century Cities.
- **Advocate for pro-net-neutrality legislation** in the Massachusetts Legislature, such as bill S2610**.**

10.1. Statement of Values & Staffing

We strongly encourage Mayor Curtatone to issue a statement supporting the values and policy objectives of internet net neutrality and a belief that residents of Somerville should have equitable access to affordable internet. We suggest this could be part of an existing Somerville initiative, such as Somervision 2040, and could bring in other local leaders, like the City Council. The goal would be to highlight our leadership and community support for internet access and for net neutrality, and to pave the way for future policy actions.

We also strongly recommend that the City appoint a point-person for internet access and net neutrality to drive future municipal and regional policy efforts forward, and lead communication. This could be delegated to an existing role, such as the CIO, with appropriate staff support; or could be a new hire.

10.2. Negotiating with Service Providers

If Somerville were to pursue an approach that includes being an owner of fiber and/or providing assistance to ISPs other companies laying fiber, the City may be able to negotiate conditions that support net neutrality and expand internet access.

Some of the suggestions below are audacious and ambitious, while others are more narrowly focused. The City would need to determine how much leverage it has to set conditions.

The following are suggestions of conditions Somerville could set to support net neutrality:

- The City requires all ISPs with presence in the Somerville Internet Exchange (IXP, a data center where all fiber drops will be terminated and which is connected to multiple transit providers) for purposes of lighting fiber to have open peering policies with others also in the exchange.
- The City asks for space such that there are:
    - Long term-tenants (ISP equipment as well as edge compute/cache devices) with five-year contracts. All ISPs must accept (or are strongly encouraged to accept) connectivity with edge compute and/or cache devices.
    - Short term tenants with one-year contracts, intended to assist new entrants into existing markets and promote early-stage technology development.
- The City can act as its own ISP to host the edge compute/caching equipment, address users, and have an open peering policy. It can possibly compete with other ISPs in the space, though this may generate litigation from incumbents.

The following suggestions are to improve customer experience/access:

- The City can require ISPs with presence in the IXP to have clear pricing and data and speed information.
- The City can require that ISPs charge prices within some range, or suggest a maximum cost for some level of service. This would take into account what we believe is the capital and upkeep cost of the dark fiber buildout.
- The City can require that an ISP must serve any user that requests access for an advertised plan.

The following suggestions are to promote universal access:

- Netly-style deployments must reach the entire city.
- Anchor tenant must provide service to any entity requesting it, at least for the duration of the monopoly on residential service.

Additional service considerations:

- It is important for the anchor tenant for a Netly-style approach to provide a competitive set of features (internet + TV + phone) to maximize the take rate among those who have not cut the cord and gone internet-only.

10.3. Purchasing Policies: Net Neutrality

We explored the possibility of local procurement policies that encourage net neutrality, and think it's a very interesting and appealing option, as purchasing policies are one of the City's major levers. **However, because of legal uncertainty due to current court cases around the country, for now, we recommend that the City continues to research and explore this option, and monitor relevant court cases.**

Under a purchasing policy, the City would commit to only purchase internet services that honor net neutrality: no blocking, throttling, or paid prioritization of internet traffic. This would be a partial solution to encourage network neutrality locally. The goal would be to use the City's purchasing leverage, with the hope that ISPs would then adjust their practices within the entire City of Somerville.

Numerous states have introduced bills to add their own state-level net neutrality protections. Governors in at least six states, including New York and Montana, have signed executive orders using a procurement policy approach to preserve net neutrality.[29] Governor Cuomo issued an order for New York, "not to enter into any contracts for internet service unless the ISPs agree to adhere to net neutrality principles" and Governor Bullock issued an order for Montana, "to incorporate into the state procurement process for internet, data, and telecommunications services (collectively, 'telecommunications services') criteria requiring that successful recipients of state contracts adhere to internet neutrality principles".[30] At least three states - Oregon, Vermont, and Washington - have passed legislation with similar intent.[31]

However, when the FCC rolled back net neutrality provisions, the Commission added a provision that prohibited states from creating their own regulations. While states have authority over telecommunications within their borders, the federal government argues that the internet's global nature makes it difficult to regulate at the state level, and therefore should be left to the federal government. So, state laws and regulations are being challenged by DOJ and USTelecom, an industry group.[32] For now, because the purchasing policy approach is based on government agencies exercising their rights as consumers, it seems the executive orders could stand. However, we won't know the outcome until the court cases conclude.

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[29] http://www.ncsl.org/research/telecommunications-and-information-technology/net-neutrality-legislation-in-states.aspx

[30] https://www.governor.ny.gov/news/governor-cuomo-signs-executive-order-protect-and-strengthen-net-neutrality-new-york and https://governor.mt.gov/Portals/16/docs/2018EOs/EO-03-2018_Net%20Freedom.pdf?ver=2018-01-22-122048-023

[31] http://www.ncsl.org/research/telecommunications-and-information-technology/net-neutrality-legislation-in-states.aspx

[32] Cecilia Kang, "Net Neutrality Repeal at Stake as Key Court Case Starts", New York Times, February 1, 2019, https://www.nytimes.com/2019/02/01/technology/net-neutrality-repeal-case.html

10.4. Local Ordinances

10.4.1. Net Neutrality

The task force looked into the option of a local ordinance to require net neutrality for Somerville residents. However, this option is legally uncertain, for the same reasons as described above about purchasing policies, so we do not recommend it. An ordinance would require ISPs to ensure net neutrality (no blocking, throttling, or paid prioritization of internet traffic) locally. If this passed and was upheld in court, it could be a solution to ensure net neutrality locally. But, it would likely lead to legal disputes, and so is not the recommended course of action.

10.4.2. Access to Affordable Internet

We recommend the City take steps to create a Digital Equity Fund, similar to the City of Boston's, to be operated in partnership with local nonprofit organizations.[33]

The City of Boston is offering $100,000 in grants to local programs that aim to increase digital resources available to Boston residents. We suggest that the City explore the level and types of needs related to internet access, and then structure funding or other resources to provide assistance to low-income residents.

For example, some ISPs give the option of leasing hardware (modem and router), which adds an additional charge onto each month's bill. But, in some of the above low-cost plan options, residents would be required to buy hardware upfront, which could be prohibitively expensive. The City could partner with a non-profit group to offer residents hardware at a discount or for free. There likely are other steps the City, in partnership with a nonprofit, could take to internet service more accessible.

10.4.3. Dig Once Policy

In addition, we strongly recommend that the City of Somerville adopt a "Dig Once" policy. We provide some initial suggestions below; developing the policy will require more research and analysis.

A "Dig Once" policy encourages the placement of fiber or conduit in the ground any time the road is dug up for a public works project. These policies have two goals: first, when the street is dug up for any reason, fiber should be laid and any possible utilities work should be done; and second, utilities help with the cost of conduit installation. Dig Once policies can be helpful tools

[33] https://www.boston.gov/departments/innovation-and-technology/digital-equity-fund

in facilitating more internet service competition, and are recommended by experts, such as at Next Century Cities and the Federal Highway Administration.[34]

As part of the current Somerville Avenue Utility and Streetscape Improvements Project, a space is being included for the installation of fiber optic cable, but Somerville does not have a citywide Dig Once policy.

The cost of installing fiber optic cable can range from a few thousand dollars for well over $200,000 per mile[35], and according to the Federal Highway Administration a large cost driver is the need for significant roadway excavation.[36] For small companies, the cost of excavation may be cost prohibitive. Establishing a Dig Once policy would help reduce installation costs, allowing smaller companies to enter the market, and could have the added benefit of encouraging larger companies to make upgrades.

There are a variety of potential approaches to Dig Once policies that the City should consider when developing its own policy[37]:

- **Joint trench agreements/joint use** would require all installation to happen when the street is being opened up and all in the same trench. The policy could require all companies to coordinate, or all utilities, or just require internet service providers. Boston's Dig Once policy, which was initiated in 1994, establishes a lead company (the company that first approaches the City) to be in charge of coordinating construction.[38]
- **Street excavation moratoriums** can be used to encourage companies to be involved in any coordinated efforts.
- **Installing empty conduit** when the road is already opened up puts the infrastructure in, even if there isn't a company ready to install at the time. If or when the City does this, it may want to establish policies about how the conduit can be used in the future.

The City should also consider whether it would establish requirements for companies to use existing empty conduit, or requirements for companies installing new conduit or fiber under a Dig Once policy. For example, the state of Arizona has minimum speed requirements.[39]

More technical policy suggestions are discussed in Next Century Cities' "Becoming Broadband Ready" toolkit[40] and in the consulting firm CTC Technology and Energy's "Gigabit Communities" report.[41]

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[34] https://nextcenturycities.org/becoming-broadband-ready/
[35] https://www.csg.org/pubs/capitolideas/enews/cs41_1.aspx
[36] https://www.fhwa.dot.gov/policy/otps/policy_brief_dig_once.pdf
[37] https://www.fhwa.dot.gov/policy/otps/policy_brief_dig_once.pdf
[38] https://www.csg.org/pubs/capitolideas/enews/cs41_1.aspx
[39] https://www.azleg.gov/legtext/50leg/2r/bills/sb1402s.htm
[40] https://nextcenturycities.org/becoming-broadband-ready/
[41] http://www.ctcnet.us/wp-content/uploads/2014/01/GigabitCommunities.pdf

10.5. Regional or Municipal Collaborative

We suggest that the City actively look to collaborate on regional or municipal efforts to increase internet access in Massachusetts, and ensure the internet is "net neutral".

In particular, we suggest that the City join Next Century Cities, which "supports mayors and community leaders across the country as they seek to ensure that everyone has fast, affordable and reliable internet access."[42] They have resources, such as a guide for hiring a city point person to manage broadband and learning sessions with other cities. This group was recommended by local leaders in Cambridge, as well as by Harvard Law Professor Susan Crawford, who is an expert on city-level internet access.

10.6. MA Advocacy for Legislation

Finally, at the state level, the Mayor could support proposed bill S2610 "An Act promoting net neutrality and consumer protection". The bill aims to use state procurement policy to ensure net neutrality, similarly to the legislation in Vermont, Oregon, and Washington.

It was introduced in July 2018 and recommended by the Senate Ways and Means Committee. However, after being read in the house and referred to House Ways and Means, no further action has been taken.[43]

[42] https://nextcenturycities.org/
[43] https://malegislature.gov/Bills/190/S2610

10.7. Complementary Approaches to Expanding Internet Access

On their own these approaches would not dramatically expand access to quality internet service, but the Task Force feels they are worth considering as complementary measures that could be enacted on a shorter timeframe and may help fill gaps left by larger scale solutions. As with all of the Task Force's recommendations, each of the below recommendations has a variety of factors to consider before implementation and some may ultimately not be feasible.

10.7.1. Public WiFi

Public WiFi could be used to provide a minimal level of free access to all residents of Somerville. Routers or WiFi hotspots could be installed in City-owned property, such as government offices, schools, and public parks. This approach piggybacks on the City's existing service, so any costs would primarily come from purchasing, installing, and maintaining additional hardware. Somerville would need to review its agreements with its ISP to ensure that such access is allowed. It would also need to separate the City work network from the public network in order to maintain the security of the City network.

In a variation on the public WiFi model, City-owned property could be used connect with mesh networking access points that fan out to cover the rest of the city. Mesh access points would be setup to automatically communicate with other mesh access points providing network redundancy and ubiquitous access throughout the city. An advantage of this system is that the network could be built incrementally, focusing on those areas of Somerville that are poorly serviced by commercial ISPs.

With any solution that uses Somerville infrastructure, there would be potential liabilities due to people violating copyright laws, criminal activity, or private ISPs claiming unfair competition. Possible solutions include requiring logins to access the network that include a user agreement stating they would not engage in illegal activity on the network, limited duration escrowed traffic logs that could only be accessed with a valid warrant, or paying a yearly copyright fee to cover all potential copyright infringement.

10.7.2. Community WiFi

Somerville could also take a more decentralized approach by providing a standardized mesh access point that residents could use to replace the WiFi access point they purchased themselves or which was provided by their ISP. Mesh access points would be purchased in bulk and provided at cost just as the City does with rain barrels. The access points would come pre-installed with software designed to provide free WiFi access and to connect to one another. Additionally, they would be designed to protect users' privacy and to gather only the data they need to maintain proper functioning of the network. Any updates to the mesh access point software would be open to all and its contents transparent so everyone could review it.

10.7.3 Building Hosted Services

Publicly owned residential buildings should be served by multiple ISPs, when possible. Somerville can encourage competition by providing information to residents about low-cost internet offerings and working with companies that may be interested in providing internet access at the building(s), such as Starry[44]. Developers of large residential buildings could also be encouraged to look into building hosted options.

10.7.4. Support for Low-Income and Low-Access Residents

Availability and affordability are key to equity and fostering digital inclusion. Although the City can't offer direct financial support to residents for internet service, there are ways it can support existing programs that help residents who are under-connected to the internet or are burdened by the costs of internet services.

The Somerville Public Library[45] currently has a small number of WiFi hotspots it loans out to patrons, as well as some iPads. Based on usage numbers, the City could fund additional hotspots, tablets, and laptops. If circulation is low, the City can also help advertise these resources and make sure staff working with low-income residents are aware of them. The Boston Public Library has a similar program and anyone who lives, works, is a student, or owns property in Massachusetts is eligible to sign up for a Boston Public Library card[46].

Along with the technology that can be checked out of the library, the Somerville Public Libraries offer one-on-one technology lessons[47]. Again, based on usage, the City could look into providing more resources or otherwise boosting the technology instruction program. For residents who have little to no experience going online, this could be a big step in helping to bridge the digital divide.

Several companies offer low-cost plans for broadband, mobile internet, and/or hotspots to income-eligible customers. In addition, some companies offer low-cost computers and laptops and digital literacy trainings. Although some programs are open to all consumers, others have specific eligibility requirements that can present significant barriers to entry. Along with income or federal benefits eligibility requirements, low-cost plans may have other restrictions (ex. you have to be a new customer) or a prohibitive upfront cost for hardware.

Existing low-cost programs include:

- Internet Essentials[48]

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[44] https://starry.com/
[45] https://www.somervillepubliclibrary.org/books-movies-music-etc/more
[46] https://www.bpl.org/hotspot/
[47] https://www.somervillepubliclibrary.org/services/technology-instruction
[48] Offered by Comcast https://internetessentials.com/

- Assurance Mobile[49]
- FreedomPop[50]
- Ting[51]
- PCs for People[52]

While these plans won't be the solution for all needs, they are resources available to the community. Finding information on some of these plans was difficult even for tech savvy Task Force members and the signup process and what services are available change over time, so City staff who work with populations that could benefit from these programs should be aware they exist, but make referrals to programs working on the digital divide like Tech Goes Home[53].

There is also the possibility of collaboration between the City and non-profit organizations to provide assistance to residents beyond the existing digital literacy educational programming and income-based internet services to make internet service and technology more accessible. For example, residents need a modem and router (if they want wireless internet) for internet service. Some ISPs give the option of leasing hardware, which adds an additional charge onto each month's bill. In some of the above low-cost plan options, residents would be required to buy hardware upfront, which could be prohibitively expensive. If a non-profit group was willing to accept donated hardware and/or purchase hardware and offer residents an affordable payment plan, that could make internet service more accessible.

10.7.5. 5G/Small Cell Networks

5G is the next generation of wireless technology being announced by all the major wireless carriers. The promise of 5G includes significantly lower latency, higher bandwidth, and the ability to connect more devices[54]. In order to support higher bandwidth and because of the limited distances of 5G millimeter frequencies, most carriers are using small cells, with smaller base stations, for the 5G roll out. The FCC has been using their regulatory authority to promote small cells, enabling 5G technology.[55] Somerville has already experienced the effect of the FCC imposed shot clocks of 60 days for collocation applications and 90 days for new installations. The City signed agreements with Mobilitie and ExteNe in 2018t. The agreements are modeled on agreements used in Boston and Brookline.

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[49] Offered by Virgin Mobile through the FCC Lifeline program. Lifeline discounts are limited to one per household and can be used either for telephone or internet service https://www.assurancewireless.com/lifeline-services/states/massachusetts-lifeline-free-government-phone-service

[50] http://www.freedompop.com/wireless-internet

[51] https://ting.com/rates

[52] https://www.pcsforpeople.org/low-cost-internet/

[53] https://www.techgoeshome.org/

[54] https://www.pcmag.com/article/345387/what-is-5g January 28, 2019 article in PCmag by Sascha Segan

[55] https://www.fcc.gov/5G The FCC's 5G FAST Plan February 26, 2019

5G could increase broadband availability in Somerville. Verizon has already launched “home 5G,” although not in Somerville, offering over 300Mbps using a 5G modem. Possible 5G applications include self driving cars, virtual reality, telemedicine, and internet of things.

5G and small cells are technologies that Somerville should watch as they develop further so the City can be ready for new mobile applications that can take advantage of 5G[56]. At the time of writing these recommendations, the City was drafting an ordinance related to small cells.The City should look at best practices from other communities to develop agreements that are beneficial to Somerville. Improving Somerville's fiber backbone can be part of that promotion as providing for backhaul of 5G bandwidth is one of the biggest challenges.

[56] ‘Small Cells in Boston Department of Innovation and Technology’ October 2017 https://www.nlc.org/sites/default/files/users/user167/Small-Cells-in-Boston-Mike-Lynch-.pdf