

MIDDLE MILE BROADBAND NETWORKS PUBLIC PRIVATE PARTNERSHIPS

Author:

Michael Kleeman
Senior fellow - University of California San Diego
+1 415 902 7300
mkleeman@ucsd.edu

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Executive Summary

Synopsis: *To address the digital divide, billions of federal and state dollars are being directed to broadband infrastructure. California broadband legislation signed in July 2021 includes significant investment in a proposed State-deployed “middle mile” network, which is the broadband network connection between the “core” Internet and the “last mile” networks that connect the home or business. Yet it is likely that building a new statewide middle mile network would take 5 or more years to complete and risks missing funding deadlines under the American Rescue Plan. Using a Public Private Partnership model that leverages and extends existing networks, instead of an entirely new build, will allow for more rapid connections to the last mile networks needed to connect rural areas and allow for competitive access in all areas.*

Existing networks can be leveraged to address over 60% of the middle mile coverage gaps, shortening the timeframe to complete middle mile coverage by two or more years and saving billions in CAPEX costs and tens of millions in operating costs, which can be invested in statewide affordability programs and last mile connections to California’s 463,000 unserved households. A successful partnership could focus investment and deliver high quality wholesale Internet services, which could virtually eliminate the technical and financial challenges faced by rural last-mile providers that today exacerbate the digital divide in California.

Middle mile infrastructure is an essential element in providing Internet access, and where it does not exist you cannot have effective economic and scalable broadband networks. And where it does exist the economics of the middle mile need to be workable for last mile providers. Today middle mile expenditures can represent a significant portion of the monthly operating costs of providing connectivity for more rural, smaller networks. An effective strategy for addressing middle mile deployment is critical to closing the digital divide. There are two primary ways of addressing the middle mile issue. Building entirely new, open access middle mile networks which connect to unserved areas or developing a Public Private Partnership model with existing providers to extend their networks and create products and pricing that meet the needs and requirements of the State. Looking at the options from a network deployment and financial perspective, the latter solution, working with existing providers, has the potential to provide several near-term and long-term advantages.

Existing networks can be leveraged to address over 60% of the middle mile coverage gaps... shortening the timeframe to complete middle mile coverage by two or more years.

- **Speed of deployment to meet federal funding timeframes.** Existing networks (including buildings with points of interconnection) can be leveraged to allow very rapid connections to many of the last mile networks needed to address the digital divide in rural areas, as well as allow competitive access in all areas. Extending the networks takes less time, and money, than building entirely new ones. Existing networks can be leveraged to address over 60% of the middle mile coverage needs. This approach would shorten the timeframe to complete middle mile coverage by two or more years. This is important because federal funding issued under the American Rescue Plan must be spent by December 2026.
- **Invested CAPEX savings to close digital divide.** Leveraging existing network assets avoids the costs of building new ones. Leveraging existing networks will save billions of dollars in capital investments and free up funds to address other broadband connectivity and affordability needs, including the critical need to ensure connectivity for California’s 463,000 unserved or underserved households.
- **Operations and maintenance savings.** New middle mile networks will have to be built, operated, and maintained. The costs of these activities are largely driven by the length and topology of the network, and only a small portion of the costs are driven by the capacity of the network or the number of last mile providers served. Existing networks can be leveraged to reduce all of these costs by spreading them over the largest possible customer base.

Introduction – The Digital Divide

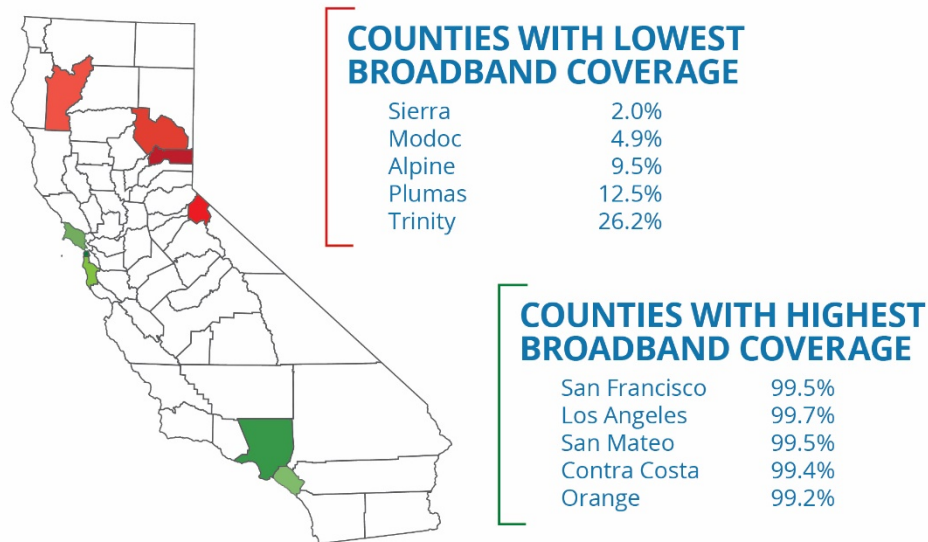
In California, a digital divide exists between citizens who can affordably access broadband Internet service of sufficient quality to support their work and education, and those who cannot. The implications of this divide on social and economic equality are significant and pervasive because there is no question that quality high speed Internet service is a critical resource and has become essential during the pandemic and will continue to be afterwards.

In most areas of the state the digital divide is largely an economic one driven by a lack of financial means or technology skills to access the Internet. In other areas, the persistence of the digital divide, particularly for unserved households, is due to the economics of network deployment which worsen when deployments occur further away from high density areas close to core Internet connections. Public sector support is needed to connect remote and hard-to-reach communities with low population densities. Connectivity costs for such remote areas can reach, on the higher end, approximately \$16,000 per household compared to an average cost of \$2,989 per household.¹

¹ “2020 Annual Report California Advanced Services Fund.” California Public Utilities Commission, Apr. 2021
<https://www.cpuc.ca.gov/industries-and-topics/internet-and-phone/california-advanced-services-fund/casf-performance-and-financial-audit-reports>

This divide is extreme in California. While 96.5% of the population has access to terrestrial (as opposed to satellite) broadband service, this leaves roughly 463,000 California households lacking high-speed Internet service, and most of them in rural areas.² The county level data are illuminating — 99.8% of San Francisco residents have access to broadband³, but less than 10% of residents of Alpine, Modoc or Sierra counties have such access.⁴

Figure 1.



The Middle Mile

Developing an effective strategy for the deployment of middle mile networks is critical to closing the digital divide. “Middle mile” refers to the network connection between the “last mile” services that connect the home or business and the “core” Internet. Last mile networks utilize the middle mile to connect their serving office, with central equipment such as a router and other technology, to the core Internet backbone, which is usually accessed at colocation centers or “carrier hotels” in major metropolitan areas and served by numerous major wholesale Internet providers. This

² “2020 Annual Report California Advanced Services Fund.” California Public Utilities Commission, Apr. 2021. 25/3 Mbps (wireline and fixed wireless) <https://www.cpuc.ca.gov/industries-and-topics/internet-and-phone/california-advanced-services-fund/casf-performance-and-financial-audit-reports>

³ “2020 Annual Report California Advanced Services Fund.” California Public Utilities Commission, Apr. 2021 <https://www.cpuc.ca.gov/industries-and-topics/internet-and-phone/california-advanced-services-fund/casf-performance-and-financial-audit-reports>

⁴ “Internet Access in California.” BroadbandNow, June 2021. <https://broadbandnow.com/California>

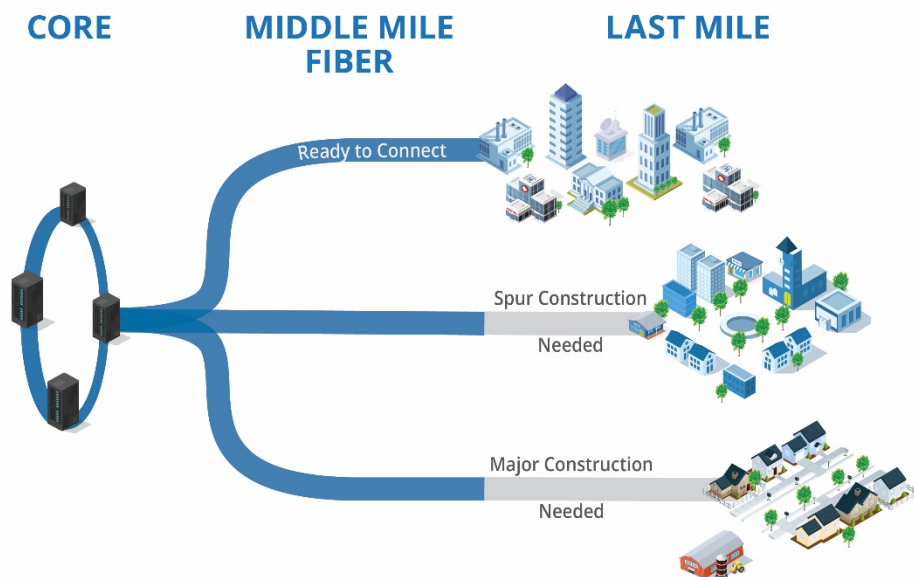
middle mile can be hundreds of miles long in some cases and is an essential element in providing Internet service.

Middle mile costs can be significant, especially for smaller communities, in many cases representing a significant portion of the monthly operating costs. Where middle mile networks do not exist or require major new construction to reach the last mile serving office, there is a physical barrier to service, which requires significant investment.

A functioning middle mile network includes several elements:

- **Fiber optic transmission system(s).** These are required to provide high capacity from the Internet core to the last mile serving network. Only fiber optic systems can support the multi-gigabit speeds needed to serve the needs of anything but the smallest communities. The marginal cost of increasing the capacity in an existing fiber network is very low, so adding capacity to an existing fiber network is relatively inexpensive.
- **Real estate and power.** The network needs access to buildings with power (including backup generators), heating, ventilation, and air conditioning (HVAC), and space for equipment for interconnection with the last mile providers. If the middle mile connection is more than 100 kilometers long, buildings and power are also needed for electronics along the route.
- **Path diversity.** Ideally the network will have more than one route between points of interconnection and the core Internet. Such path diversity is the standard in telecommunications network design.
- **Connections.** Extensions or spur connections from the interconnection point to the last mile serving office.
- **Skilled personnel.** Operations and maintenance personnel who are close enough to respond quickly to an equipment failure.

Figure 2.



For last mile providers, adding to the complexity of availability and cost of the middle mile is the contractual and technical complexity of interconnection at the carrier hotel, which can require at least two and sometimes three additional service agreements with the operators of that facility as well as Internet backbone providers. Additionally, the quality of the service provided by operators can vary widely in reliability, cost, and service quality/access to important network services such as content delivery networks like Akamai, Google and Amazon Web Services, which host the streaming and conferencing services driving most Internet use.

The right middle mile infrastructure is an essential element in providing Internet access, and an effective strategy for addressing middle mile issues is critical to closing the digital divide. It is important to have the right kind of middle mile for three important and related reasons:

1. The right middle mile is needed to provide **connectivity**, without it even the best wireless or fiber optic last mile network cannot provide good broadband service.
2. The right middle mile **service costs** for the last mile provider needs to be reasonable and scalable so that smaller and more distant last mile networks do not face a price penalty.
3. The right middle mile service includes highest **quality of service** from end to end, allowing last mile providers access to high quality core Internet transport and related services, making it easy for last mile providers, especially providers serving smaller populations, to obtain Internet services and take advantage of improved core services when available.

How Do We Get the Right Middle Mile?

There are two primary ways of realizing the middle mile described above. The first, is to build a new one which connects to all unserved areas and provides the services and economics described above. The other is to partner with incumbents, which already have broad coverage (including supporting personnel), to extend their networks and create products and pricing that will allow for access to the right middle mile.

In California, and elsewhere, there are calls to deploy an entirely new open access middle mile network rather than extend existing networks. The hope is that such a network would allow all providers (and other permitted customers) to connect with quality from their service location to the core Internet. Providers could obtain their own fiber or part of the fiber capacity and take advantage of the underlying economics of fiber to add capacity at low cost. This approach has some potential challenges:

- **Time constraints and access to materials and personnel.** New federal funding will make materials and personnel scarce for years, and a new network would require thousands of route miles. It is likely that a new network would take 5 or more years to complete at a minimum.
- **Pricing challenges.** There are many different business models and open access does not mean free. Cost allocation and pricing needs to avoid worsening the digital divide. In a typical open access fiber network the last mile provider would be required to “light” the fiber, requiring equipment at both ends, and in longer circuits, along the route. This adds cost and complexity and may limit the options of locations for core interconnection. Those most in need today would be at the ends of these networks on small usage (or thin) routes with higher unit costs. Fiber optic networks have high first and low marginal costs. Avoiding penalizing them would mean subsidizing their service.
- **Field and maintenance personnel.** The initial deployment and operations/maintenance of a new network would require a highly distributed group of field personnel and maintenance services. Given that this new network would serve a relatively small number of customers this operating cost could be high on a unit basis.
- **Thousands of facilities.** Networks require thousands of facilities for connection which need power, HVAC and space and any fiber route longer than 60 miles would require similar space for amplifiers.
- **Reaching scale.** There are real scale advantages in operating and maintaining a network. The same people can maintain 10 networks operating on the same fiber for close to the cost of one network if there are not a lot of rearrangements of physical facilities. However, if a new network is built it will have to carry the whole cost unless ways are found to cost share.

The second alternative is to develop a Public Private Partnership model, working with the incumbent carriers. The benefits of this model include:

- **Leveraging existing networks.** Existing networks can be leveraged to address more than 60% of the middle mile coverage gaps. This would allow very rapid connections to many of the last mile networks needed to address the digital divide in rural areas, as well as allow competitive access in all areas. Extending the networks takes less time, and money, than building entirely new ones. Given the relatively small populations needing to be served, the existing fiber optic systems should, in most cases, have sufficient capacity or could be upgraded inexpensively to serve the additional customers.
- **Cost savings, both initial and long-run.** Leveraging existing network assets avoids the costs of building new ones and leveraging existing operations and maintenance personnel avoids the costs of hiring or contracting for new statewide staff. This capital savings would be in the billions of dollars and the operations savings would be in the tens of millions.
- **Back-up power and real estate.** The incumbent operating offices typically have back-up power and sufficient space to support interconnection and these can be used further saving costs and construction time. There may be security upgrades needed to allow last mile providers access to these centers, but this is much less than securing new suitable real estate on a statewide basis.
- **Speed of deployment.** This may be the biggest benefit of a partnership. Since a partnership would immediately bring facilities closer to the unserved communities it would speed the deployment of service. At the least it significantly reduces the risk of the middle mile being the network element that delays service to unserved communities. It can also increase deployment if a partnership delivers more economically-priced service to customers allowing more capital for high quality last mile builds. It would probably shorten the time to complete middle mile coverage by two or more years, especially in the next few years when network construction elements will be in high demand and relieve a bit of the supply pressure we expect for fiber and related network elements. This is important because federal funding issued under the American Rescue Plan must be spent by December 2026.
- **CAPEX savings could be invested in digital divide programs.** Billions of federal and state dollars are being directed to broadband and closing the digital divide. This includes significant middle mile investments. There is a real threat of overbuild. Leveraging existing networks will help maximize the reach of public sector investments, which is necessary because of the high cost of reaching California's remaining unserved households.
- **Strengthening existing networks.** Some of those funds could be used to extend and improve the incumbent's network (under the right terms and conditions). Extending and improving the reliability of the middle mile networks would help support incumbent mobile network expansion which could add to their customer base. Also a rapidly deployed, low cost, ubiquitous middle mile network would provide a platform for expanded emergency services, earthquake early warning and fire warning and monitoring systems.

What Would the Ideal Public Private Partnership Accomplish?

All last mile providers want high quality, reliable and economic core Internet connections, including a middle mile that supports these connections. If you are a service provider in a major metropolitan area you can get an inexpensive fiber connection to a carrier hotel and then secure core Internet resources priced on the basis of dollars per megabit per month. The products come both in fixed quantities (100 megabit, 1 gigabit, 2, 5, 10, etc.) and also fixed with a burst capability to allow the use of more bandwidth intermittently when demand peaks (for example, the payment of a base amount and then the right to use more capacity on an intermittent basis for an added fee).

In order to close the digital divide, the ideal middle mile partnership and prioritization of funding would reduce the cost penalty paid by last mile providers in more distant or rural areas, particularly unserved areas. A middle mile partnership, should as much as possible, enable rural last-mile providers the same capabilities and services that urban providers receive. And there should be no cost penalty if the service provider is 100 miles further away, required new construction, or is the only customer on a 50-mile connection.

To help close the digital divide, where middle mile is a critical element, what is needed are the following:

- **Lower operating costs for rural last-mile providers.** Focus investments and enable products and services for rural providers that are comparable to those available to urban providers. This means more comparable pricing and access to products that are more scalable, especially at lower wholesale speeds, and allow for unexpected customer peak service demands to be easily and economically met. This would allow middle mile and last mile providers who are serving rural communities to have access to lower pricing, which would stimulate rural network deployment.
- **Enable quality of service for last-mile providers.** Ideally, investment and products would allow smaller last-mile providers to offer greater quality of service. Larger networks operators can afford to oversize their core Internet service access because there is a very small marginal cost to do so, but smaller operators have fewer customers to spread the costs across. This can be accomplished by products that allow smaller providers to provide “bursting” or expanded bandwidth above a base level capacity during these peak periods (this implies a pricing flexibility). This would allow reliability and the ability to have the same network performance, measured from customer to content or customer to customer.

Conclusion

The current influx of federal and state dollars for broadband infrastructure signals the best opportunity to close the digital divide in California. However, risks remain, including federal funding deadlines and complexity around building an entirely new statewide middle mile network. With these inherent risks, we should consider a framework that utilizes existing broadband networks. A thoughtful Public Private Partnership structure will cut down project timeframes and realize significant savings for the State. A successful partnership could focus investment and deliver high quality wholesale Internet services, which could address the technical and financial challenges faced by rural last mile providers, that today exacerbate the digital divide in California.