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CHA Housing Broadband Pilot Engineering Report

Prepared for the City of Cambridge and the Cambridge Housing Authority

June 2021

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1 Introduction and Background

The Cambridge Housing Authority (CHA) and the City of Cambridge (the "City") are exploring ways to increase the affordability and quality of broadband access in part by facilitating competitive wired broadband service options to low-income residents of the City. The CHA manages more than 50 housing developments containing approximately 3,000 housing units and administers more than 4,500 Housing Choice vouchers.

Information about gaps in broadband access, affordability, devices, and skills in Cambridge generally and CHA housing specifically is provided in the main body of the digital equity study performed for the City of Cambridge by CTC Technology & Energy (CTC). This report represents an added task in that effort. The goal of this task was to provide preliminary high-level capital and operating cost estimates for providing the necessary infrastructure to support a competing option for high-speed wired broadband service at three CHA sites: the Frank J. Manning elderly housing high-rise in Central Square and the Washington Elms and Newtowne Court apartment complexes just north of Kendall Square. It is important to note that this report does not describe a business model for service provision, but rather the capital and operating costs (which in this context is limited to the maintenance costs) for providing the necessary infrastructure to all units in these three sites as a foundation for such service.

Comcast cable is present throughout CHA developments—including these three—with the same service options available elsewhere in the City. (This includes Comcast Internet Essentials, which costs $9.95 per month for 50Mbps service and is available to eligible low-income residents who are able to navigate an application process. Further information about this program and barriers to its usage are provided in the main body of the digital equity report.) Additionally, the CHA has facilitated the entry of a broadband competitor at some of its sites from a fixed wireless provider, NetBlazr. The CHA also recently issued a request for proposals (RFP) for fixed wireless providers to serve all CHA-owned units. At the time this report was submitted, in late June of 2021, the outcome of that process was not yet known.

Washington Elms and Newtowne Court—low-rise complexes which adjoin each other—are also served by free outdoor Wi-Fi over fiber provided by the Massachusetts Institute of Technology (MIT). This service (known as Kendall Wi-Fi) was launched five years ago thanks to a collaboration among MIT, Google, Boston Properties, the City and the CHA. MIT hosts and maintains Kendall Wi-Fi within its existing network system. In the context of this study, the CHA and the City anticipate potentially leveraging existing fiber connectivity provided by MIT near Washington Elms and Newtowne Court to support a pilot that would serve as a test bed for developing a scalable operating model and technical approaches for wired residential service at those sites.

Because MIT fiber already serves a free Wi-Fi service in the outdoor areas of Washington Elms and Newtowne Court, MIT fiber is present already at the centrally-located Pisani Community Center at Washington Elms. There is no MIT fiber present at Manning Apartments, but City fiber is nearby and could potentially be used for backhaul.

CTC conducted site visits at all three locations in May to ascertain feasibility and costs associated with extending wired broadband services to individual residential units. At a high level, we found that the necessary infrastructure is largely in place to residential units at Newtown Court and Manning Apartments through cabling recently installed by the CHA to each unit. At Washington Elms, repurposing existing cabling and/or conduit paths into each unit could not be verified and may require construction of new cabling to each unit.

2 Solution Design Criteria

A primary objective of the proposed CHA broadband pilot initiative is to enable broadband services capable of delivering connection speeds and reliability necessary to support remote learning, telehealth, teleworking, and other essential applications. Moreover, it is the intent that the selected technical approach will facilitate viable competition to Comcast, already present in each of the selected CHA properties.

The following outline the particular design criteria used in evaluating and selecting the technical options presented in this study:

- Wireline access connection (fiber or copper) to each residential unit capable of delivering symmetrical 1 Gbps capacity;
- Low oversubscription ratio of backhaul connections to each apartment building consistent with industry norms for fiber-to-the-premises (FTTP) to ensure consistent delivery of target access speeds – while this varies depending on the specific hardware configuration, we estimate total aggregate backhaul capacity of 10 -20 Gbps is required for the three selected CHA properties;
- Leverage existing infrastructure to the greatest extent possible to reduce costs;
- Use of standards-based technologies for access-layer and distribution-layer network components, including supported network management protocols and capabilities, that can readily be integrated into the operations of a wide range of candidate service providers; and
- Customer premises equipment capable of functioning as an internet gateway and providing both wired Ethernet (1 Gbps) and Wi-Fi client connections for customer devices within each unit.

3 Infrastructure is Largely in Place to Support Wired Broadband at the Pilot Locations

During our site visits we found that the wired infrastructure is largely in place to support service provision at the three sites.

3.1 Frank J. Manning Apartments

The Frank J. Manning Apartments is a recently renovated 19-story tower with 192 one-bedroom apartments and 12 two-bedroom apartments. The building is served by Comcast cable, and during a recent building renovation the CHA, with considerable foresight, added Category 6 ("Cat6") unshielded twisted pair (UTP) wiring running from the basement to each unit. The Cat6 wiring is the blue wiring shown running through basement in Figure 1. Each Cat6 cable is terminated at a wall-plate in one of the residential units as shown in the example in Figure 2.

Figure 1:Cat 6 Wiring in the Basement of Manning Apartments

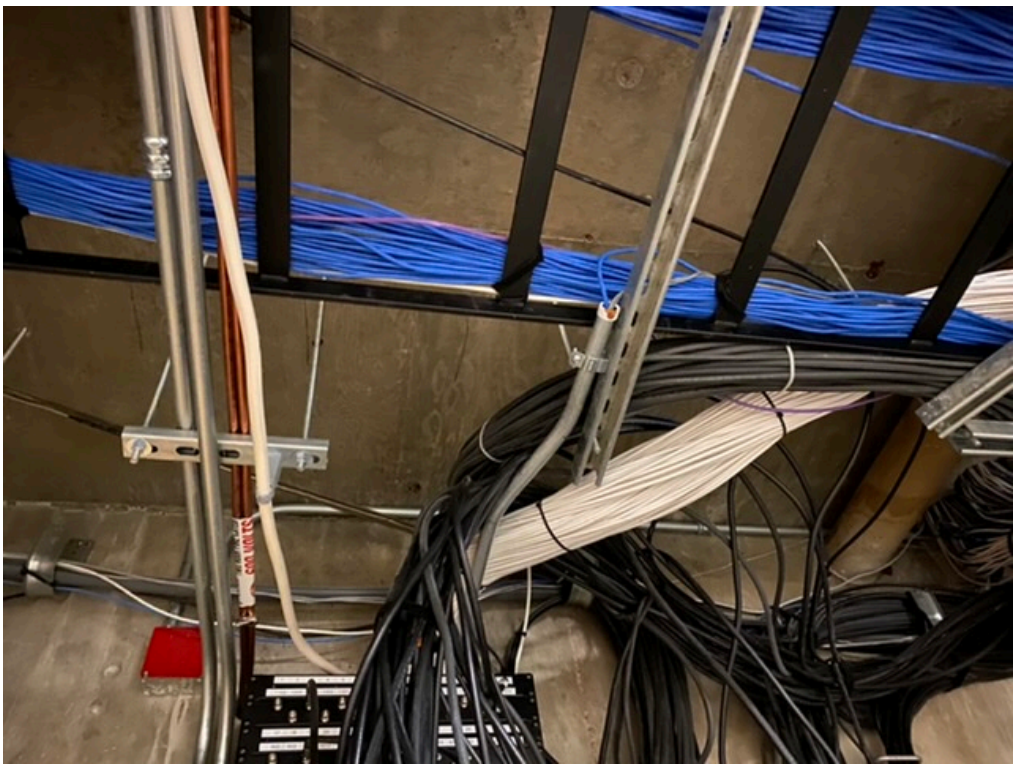
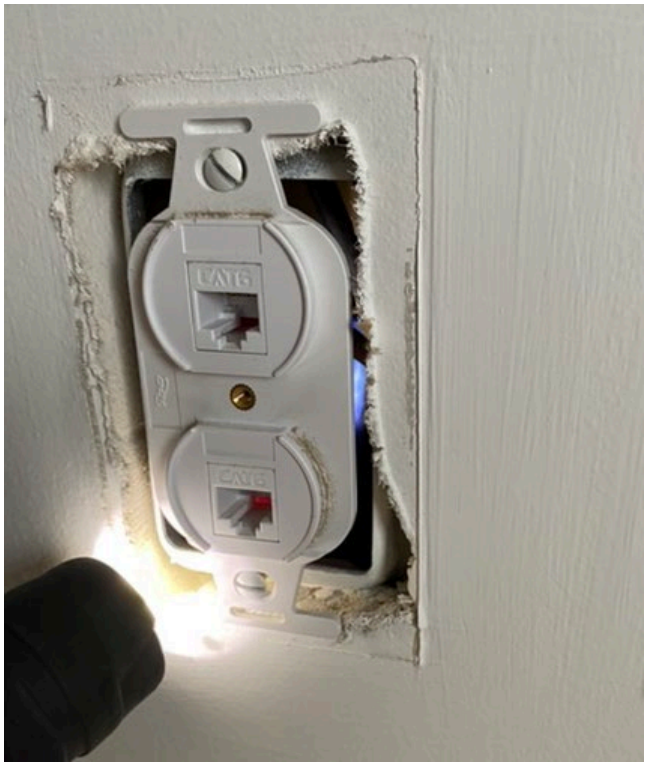


Figure 2: Ethernet Jack in Manning Apartment Unit



3.2 Newtowne Court

The Newtowne Court development has 268 apartments in eight three-story walk-up buildings. The Newtowne Court development has full basements and has been recently renovated, which also included installation of Cat6 wiring from the basement to each unit. The exterior areas of this development are served by free Wi-Fi from the Kendall Wi-Fi Project.

Figure 3 shows the Cat 6 wiring in the basement; Figure 4 shows a Cat 6 ethernet jack in a unit.

Figure 3: Cat 6 Wiring in Basement of Newtowne Court

Figure 4: Ethernet Jack with Cat 6 cabling in Newtowne Court Unit

MIT fiber is located at the Pisani Center, and a fiber loop passes through and between all the Newtowne Court buildings terminated in equipment racks in the basements to serve security

cameras. For the purposes of this study we assume there are extra strands that could be used for backhaul based on the cable sizes and strand allocations identified in the system plans provided by CHA in Appendix A.

3.3 Washington Elms

The Washington Elms project is similar to Newtowne Court; it has 175 residential units in 15 three-story buildings. But the buildings lack full basements and no Cat6 wiring has been installed. Moreover, spray-foam insulation on the basement ceilings of the buildings could make finding conduit paths challenging, but not necessarily impossible.

The buildings are also served by Comcast cable and contain twisted-pair copper telephone wiring. The twisted-pair wiring is owned by the CHA and potentially could be used to provide broadband service to each unit, depending on the condition of this cable and whether this cabling terminates at some point in each building that is accessible and suitable to house network equipment. Figure 5 shows the basement ceilings.

Figure 5: Spray Foam Insulation Covers Ceiling of Washington Elms Basements

Unlike Newtowne Court, Washington Elms has no fiber between buildings, but does have a Cat6 loop serving cameras and thermostats. For the purposes of this study, we assume there is space in existing conduit that can be used to pull fiber between buildings to form a backbone for broadband distribution.

The buildings are of masonry construction; and if required, fiber and conduit could be installed along exterior walls and new cable entry points created through the exterior wall into the residential units for direct access. Figure 6 shows the exterior of a Washington Elms building.

Figure 6: Exterior of Washington Elms Buildings

3.4 MIT Fiber Terminates in Pisani Center Between Newtowne Court and Washington Elms

The Newtowne Court and Washington Elms developments are served by a community center called the Pisani Center. MIT fiber terminates at the Pisani Center. Based on building plans provided by CHA depicting conduit infrastructure (Appendix A), it appears that underground conduit paths could support placement of central network electronics within the Pisani Center and fiber connections to both Newtowne Court and Washington Elms.

In Figure 10, the Pisani Center is the building depicted at the top of the drawing, and the Newtowne Court project is the complex beneath that in the drawing.

4 Cost Estimates

The following sections describe the proposed broadband access solutions and estimated costs.

4.1 Key Assumptions and Scope

As an initial effort towards providing affordable, high-quality broadband service ubiquitously across CHA's properties, a number of details around the ongoing operations and the overarching technical approach for CHA broadband remain open. These pilot efforts will provide an opportunity to assess the technical approaches for broadband access, while establishing a testbed for development of the broader approach.

The proposed technical solutions were developed under the following main operating assumptions:

- Service offerings will be limited to internet only, and will not include voice or video products;
- Costs and technical solutions encompassed by the cost estimates in this document are limited to customer access, extending from each residential unit to existing fiber that can be made available to a service provider, whether owned by the City or MIT, to reach the CHA properties;
- Core systems required to aggregate connectivity from the CHA properties, manage and provision service, and provide connectivity to the internet are considered outside the scope of this document;
- Use of MIT fiber, City fiber, CHA in-building cabling, and existing conduit on the campuses of CHA properties is assumed to be provided at no cost; and
- Space will be made available by the CHA and the City to house any required network electronics and related components described for the particular technical approaches.

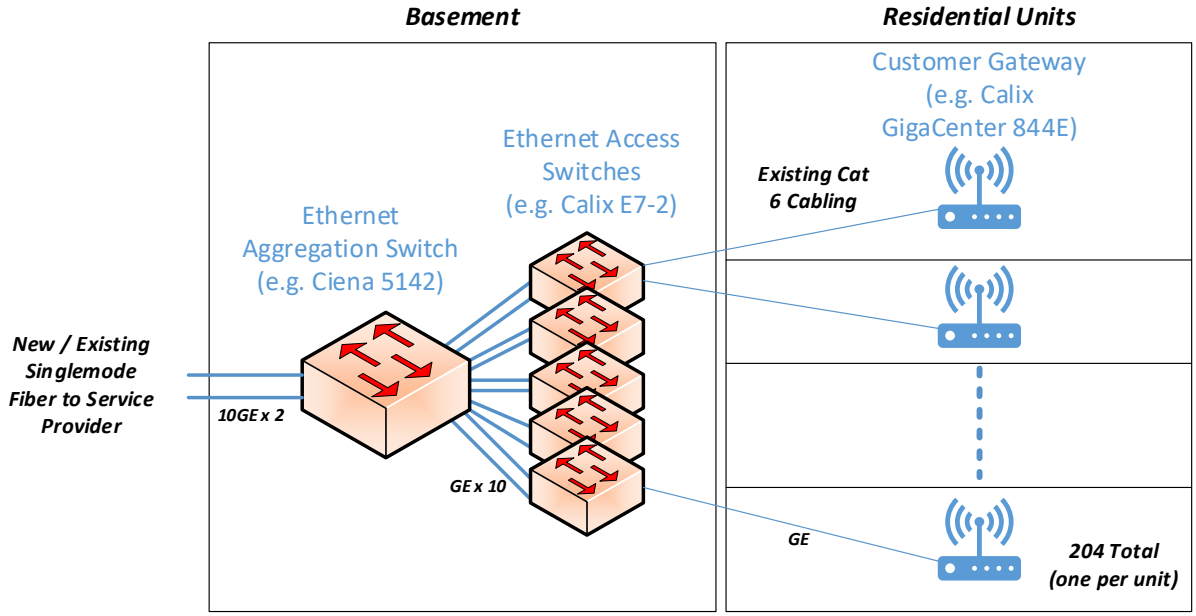
4.2 Proposed Broadband Access Solutions

4.2.1 Frank J. Manning Apartments

The proposed solution for Manning Apartments leverages existing Cat6 cabling to deliver a dedicated Gigabit Ethernet connection to each residential unit. This entails placement of Ethernet access switches in the basement to provide Gigabit Ethernet (GE) interfaces for Cat6 connections to each residential unit. Depending on the particular hardware selection, a distribution-layer switch may be needed to aggregate connections from each access switch, providing redundant 10 GE uplinks to the selected service provider.

A CPE device placed in each unit will provide wired Ethernet and Wi-Fi access for customer client devices (Figure 7).

Figure 7: Manning Apartments Conceptual Equipment Configuration



For the purposes of this report we assume that new fiber construction will be required from the basement of the Manning Apartments to a proposed meet-point with existing City fiber at the CHA Headquarters (362 Green Street). There is a possibility that City fiber exists in the basement of Manning Apartments, but this remains to be verified by CHA. Depending on the pathway selected, this may require approximately 1,200 feet of new underground fiber construction. The route options require traversing multiple intersections and construction along routes with little or no green space. For budgetary purposes, we estimate a rough cost of approximately $100 per foot for placement of conduit and fiber, not including engineering, splicing, testing, and other related costs included in the estimate below. This particular cost component requires further vetting to identify cost savings options, such as availability of existing City conduit, feasibility of microtrenching, or City fiber splice points located in closer proximity in or near the Manning site.

A breakdown of the the total estimated cost of $320,000 for this candidate solution are shown in Table 1.

Table 1: Manning Apartments Broadband Access Solution Estimated Costs

Cost Component	Estimated Cost
Ethernet access and distribution switches	$80,000
Network engineering and integration *(including required equipment cabinet, UPS, cabling, and related materials)*	$25,000
Customer premises equipment *(204 units)*	$70,000
Fiber lateral construction to CHA Headquarters	$145,000
Total	**$320,000**

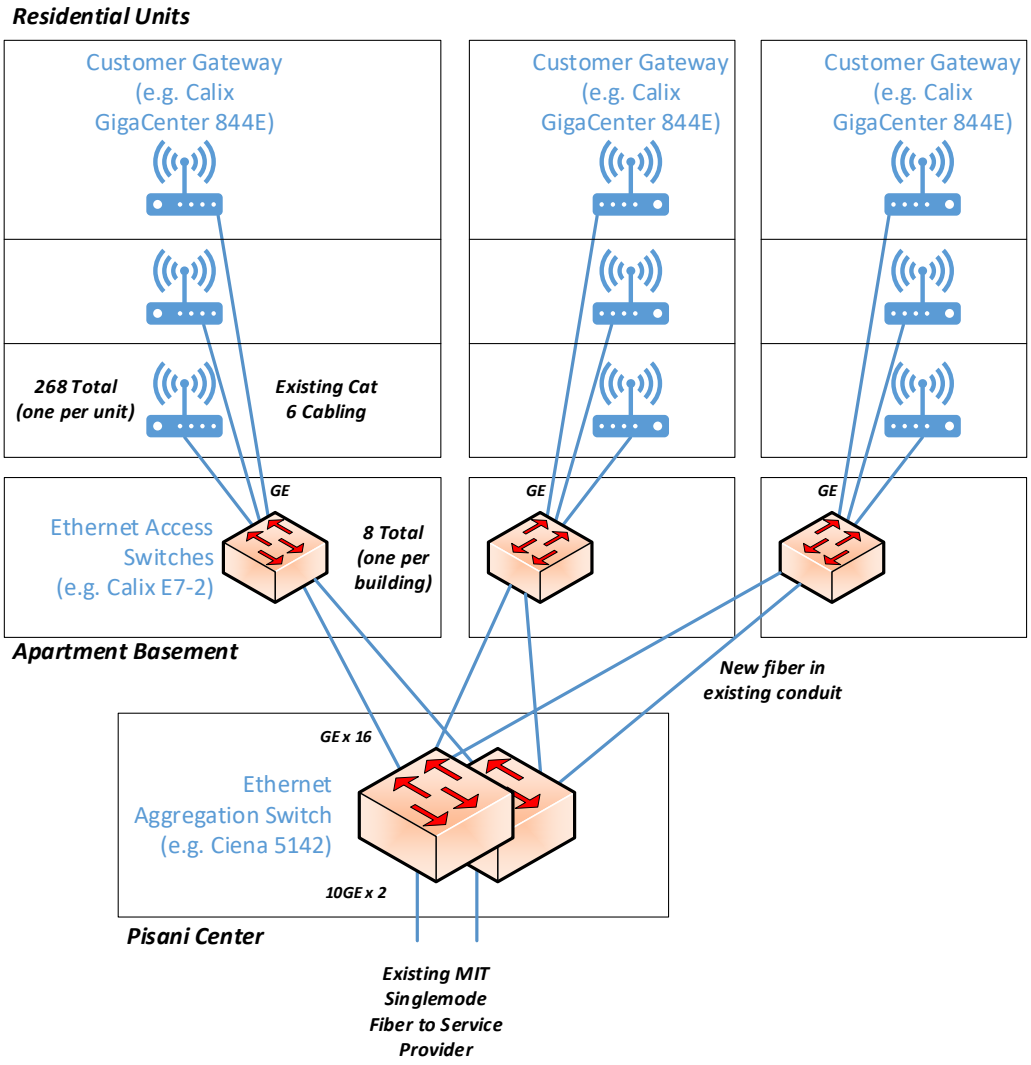
4.2.2 Newtowne Court

The proposed solution for Newtowne Court leverages existing Cat6 cabling to deliver a dedicated Gigabit Ethernet connection to each residential unit. This entails placement of Ethernet access switches in the basement of each apartment building to provide GE interfaces for Cat6 connections to each residential unit.

Fiber will be placed in existing conduit between each apartment building and the Pisani Center. A pair of redundant distribution-layer switches will be placed in the Pisani Center to aggregate connections from each access switch over the new fiber, and to provide redundant 10 GE uplinks to the selected service provider over existing MIT fiber.

A CPE device placed in each unit would provide wired Ethernet and Wi-Fi access for customer client devices (Figure 8).

Figure 8: Newtowne Court Conceptual Equipment Configuration



A breakdown of the total estimated cost of $300,000 for this candidate solution are shown inTable 2.

Table 2: Manning Apartments Broadband Access Solution Estimated Costs

Cost Component	Estimated Cost
Ethernet access and distribution switches	$140,000
Network engineering and integration *(including required equipment cabinets, UPS, cabling, and related materials)*	$40,000
Customer premises equipment *(268 units)*	$95,000
Fiber installation between Pisani Center and basement termination points *(8 buildings, assumes existing conduit)*	$25,000
Total	**$300,000**

4.2.3 Washington Elms

The suggested solution for Washington Elms consists of an end-to-end FTTP design leveraging Gigabit Passive Optical Network (GPON) technology to deliver symmetrical gigabit connectivity to each unit. Due to a lack of high-quality data cabling and uncertain condition of the existing telephone wiring, installation of fiber service to each unit is recommended. Fiber provides the most viable long-term solution to deliver reliable gigabit services initially with support for ten gigabit and greater services in the future using the same cables.

This approach entails the installation of new conduit pathways to support fiber service drops to each unit. Electrical metallic tubing (EMT) or similar rigid metal conduit can be affixed to the exterior of each apartment building to create pathways between the basement and new conduit entry points to each residential unit.

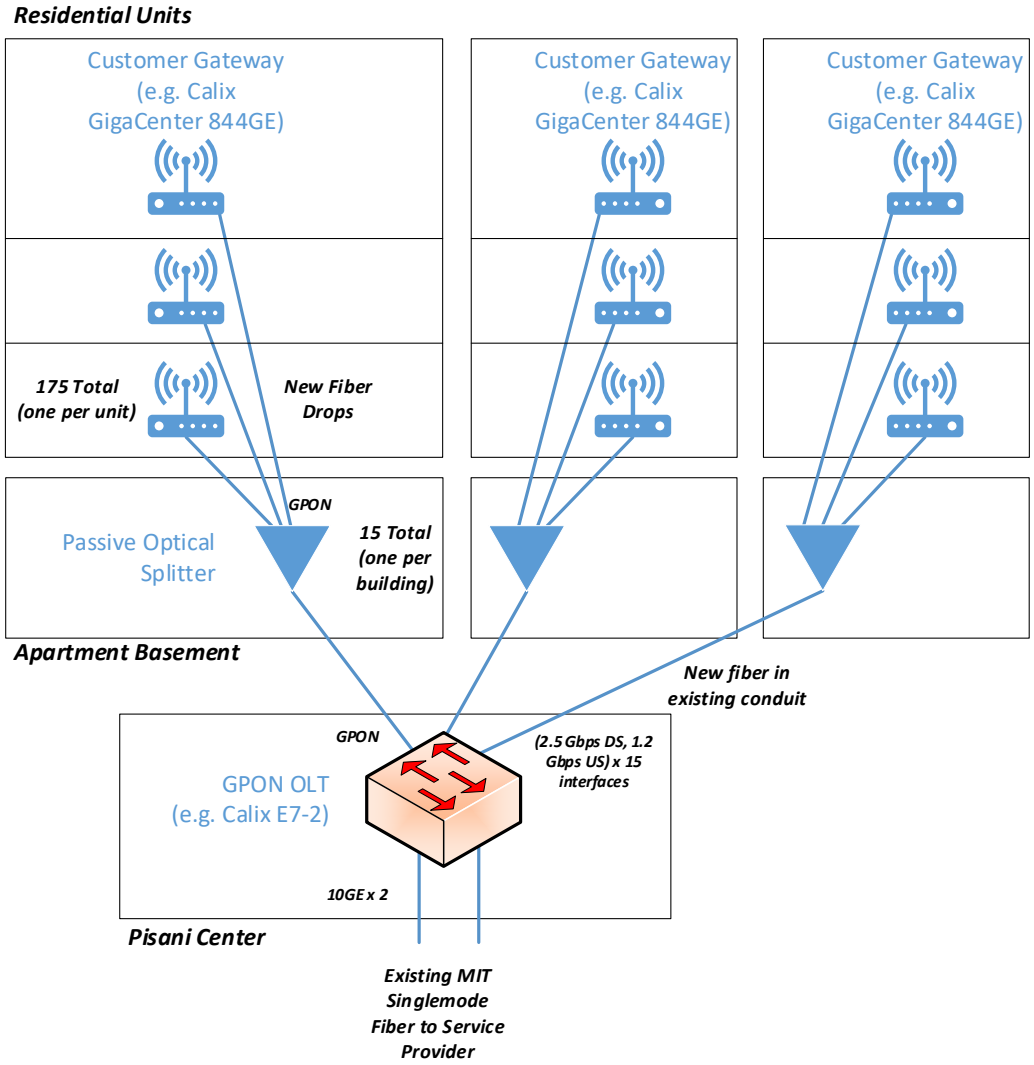
Fiber will be placed in existing conduit between the basement of each apartment building and the Pisani Center.

GPON Optical Line Terminal (OLT) hardware will be placed in the Pisani Center, capable of centrally providing gigabit connectivity to all of the connected residential units and redundant 10GE uplinks to the service provider over MIT fiber. The OLT will be equipped with 15 GPON interfaces (one per apartment building), supporting an average split ratio of only 12:1 – well

below the industry norm of 1:32 or 1:16 in most recent FTTP deployments. A single splitter will be located in each basement to serve the corresponding units in the building.

A CPE device placed in each unit would provide wired Ethernet and Wi-Fi access for customer client devices (Figure 9).

Figure 9: Washington Elms Conceptual Equipment Configuration



A breakdown of the total estimated cost of $240,000 for this candidate solution are shown inTable 2.

Table 3: Manning Apartments Broadband Access Solution Estimated Costs

Cost Component	Estimated Cost
GPON Optical Line Terminal	$40,000
Network engineering and integration *(including required equipment cabinets, UPS, cabling, and related materials)*	$10,000
Customer premises equipment *(175 units)*	$60,000
Fiber installation between Pisani Center and basement termination / splitter points *(15 buildings, assumes existing conduit)*	$35,000
Service drop conduit and fiber to each residential unit	$95,000
Total	**$240,000**

4.3 Summary of Costs and Technical Approaches

The following table summarizes the costs and the key attributes of the broadband access configurations presented above.

Table 4: Summary of Costs and Technical Approaches

Attribute	Manning Apartments	Newtown Court	Washington Elms
Building Type / Quantity	19-story high-rise / single building	Three-story garden-style apartments / 8 buildings	Three-story garden-style apartments / 15 buildings
Housing Units	204	268	175
Backhaul	New fiber construction to CHA Headquarters	Existing MIT fiber present in adjacent Pisani Community Center.	Existing MIT fiber present in adjacent Pisani Community Center.
Distribution Cabling	N/A (single building)	New fiber to be placed in existing conduit between Pisani Community Center and each apartment building.	New fiber to be placed in existing conduit between Pisani Community Center and each apartment building.
Access Technology	Gigabit Ethernet	Gigabit Ethernet	GPON
Access Cabling	Existing Cat6 UTP cable between basement and each unit	Existing Cat6 UTP cable between basements and each unit	New conduit and fiber service drops to be constructed from basement to each unit
Capital Cost	$320,000	$300,000	$240,000
Cost Per Unit (without backhaul)	$860	$1,120	$1,370
Cost Per Unit (with backhaul)	$1,570	$1,120	$1,370
Annual Hardware Maintenance Cost	$19,000	$28,000	$15,000

5 Navigating Service Provision Options

If the CHA were to decide to move forward with providing a new wired broadband service at these sites, it appears that completing the infrastructure component would be relatively straightforward. And it is clear that there is political will and funding likely available from the CHA and/or willing partners such as MIT, foundations, or other entities who could provide the necessary funds.

The main task would be to identify a business model (which could include service being free to residents, but subsidized by the City, CHA, or other entity) and an entity to provide service. Identifying and evaluating these options was beyond the scope of this initial engineering task. However, the likely approach would be for CHA to engage in a competitive RFP process for a private service provider to offer service over the CHA-built infrastructure. As part of the RFP the CHA could seek input on whether the service would be a business run by the partner, or a free service subsidized by the CHA. We reiterate that the CHA is still in the middle of an RFP process to identify potential fixed wireless providers at CHA sites. CTC was not involved in that RFP process. The results and resolution of that process should be taken into consideration as the City, the CHA, and any partners weigh next steps.

Although CTC did not examine service provider options with respect to Cambridge, there are several examples around the country where housing authorities engaged in engineering and cost estimation or facilitated the entry of new broadband providers. There exist several cases where a City or its Housing Authority undertook some infrastructure upgrades—including to bring fiber to a building or improve in-building wiring—and facilitated entry of new private partners through local procurement processes. CTC could potentially support Cambridge in researching best practices around the county and identifying solutions in Cambridge.