Comparing the network upgrade costs of DOCSIS 4.0 ESD to overbuilding with Fiber-To-The-Home

White paper

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Introduction

For over a decade, cable operators have dominated the residential broadband market in North America. They have done so by having an unwavering commitment to their existing embedded infrastructure while making incremental strategic investments in DOCSIS®-based technology. The coaxial cable networks, originally built for broadcast video, have morphed over the years to support the delivery of broadband services with remarkable efficiency. The hybrid fiber-coaxial (HFC) infrastructure has allowed cable operators to adapt and leverage their assets to remain relevant by offering fast and reliable internet, coupled with other value-added services such as Voice over IP. Cable operators have generally outpaced their telco competitors in terms of customer acquisition, retention, and broadband speed, all for a competitive price.

Cable's physical outside plant (OSP) has undergone significant changes in recent years. Operators have brought optical fiber closer to subscribers, reduced the number of homes connected per node, and leveraged new modulation techniques to keep up with the growing demand for bandwidth-intensive applications such as streaming, online gaming, and the work/study-from-anywhere culture. This sustained and carefully measured commitment to incremental network improvements, coupled with widespread service coverage, made cable broadband the go-to-choice for residential broadband in North America.

Over the last several years, cable operators have been preparing to once again increase network capacity and broadband speeds with DOCSIS 4.0 (D4.0). While D4.0 represents a significant technological leap, it may still fall short. Today, broadband service providers with fiber-to-the-home (FTTH) networks can differentiate their service offering from cable broadband by offering symmetrical, multi-gigabit, speeds. DOCSIS 4.0 will most certainly enable higher gigabit download speeds and dramatically improved upstream speeds, enabling symmetrical services – to a point.

FTTH, on the other hand, is widely accepted by broadband service providers as the gold standard of internet connectivity with ultra-high-speed internet, virtually unlimited capacity, and higher reliability. In an era where bandwidth-intensive applications like 8K video streaming, virtual reality, and the proliferation of IoT devices are becoming more prevalent, fiber's superiority for delivering consistent, low-latency, and symmetrical high-bandwidth connections makes it a formidable rival. It is also easier to upgrade over time, having to only change the electronics or optics at the end points with no change to the OSP.

Decisions to deploy fiber or incrementally upgrade existing HFC networks have always been based on cost and performance. The true cost to deploy DOCSIS 4.0 is still up for debate. The cost to pass and/or connect customers with D4.0 is largely dependent on the network starting point. In fact, one question which is hotly debated by the industry and many operators is how much it costs to provide an existing cable broadband subscriber with a DOCSIS 4.0 connection comparable to the ultra-high broadband speeds being delivered to customers with fiber-to-the-home network connections. Is the cost of the upgrade worth it? Will the incremental network changes and product required to support D4.0, along with the corresponding time-to-market, enable cable operators to maintain their dominant market position against overbuilders and other competitors? One thing is certain; there is no easy black and white answer. The "right" decision is not only unique to every operator, but could vary across regions within a single operator's network as well.

Study Parameters and Cost Categories

To help cable operators in choosing the most viable upgrade path, Nokia, in cooperation with tech consultancy ePlus, conducted an extensive study to evaluate the cost to design, construct, and deploy:

a) An Extended Spectrum DOCSIS 4.0 (ESD) network with a Distributed Access Architecture (DAA) with aggregate speeds of 9 Gb/s downstream and 3 Gb/s upstream, capable of multigigabit symmetrical broadband (i.e., DOCSIS 4.0 DAA HFC network at 1.8 GHz with a 396/442 MHz split) and

b) An XGS-PON fiber-to-the home network with an aggregate speed of 8.5 Gb/s symmetrically in the same serving areas.

The base network on which the upgrade was performed was a DOCSIS 3.0 HFC network at 1 GHz with a 43/54 MHz split for low and medium densities and 870MHz bandwidth for high density, all with a 42/54MHz return split.

The study was conducted for three different serving area densities including low (30 homes/mile), medium (56 homes/mile), and high (116 homes/mile). The study assumed a subscriber take rate of 40% on either technology for the given areas.

To provide a comprehensive picture, the following cost categories were included:

- **Engineering:** Includes the walkout/fielding of system, application, submission and coordination of permits, design and drafting of both HFC and FTTH
- **Construction:** Strand, fiber, and cable placement; conduit and ped placement, fiber splicing. Work done by technicians and laborers
- **Upgrade labor:** Installing hardware (taps, passives, node) based on the design done by engineering. Configuration and balancing of levels on RF system. Work typically done by a field engineer
- **Materials:** Includes construction materials, OLTs, nodes, actives, taps and passives, fiber, coax, fiber splices and fiber taps
- **DAA CMTS:** Hardware and installation of a Distributed Access Architecture (DAA)-capable DOCSIS 4.0 CMTS to accommodate DOCSIS 4.0 on the HFC outside plant
- **Subscriber:** Includes modem or ONT along with associated materials needed to get to house or in the home

Upgrade Cost Modeling Results

The tables below show the cost per subscriber for the D4.0 and FTTH upgrades across the three deployment densities. In the first table, it is presumed the DAA D4.0 CMTS can't be shared across multiple areas. This scenario results in the FTTH overlay cost per subscriber ranging from 5% lower to only 7% higher than the D4.0 upgrade depending on deployment density:

Modeled upgrade cost/subscriber – Dedicated CMTS			
	D4.0	FTTH	FTTH/D4.0
Low Density	$ 3,250	$ 3,100	94.5%
Medium Density	$ 2,105	$ 2,251	106.9%
High Density	$ 1,495	$ 1,528	102.2%

However, if the CMTS can be shared across areas by having it centralized, the operator spend comparison between the two technology upgrades shows that FTTH overlay is more expensive than the D4.0 upgrade by 17% - 39% depending on deployment density and how efficiently the CMTS can be shared.

Modeled upgrade cost/subscriber – Shared CMTS			
	D4.0	FTTH	FTTH/D4.0
Low Density	$ 2,511	$ 3,100	123.3%
Medium Density	$ 1,627	$ 2,251	139.2%
High Density	$ 1,292	$ 1,528	117.4%

Sharing of the CMTS across locations is a distinct possibility, but it may limit its peak capacity and might be shared across dissimilar area densities, the reality for an operator would lie somewhere between these two tables. This suggests that in most situations, the cost to upgrade an DOCSIS 3.0 HFC plant to DOCSIS 4.0 ESD and the cost to overlay an FTTH network will be similar.

The study also provides a percentage split of the overall cost for the operator into three distinct components:

(i) Headend, including CMTS/ OLT and the switches/router and the management system.

(ii) OSP, including engineering, construction, material and upgrade and

(iii) Drop cost, including the drop cable, truck roll and the modem/ONT

As with the upgrade cost modeling, this breakdown was done both for deployments with dedicated CMTS and shared CMTS.

Percent of upgrade cost by network section with dedicated CMTS

	Low Density Area		Medium Density Area		High Density Area	
Network Section	**D4.0**	**FTTH**	**D4.0**	**FTTH**	**D4.0**	**FTTH**
Headend	25%	8%	25%	8%	17%	13%
OSP	57%	72%	47%	65%	43%	47%
Drop	18%	20%	28%	27%	40%	40%

In the case of a dedicated CMTS, the percentage spent for drop costs for all three densities are very similar in both the technologies. The increased cost of the headend for the DOCSIS 4.0 upgrade is offset by the lower spend in the OSP upgrade, thus providing a balance in expenditure for the two types of networks.

Percent of upgrade cost by network section with shared CMTS

	Low Density Area		Medium Density Area		High Density Area	
Network Section	**D4.0**	**FTTH**	**D4.0**	**FTTH**	**D4.0**	**FTTH**
Headend	3%	8%	3%	8%	4%	13%
OSP	73%	72%	61%	65%	50%	47%
Drop	24%	20%	36%	27%	45%	40%

When the CMTS is shared across locations, the percentage spent on the headend, of course, drops very significantly with a corresponding increase in the percentage spent on the OSP and drop.

Powering Comparison

Powering is also a major consideration in any OSP network. The D4.0 upgrade required additional power supplies to accommodate more nodes, as well as amplifiers and line extenders. However, the FTTH design was able to reuse existing HFC power supplies to power the remote OLTs (nodes).

For the low density areas, FTTH nodes required only 30% of the existing RF system's power supplies. Existing coax cable was used to connect areas to use same power supplies, with an average 3 OLTs per power supply.

For medium density areas, FTTH nodes required only 50% of the existing RF system's power supplies. Existing coax cable was used to connect areas to use same power supplies, with an average 2 OLTs per power supply.

For high density areas, FTTH nodes required only 31% of the existing RF system's power supplies. Existing coax cable was used to connect areas to use same power supplies, with an average 3 OLTs per power supply.

Using existing power supplies and coax to feed multiple nodes provides implicit cost savings (i.e., no need for power supply, location development, or licensed electrician).

Going a step further and analyzing the power consumption in the outside plant shows the average current draw per power supply for the HFC network is 3.4 to 4.7 times greater than for the FTTH network. Combining the impact of fewer power supplies and reduced power consumption per power supply in the FTTH network results in an enormous power and OPEX savings compared to the HFC network.

Outside plant power consumption and associated FTTH OPEX savings			
	Low Density (15,450 Homes Passed)	**Medium Density (29,136 Homes Passed)**	**High Density (59,712 Homes Passed)**
HFC Power in sample area (KW)	114.88	126.30	176.97
FTTH Power in sample area (KW)	10.24	14.45	31.19
Ratio of HFC: FTTH Power	**11.2**	**8.7**	**5.7**
HFC Power Cost/Year/ 100K Homes*	$976,326	$569,577	$389,431
FTTH Power Cost/Year/ 100K Homes*	$87,046	$65,170	$68,636
Annual OPEX Savings/ 100K Homes	$889,321	$504,407	$320,795
% OPEX Savings for FTTH (Power)	**91.1%**	**88.6%**	**82.4%**

* Calculated at $0.15/KWh

As shown in the table above, depending on the home density of the area, the HFC network requires 11.2 (low density), 8.7 (medium density), and 5.7 (high density) times more power to operate the outside plant than the FTTH network. Calculating the annual cost of power shows that FTTH delivers an OSP power OPEX savings of 91.1% (low density), 88.6% (medium density), and 82.4% (high density) compared to the HFC network. This is not the only significant OPEX savings with FTTH – for example, FTTH network maintenance costs are much lower than HFC – but power is one that lends itself to a more definitive calculation.

Summary

In summary, the cost estimate for the D4.0 upgrade (ESD) and an FTTH brownfield overbuild yielded results that were very similar to one another, especially in the case of a dedicated CMTS. In the case of the HFC (Hybrid Fiber-Coaxial) upgrade, the need for a new DAA (Distributed Access Architecture)-capable CMTS (Cable Modem Termination System) to accommodate DOCSIS 4.0 represented a significant additional expense compared to the OLT for FTTH. The HFC upgrade also required entirely new active and passive equipment for the OSP (e.g., nodes and the splitters), equivalent to the materials needed for FTTH.

In the past, the ability to enhance bandwidth by changing electronics in headend and customer end equipment without splicing or rebuilding made HFC more cost-effective from a CAPEX standpoint. However, with a 1.8 GHz by 396 MHz networks, the OSP needs significant capital investment from the operators. Additionally, cost comparability was influenced by using remote OLT (Optical Line Terminal), which eliminated high-count fiber typically associated with FTTH builds, resulting in significant savings.

It is also important to note that DOCSIS 4.0 upgrades still present some uncertainties. The specification was released by CableLabs in March 2021, but the technology is still immature and deployments are in their very early stages, with only a limited number of MSOs having initiated upgrades.

On the other hand, upgrades to FTTH networks are easy and straightforward. XGS-PON (10 gigabit symmetrical) has been widely rolled out since the early 2020s and is the predominant PON technology being deployed today. There are already operators deploying 25G PON (25 Gb/s symmetrical connections), with 50 Gb/s symmetrical arriving within the year. As previously noted, upgrading a fiber network to these higher speeds does not require any changes to the fiber itself; only new electronics and/or optics at the end points. Fiber networks also benefit from higher reliability and lower OPEX well beyond the power savings discussed in this study. Additionally, the much higher speeds already available and forthcoming on fiber networks enables a broader range of high average revenue per user (ARPU) network use cases including enterprise 4.0, mobile transport, smart city, wholesaling, and converged network services, leading to greater operator revenue.

Each operator’s situation is unique, and there are a great many variables involved, but given all of these considerations, most operators will find a fiber overbuild is a superior option. While it may be capitally infeasible for some MSOs to implement a comprehensive “all-at-once” overbuild, a phased strategic transition plan could serve them and their customers well, ultimately resulting in better service to subscribers, easier and more cost-effective upgrades, lower operating costs, and more revenue generating opportunities.

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