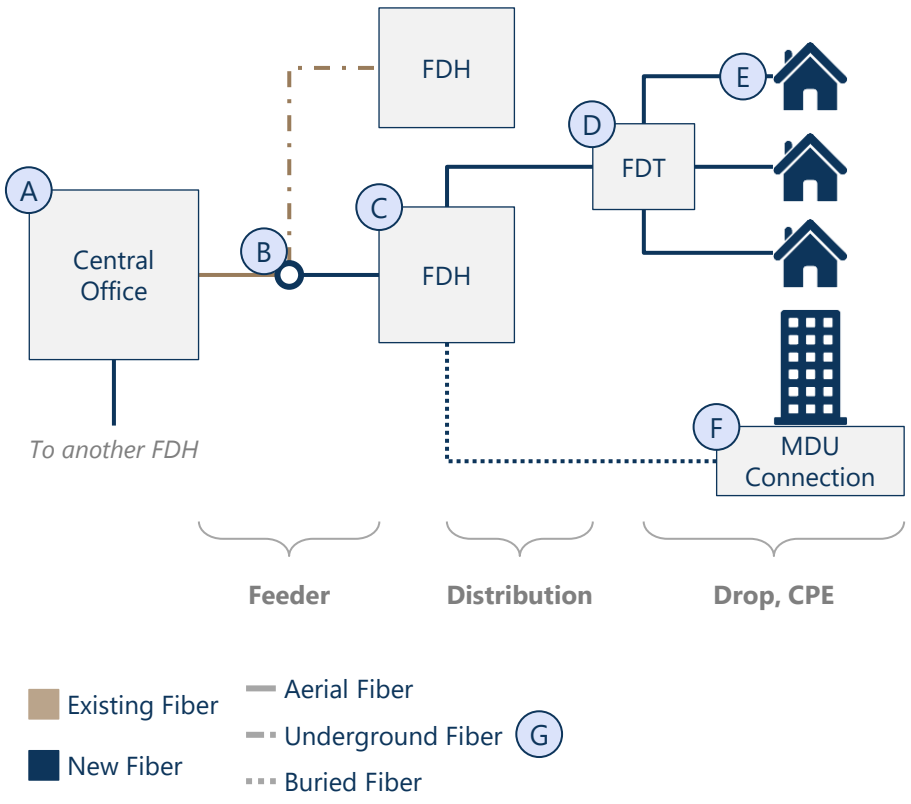
Arrow Platform

Network Topology

Arrow models costs associated with building FTTP networks

Arrow FTTP Network Model Topology



- (A) **Central Office** – Hub of local loop connections
- (B) **Splice Point** – Location where possible to splice new fiber off of existing fiber strands
- (C) **Fiber Distribution Hub** – Splits fiber at the junction between "feeder" and "distribution"
- (D) **Fiber Distribution Terminal** – Splits fiber at the junction between "distribution" and "customer drop"
- (E) **Success-Based Capex** – Equipment and labor costs associated with connecting a customer; includes drop, ONT, and other hardware and installation at the customer premises
- (F) **Multi-Dwelling Unit** – Variable equipment and labor costs associated with connecting units in a MDU
- (G) **Fiber** – Fiber costs can be assigned by location: aerial, underground *(usually located in urban conduit)*, and buried *(dug in shallow trench)*

Input values may be varied by morphology/location

Sources: Altman Solon Research & Analysis

Fiber costs drive the largest capex deployed in a plan; splice points and success-based capex are also important factors

Ordered by model impact

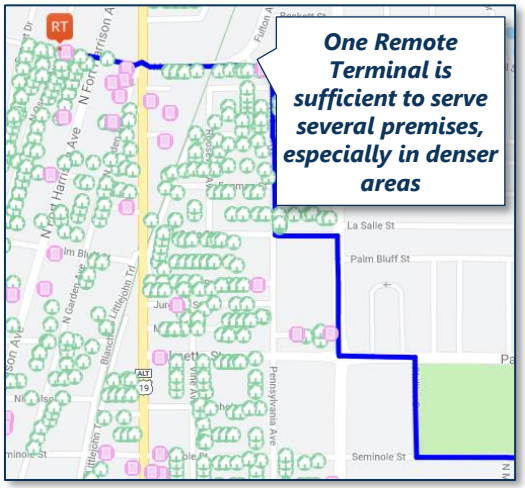
	Arrow Input	Description	Received	Impact on Plan Financials
G	Fiber Costs	Fiber costs can be assigned by morphology and by location: aerial, underground *(usually located in urban conduit)*, and buried *(dug in shallow trench)*; includes materials and labor		
B	Splice Points	Location where possible to splice new fiber off of existing fiber strands; splice point locations have a **significant effect on fiber routing**		
E	Success-Based Capex	Equipment and labor costs associated with connecting a customer; includes drop, ONT, and other hardware and installation at the customer premises		
C	Fiber Distribution Hub	Splits fiber at the junction between "feeder" and "distribution"		
D	Fiber Distribution Terminal	Splits fiber at the junction between "distribution" and "customer drop"		
A	CO Upgrade Cost	Hub of local loop connections; upgrade costs include installing and upgrading equipment for GPON		
F	MDU	Variable equipment and labor costs associated with connecting units in a MDU		

In past Arrow analysis, **fiber costs** have accounted for **the majority of plan capex**

Sources: Altman Solon Knowledgebase

Low → High

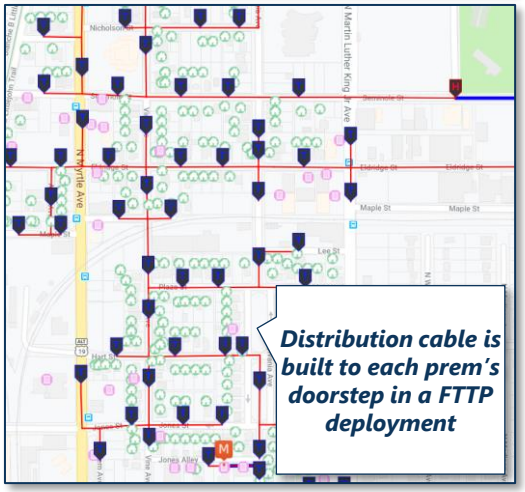
While FTTP and FTTN network deployments use similar general architectures, there are a few key differences around connecting prems



FTTN Deployment

(assumes node is in range of prems to guarantee 25Mbps target speed)

- A FTTN network deployment lays fiber from the CO to remote terminals in sufficient range to guarantee a 25Mbps target speed for each connected prem
- The network uses Remote Terminal (RT) equipment at network end nodes
- When a prem subscribes, connect cost is assumed to cover both equipment and installation



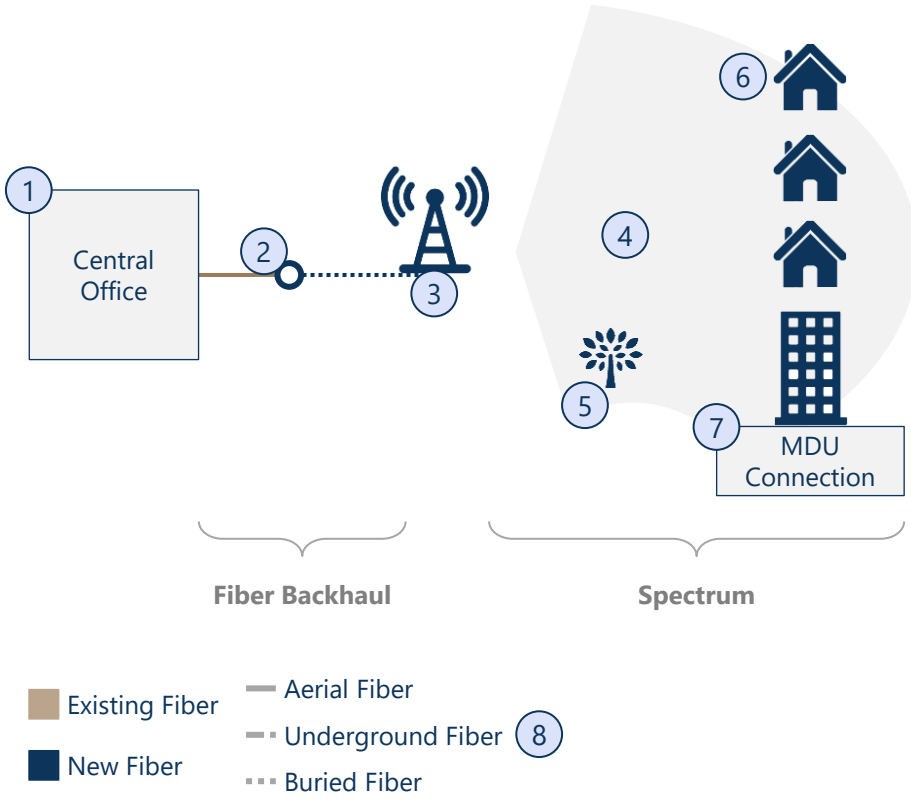
FTTP Deployment

(fiber is built to the prem doorstep and can offer 100Mbps+ speeds)

- A FTTP network deployment lays fiber from the CO all the way to the doorstep, guaranteeing speeds over 100Mbps for each connected prem
- The network uses FDHs and FHTs / MDU equipment to pass all prems
- This is a more capex intensive deployment compared to FTTH since it requires additional fiber miles and equipment
- When a prem subscribes, higher connect cost in assumed, given the different CPE required

Arrow models costs associated with the following FW network topology

Arrow FW Network Model Topology



1. **Central Office** – Hub of local loop connections
2. **Splice Point** – Location where possible to splice new fiber off of existing fiber strands
3. **5G Fixed Wireless Node** – Access Node and tower for 5G signal; associated costs include equipment, labor
4. **Spectrum** – Bands of frequencies for propagating wireless information; radius (propagation distance) can be a model input

   No costs associated with spectrum in Arrow
5. **Obstacles** – Foliage and buildings can impede the propagation of high-frequency wireless signals
6. **Success-Based Capex** – Equipment and labor costs associated with connecting a customer; includes hardware and installation at the customer premises
7. **Multi-Dwelling Unit** – Variable equipment and labor costs associated with connecting units in a MDU
8. **Fiber** – Fiber costs can be assigned by location: aerial, underground *(usually located in urban conduit)*, and buried *(dug in shallow trench)*

Input values may be varied by morphology/location

Sources: Altman Solon Research & Analysis

Spectrum propagation and fiber costs drive most capex in a fixed wireless build plan; splice points and success-based capex also important factors

Ordered by model impact

Arrow Input	Description	Received	Impact on Plan Financials
4 5 Spectrum Radius, Obstacles	Propagation distance of wireless signal		●
8 Fiber Costs	Fiber costs can be assigned by morphology and by location: aerial, underground *(usually located in urban conduit)*, and buried *(dug in shallow trench)*		●
3 5G Fixed Wireless Node Cost	Access Node and tower for 5G signal; associated costs include equipment, labor		●
2 Splice Points	Location where possible to splice new fiber off of existing fiber strands; splice point locations have a **significant effect on fiber routing**		◔
6 Success-Based Capex	Equipment and labor costs associated with connecting a customer; includes hardware and installation at the customer premises; based on % prems requiring truck roll		◑
1 CO Upgrade Cost	Hub of local loop connections; upgrade costs include installing and upgrading equipment for GPON		◔
7 MDU	Variable equipment and labor costs associated with connecting units in a MDU; can MDUs be served with FW?		◔

Sources: Altman Solon Knowledgebase

Low ◔ → High ●

Wireless node placement software uses the following methodology

1

Determine Set of Potential Site Locations

Potential site types consist of:

- *Existing structures*
- *Existing client sites*
- *New sites*

Each site type has different costs associated with it

2

Estimate Rate Reach Curves for Potential Sites

NASA has 30m x 30m data on:

- *Foliage density*
- *Clutter density*

Based on this data, Arrow can estimate impedance near site and **calculate a rate reach boundary***

3

Optimally Place Nodes for 100% Coverage

Begin by placing nodes in lowest capex/prem-passed locations, based on:

- *Coverage (# of households)*
- *Costs (site type)*

Continue placing nodes until 100% coverage for geography is reached

4

Forecast Detailed Cash Flow for All Nodes

Calculate detailed cash flow for each of the sites placed in step 3 based on:

- *Site CapEx (site type, morphology)*
- *Penetration (competition)*
- *Incremental CPGA*
- *ARPU*
- *CCPU*
- *Sub lifetime*

5

Route Fiber and Prune Low IRR Nodes

Route fiber to all nodes in the 100% coverage placement

Leverage pruning engine to **sequentially remove nodes until IRR or budget constraint is met**

- *Decision to prune is based on capex of fiber as well as detailed cash flow projections from previous step*

6

Calculate Overall Scenario Financials

Calculate scenario financials for pruned scenario incorporating:

- *Site CapEx*
- *Fiber CapEx (or OpEx)*
- *Subscriber Revenue, OpEx*
- *Cash Flow*

*Not intended to replace detailed RF designs but highly effective to accelerate planning purposes