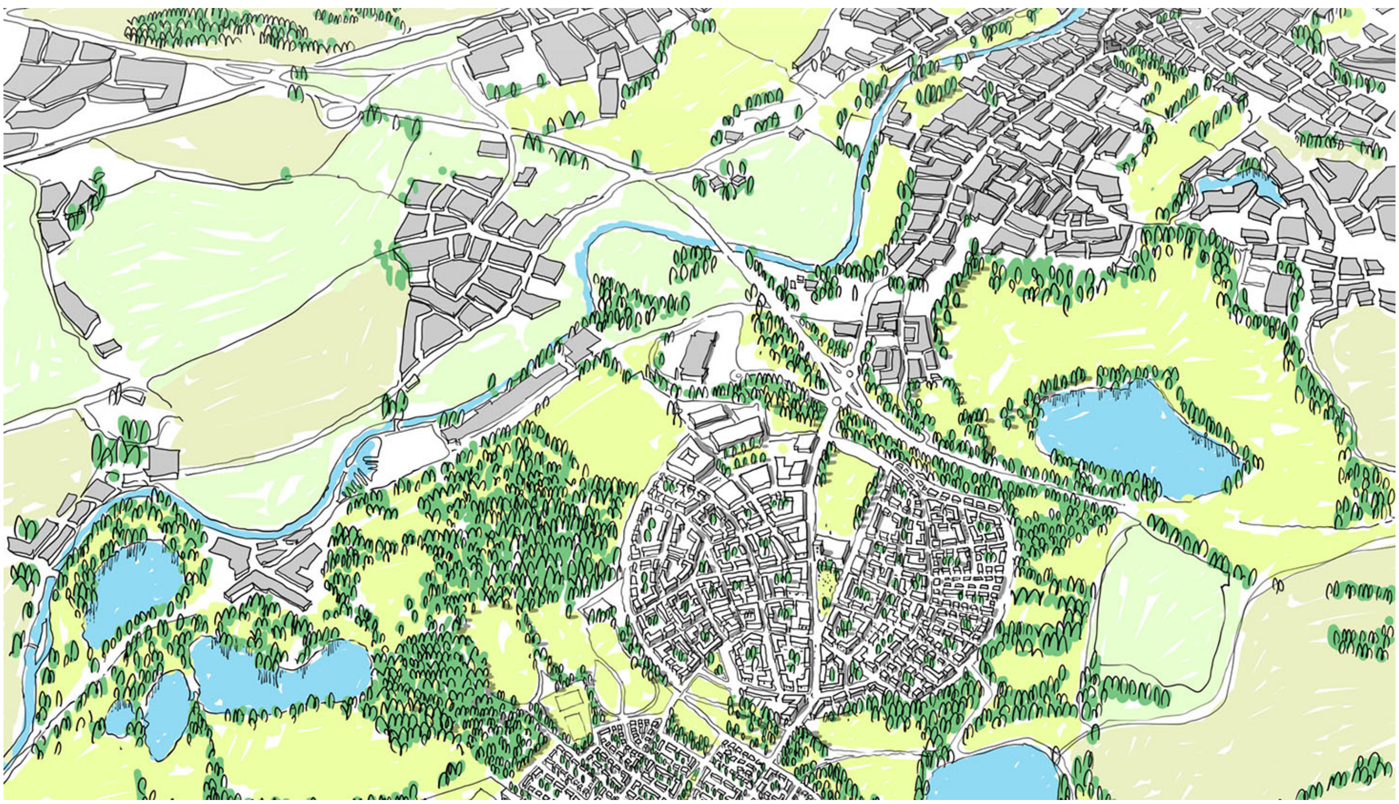

Solving the Access Network Footprint Expansion Enigma

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Executive Summary

An ever-growing array of access technology options are available to service providers to deliver state-of-the-art broadband service. With all these choices, service providers are faced with increasingly complex deployment decisions. Planning deployments with only a short-term view, or by using a simple blanket guidance, can lead to suboptimal results with regrettable investments in the long run. This is particularly true when planning for network expansion projects such as onboarding new greenfield areas.

In this paper we have outlined a methodology to identify deployment choices that are optimal for your greenfield expansion plans, which can be seamlessly operationalized. The paper also provides insights into some of the key factors that should be taken into consideration while planning greenfield expansion projects:

- Before deciding on any network changes, the long-term impact should be analyzed. What seems preferable in the short-term can be sub-optimal in the long run.
- Network expansion cannot be analyzed in a vacuum. Impact on existing network infrastructure and any broader transformation plan needs to be carefully considered.
- Only a comprehensive Integrated network expansion planning approach across brownfield, greenfield and other network expansion initiatives can provide a full assessment and effectively leverage any cross-domain synergies.

In order to demonstrate the importance of taking a long-term integrated approach while planning network expansion, we have used our access network planning tool Jibe™ to tackle three typical footprint expansion use cases service providers face:

- Which technology should I use to build new greenfield areas?
- How do I plan budget and resources for long term greenfield expansion?
- How do I perform integrated access planning to create a comprehensive synergistic view of:
  - Short and long-term greenfield projects
  - Different lines of business (small cells, business etc.) expansion
  - Brownfield transformation projects

WHAT IS THE PROBLEM?

While planning for network expansion projects such as onboarding new greenfield areas, network operators are faced with many technology and architecture options.

Such planning is often done in a siloed atmosphere with a short-term view. This often results in plan that is sub-optimal in the long run that fails to accurately predict budget and resource requirements.

KEY TAKEAWAYS

When you are creating network expansion plans

- Plan for the long-term
- Leverage your brownfield network knowledge
- Build integrated network plans enabling:
  - Enterprise level decisions
  - Cross domain synergies
  - Consistent strategies
  - Planning efficiencies

At the end – leverage planning tools, such as Jibe™, to perform integrated planning while you are fine tuning the business strategies.

Jibe is used to analyze these use cases. The details and insights gained through integrated long-term planning are presented in the appendices.

NOTE: *The results shown in the example use cases are specific to the assumption used in these scenarios and should not be interpreted as a blanket solution preference in all cases.*

What is “predictive” access network planning – why is it important?

A predictive access network plan or access network transformation plan defines the evolution over time of the access network infrastructure. The transformation plan should:

- Address any changes and activities required to keep the access network in line with subscriber demands, competitive threats, and any corporate strategic directions including technology upgrades, network architecture changes, and any required outside plant construction activities (see [1] for more details)
- Forecast resource requirements including staffing, material, fleet, operational impact etc.
- Forecast budget needed to perform these activities

Why is it important? Investments in access network infrastructure can take up to 90% of a service providers yearly capital investment. A network transformation path that is not finely tuned can waste millions in regrettable investments, increase churn, and impact the network’s competitiveness. A flexible, long-term transformation plan is mission critical in such a competitive world.

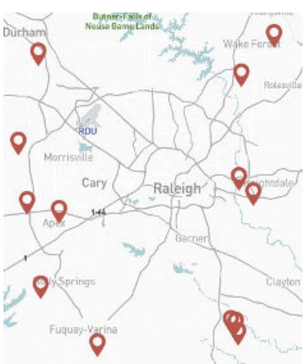
Creating a network transformation plan is a multidimensional problem of coordinating subscriber demands with network technologies and associated budgetary and operational constraints. This planning is influenced by customer broadband needs, capacity constraints, corporate strategy, current and emerging competition, operational expense minimization, and technology innovation (see [1] for more details). Such a complex plan needs to be sufficiently detailed - preferably at access node level - while keeping end to end strategic integrity.

It is critically important for the transformation plan to always consider the long-term transformation impact at the enterprise level - not just the first or first few transformation actions.

For example, let’s consider a case where the current demand growth is expected to exceed on your upstream capacity for the coming year. You decide that you can easily handle this in your HFC network by introducing “high-split” on the affected network elements and avoid any node-split and construction activities, thereby drastically reducing short-term budget needs. However, looking at the long-term transformation needs of the affected nodes may reveal that you are only delaying the construction needs which will result in a spike in construction activity at a time when you cannot operationally accommodate it. Taking the long-term enterprise level view in the plan may reveal that the best overall approach could be to still select the “high-spit” short term reveal action and use the available budget and resource to pull forward construction activity high priority nodes to reduce the future spike. Effectively transforming your network upgrade planning from a reactive need driven mode to a proactive strategy driven mode.

The ever-increasing service demand combined with fast-paced technology evolution in a very competitive environment make long-term predictions a fast-moving target requiring constant refinement of any long-term transformation plan. While in general a 10-year plan is far superior that ten 1-year plans, when it comes to network transformation the only viable approach is ten 10-year plans.

Short term greenfield expansion planning



New communities pop up all the time and they demand state of the art telecommunication services. Service providers must constantly evaluate the best options to serve the customers in these communities.

At first this seems to be a straightforward task. After all you have the exact details of the new neighborhoods being built in terms of households passed, amount of construction required, and service level that needs to be provided. You may even have access network elements with spare capacity serving subscribers nearby. So, isn’t using spare capacity or duplicating the nearby access node designs always the best option? Well, it depends.

While expanding existing network deployments to serve nearby greenfield areas seems to be an obvious choice, it should be complemented with a detailed evaluation of any other new technology and architecture options that are available at the time.

When you start with a blank piece of paper and all-new construction, you have the luxury of evaluating all technology and architecture options such as:

- Traditional Hybrid Fiber Coax architecture
- Deep fiber N+0 HFC architecture
- FTTH architectures (EPON, GPON, Active Ethernet)
- Fixed Wireless

Most of the deployment choices are made keeping in mind the lowest cost solution as of today. While this may look great in the short-term it will not necessary give you the best long-term solution. This greenfield deployment will be around for a long time (today's greenfield is tomorrow's brownfield) with growing service demand and increasing competitive pressure.

OBSERVATIONS FROM THE GREENFIELD EXPANSION USE CASE (APPENDIX A)

- Greenfield construction costs are relatively similar for various technologies
- Expansion of existing brownfield nodes may result in additional node upgrade actions effecting brownfield and greenfield subs
- High upfront cost should be favored over multiple low-cost upgrades.

At a minimum, deployment options should be evaluated to include the long-term network transformation costs required to keep the network competitive. That (as illustrated in appendix A) may drastically change which option is considered the most effective. The good news is that you can use the surrounding brownfield information (such as growth, competitive pressure and planned service evolution) to accurately plan for this greenfield deployment. So, instead of performing a standalone greenfield extension strategy, why not use the matured brownfield strategy for that area?

The benefit of doing such and integrated analysis using a planning tool, such as Jibe, is that it basically gives you greenfield long-term planning without any additional effort.

Doing all this analysis to make a directional decision for every individual greenfield deployment is most likely not feasible for the planning organization. However, it is feasible to create a limited set of greenfield deployment categories based on size and urban morphology**. Given the benefits of long-term integrated analysis, it is certainly worth the effort to create preferred deployment models for each deployment category based on a full analysis of a representative greenfield area.**

Predictive macro level greenfield planning

A completely different but equally important activity is the long-term predictive greenfield planning. Every year the network footprint grows. Any long-term strategic network plan is not complete if it does not include the deployment and transformation for the greenfield extensions.

Once a greenfield footprint expansion area is built and made operational, it becomes part of the brownfield network. Over time, it will evolve just like any other parts of the network. As we have witnessed in detailed brownfield analysis, network transformation cost and resource requirements may eclipse the initial installation requirements. Ignoring greenfield transformation leaves a big gap in any long-term strategic plan. As discussed in the previous section, ignoring future transformation requirements can lead to sub-optimal selection of initial technology and architecture leading to a significantly higher lifetime cost.

It is therefore very important that we should not look at the greenfield deployment and transformation plan in isolation, but carefully consider the interdependences with the brownfield network, and more importantly, the brownfield transformation plan. This is especially true since looking at all the future footprint expansion deployments as stand-alone networks is unrealistic, needlessly complex, and suboptimal. The ultimate goal is to create a fully integrated network transformation plan for the complete planning time-scope (e.g. 10 year quarterly) encompassing all greenfield expansion and brownfield transformation needs.

One of the biggest challenges with performing long term predictive greenfield planning is the lack of available details. Typically, based on historical information and area market drivers, operators have a general idea about the overall size of greenfield expansion that is expected in the coming years in a market or sub-market. However, since details about the future deployments are not available, only high-level cost and resource requirements for the initial build-out of the total greenfield homes are planned. Without the deployment starting details, how can we even begin to consider creating a standalone transformation plan, let alone a full integrated one?

The answer can be found in the close ties between greenfield and brownfield. It is safe to assume that future greenfield areas will have similar urban layouts to the surrounding brownfield areas. Studying the brownfield footprint shows that there are only a handful of fundamentally different urban morphologies (e.g. rural remote, rural, urban, urban downtown) in the entire footprint. For each of the morphologies, we have a solid grasp on all the key parameters needed to define network architectures and select suitable technologies.

Urban

Suburban

Rural

Using the urban morphology knowledge, it is relatively straightforward to turn a high-level homes-passed number for a selected greenfield area into a fictional, but fairly realistic and detailed network model. This model can then be treated just like the existing brownfield network for long term predictive planning, thereby achieving an integrated greenfield and brownfield plan.

Use the knowledge about your brownfield network morphology to model your future greenfield network deployment.

Appendix B provides additional details of the process for creating an integrated predictive greenfield plan for a sample scenario along with results of the analysis.

Need for Integrated comprehensive network planning

As we have seen above, it is very important to have an integrated long-term greenfield and brownfield network transformation plan. Many network operators typically also have separate lines of business (e.g. Residential vs Business, Wireline, Wireless etc.) with dedicated access network infrastructure. These lines of businesses usually plan their networks in a siloed manner.

In the previous sections we highlighted the importance of creating a fully integrated planning view for brownfield and greenfield rather than siloed plans. Adding more individual plans into the mix compounds the need for a fully integrated access network planning effort.

Let us zoom in on the key benefits of creating fully integrated access network deployment and transformation plan:

- **Comprehensive**: A big risk in developing network deployment and transformation plans in silos is that while individually they may look implementable, but when put together, they can far exceed your total resource capacity. At some level in the organization all the plans need to be put together. When this is done, adjustments may have to be made to these plans which may not be optimal. Having a comprehensive planning view can easily avoid such problems.
- **Consistent:** When plans are made in silos, each plan makes its own assumptions about various drivers including upgrade growth, strategic direction triggers, business-driven constraints, and network element transformation options. It is difficult to keep these aligned across various plans. A comprehensive plan on the other hand is based on a single set of assumptions.
- **Synergies:** Creating plans in silos makes it difficult to leverage synergies across planning domains. Having an integrated plan allows you to look for activities that can be combined. For instance, the integrated plan may reveal that greenfield and brownfield activities are planned for the same area within a few months of each other. Combining the effort could lead to significant savings.
- **Information inference:** Another benefit of an integrated plan is that we can leverage planning information from multiple sources. For instance, network utilization data from existing brownfield nodes can be used to model new greenfield nodes in the same area.

Recent technical innovations in the access network technology are driving network deployments from using independent overlay access networks with convergence in the metro and core to convergence of services in the access network itself. This move to converged access networks will place an even greater emphasis on the need for comprehensive integrated network planning.

How do we do comprehensive integrated network planning?

We have seen the importance of comprehensive integrated network planning. However, it is not easy to do.

Traditional planning tools used by network operators do not make it easy to compile a long-term integrated network plan. We at FPI have been specifically focusing on this problem and have developed a tool called Jibe that is specially designed for long-term integrated network planning - thus **closing one of the biggest common access network planning gaps!**

By performing an integrated analysis using a planning tool such as Jibe, you not only get the greenfield long-term planning view, but also:

- Consistent application of network transformation rules and strategic direction across greenfield and brownfield networks
- Operational synergies between greenfield and brownfield deployments (e.g. if I have a greenfield construction crew in the area can I pull forward future planned brownfield updates, realizing cost benefits and avoiding sending crews to the same are twice)
- A comprehensive cost, resource, and operational view for the entire network over the long-term covering both greenfield and brownfield
- An enterprise view of forward looking budged and resource requirements

While it may not be practical to perform such a detailed analysis for every individual greenfield deployment, it can be done for a limited set of greenfield deployment categories based on their size and urban morphology. Given the benefits of the long-term integrated analysis, it is certainly worth the effort to create preferred deployment models for each category based on a full analysis of a representative greenfield area.

Once the process of creating greenfield deployment models is in place, it can easily become part of the brownfield network transformation planning cycle so that any directional change in network transformation strategy is automatically reflected in greenfield deployment guidelines.

In its first release, Jibe fundamentally changed the long-term brownfield transformation planning process form a tedious modelling exercise to a fast, interactive process. This enabled network planners to easily compare limitless transformation scenarios and converge to their ideal long-term transformation plan.

In its latest release, Jibe allows you to seamlessly attached footprint expansion schedules and automatically create a fully integrated plan following your optimized transformation strategy. With Jibe your network expansion planning effort is reduced to defining the deployment schedule. Integrated long-term transformation planning rolls-out with no additional effort.

We have illustrated the power of Jibe in two scenarios outlined in Appendix-A and Appendix-B.

Appendix A shows how Jibe can be used to determine an optimal greenfield network expansion plan keeping the long-term view.

Appendix B illustrates Jibe's ability to develop an integrated predictive greenfield plan based on just a high-level forecast.

Conclusions

Access networks are continuously expanding to serve the needs of new greenfield areas or to expand capacity. No matter the reason, network expansion is a highly resource intensive effort (cost, material, labor, ..) that needs to be planned carefully. Also, network infrastructure is in place for a long time, and will require significant future upgrade in order to keep up with demand and remain competitive. Cost of upgrading the network in the long run often eclipses the initial deployment cost. As such, it is important to consider long term impacts before planning any network expansion or upgrade projects.

As we have outlined in this whitepaper:

- Network expansion needs to be carefully planned with a long-term horizon to ensure an optimal solution selection and a correct evaluation of total resource impact over time.
- Network planning must be done in a comprehensive integrated manner across all network activities including greenfield, brownfield, and other lines of business in order to arrive at a consistent and optimal plan that takes advantage of any cross-domain synergies.
- Using planning tools like Jibe, specially designed to enable easy long-term integrated planning with dedicated greenfield extensions, simplifies this task to a level allows for effortless integration in the recurring planning process

References

[1] Luc Absillis," Access Transformation – Technology Basics", https://www.firstprinciplesinnovations.com/,2018
[2] Sudheer Dharanikota, "Understanding the basics of Transformation in Telecom Industry," DTS Magazine, 2Q 2017

About the Author

Luc has over 25 years of experience in the telecommunications industry as a CTO, solution team lead, architect, product line manager, and fundamental researcher.

Luc earned his PhD and MS in computer science from the Vrije Universiteit Brussel in Belgium. He lives in Raleigh, North Carolina, with his wife and two children.

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Appendix A: Detailed short-term greenfield analysis

This appendix demonstrates the most common use-case in greenfield network expansion - onboarding of a new real-estate development in the footprint.

Let's look at a specific scenario.

"In Q2 2019 a new neighborhood with 90 homes will be completed in the area covered by network access node "Raleigh North_111". Question how do we best serve these new nodes?"

To answer this question, we analyzed three different options and their impact over a 10-year period:

Option-1 (Node Expansion): Serve the homes by extending existing DOCSIS 3.1 Node Raleigh North_111

Option-2 (EPON Overlay): Introduce a new EPON OLT in the network to serve the new homes with FTTH

Option-3 (N0 Overlay): Introduce new fiber deep DOCSIS 3.1 N+0 nodes to serve the new homes

NOTE: *The goal of this analysis is to demonstrate the methodology for detailed greenfield analysis and showcase the insights that can be gained. Actual results are of less significant as they depend heavily on cost assumptions made for all the network upgrade actions.*

Setup

To illustrate this scenario, we started with a sample fictitious brownfield network in-place in the state of North Carolina with 10,000 active access network elements serving approximately 3.8M homes passed distributed over 3 markets and 46 facilities.

Before starting the greenfield use case a simplified 10-year quarterly network transformation plan was created using Jibe for the 10,000-node brownfield network.

The analysis was done in the context of a simplified 10-year network transformation strategy for the complete network created using the Jibe network transformation toolset. A conscious decision was made to use a basic network transformation plan in order to focus purely on the greenfield impact.

To establish a baseline for easy comparison, the network transformation analysis was limited to only a single brownfield node - Raleigh_North_111 (392 HHP) in "Raleigh North" facility.

In order to perform the greenfield analysis, Jibe requires following additional input:

Cost and resource parameters unique for both node expansion and greenfield node installation.
Detailed definition of access network element(s) to be added for overlay options
Feeder and distribution mileage to be constructed for new end-points and network elements.

Network transformation assumptions

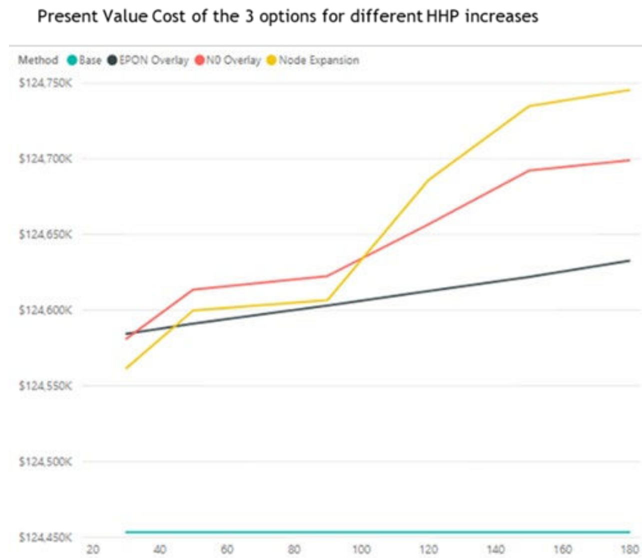
The simplified brownfield transformation plan used for this analysis included the following upgrade rules:

- DOSCIS 3.1:
  - If node size >256 HHP -> 2-way Nx split
  - If node size <= 256 HHP.> split to N+0 RDP nodes
  - If N=0 node -> upgrade to Full Duplex
- EPON: upgrade to 10G EPON
- Trigger for node upgrade:
  - Utilization > 70 % of capacity
- Node utilization growth:
  - downstream 40% YoY
  - upstream 20% YoY

A quick run of the Jibe tool showed that Option-2 (EPON Overlay) was the lowest long-term cost option. We were curious to see how the number of homes-passed would affect the result. We therefore ran the analysis for different number of homes-passed, keeping all other inputs, such as feeder and user miles to be constructed, constant.

Let us first examine the results of varying the homes-passed to be added and look at present value cost impact as well as future value const impact.

Long-term Node Cost by homes-passed



The charts on the right shows the total present value cost of a full 10-year network transformation plan for the Raleigh_North_111 brownfield node with the addition of the new greenfield HHP using the three options.

NOTE: The Base cost in the charts refers to the node upgrade cost of the base Raleigh_North_111 brownfield node over the 10-year period which is the same for all options.

Here are some observations of our results:

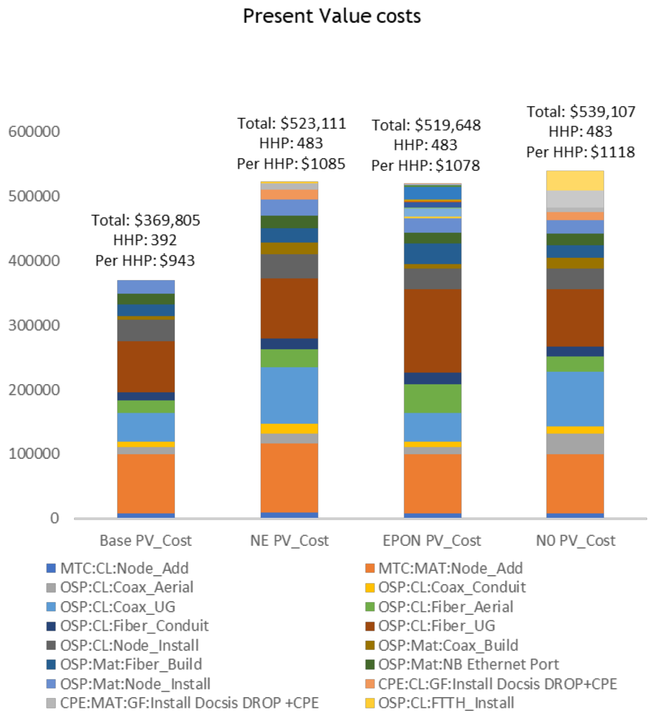
- The EPON Overlay option cost starts as the highest at around 30 HHP, but only increases slowly with additional HHP. This can be explained by the fact that we assumed the deployment based on an 8-port remote OLT. With 32-split per port it can serve up to 256 HHP. The initial deployment cost of the OLT is high and the same for the full range of HHPs considered. Cost of additional HHP on the other hand is only limited to additional drop and CPE costs. If we extended the analysis to over 256 HHP, it would show an additional step in the graph.
- The N+0 Overlay option cost starts as the second highest at around 30 HHP. However, it quickly jumps up in a few large steps. This can be explained by the fact that we have assumes an N+0 node serving a maximum of 48 HHP per node. After each 48 HHP a new node is needed leading to a jump in cost.
- The simple Node Expansion option cost starts as the lowest at around 30 HHP. This is intuitive from the fact that it requires minimal cost to add the additional HHP. However, the cost quickly rises and far exceeds the cost of the other two options. This is due to the fact that additional HHPs lead to additional node splits in the future driving to a much higher cumulative cost.

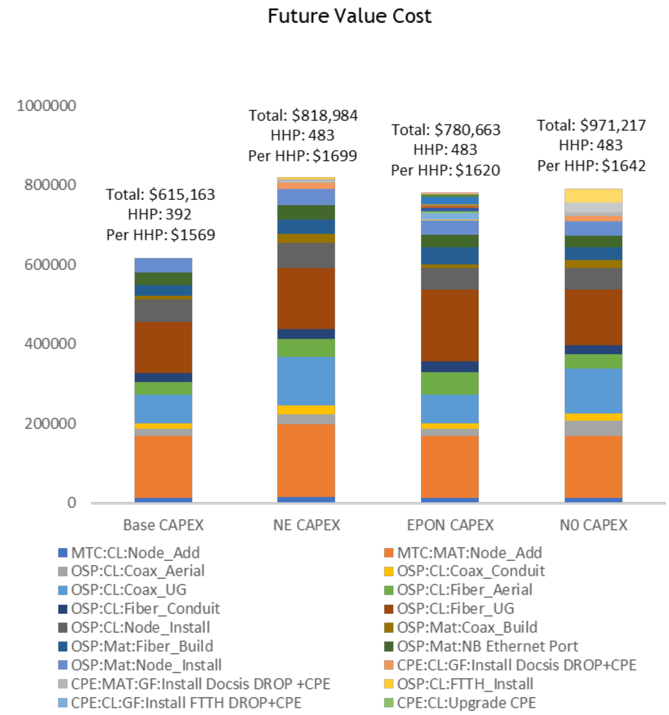
In this scenario, except for very small HHP additions, EPON Overlay would be the lowest cost long-term option. This is obviously based on the cost and network element definitions we used in our example.

Zooming into the 90 HHP example scenario

Now that we have a high-level understanding on the relative cost of the different options, it is time to zoom in and examine the impact of each of the options more closely.

The charts below show a detailed breakdown of the total node cost in present as well as future value methods as shown by Jibe.





Looking at above charts it is immediately evident that for all scenarios a large portion of the total costs is for cable construction labor cost (This is to be expected since the scenario includes first time construction for all the new endpoints).

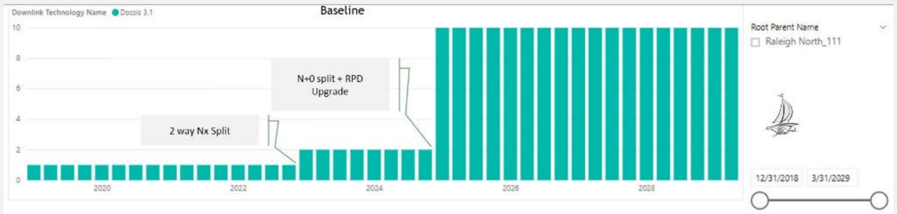
Comparing the cable construction cost between the different scenarios will reveal that the variance is minimum. Consequently, while outside plant cable construction costs are the major contributor to greenfield costs, they are not a relevant parameter when comparing different wired connection options. The same argument can be made for CPE drop and labor costs.

Where can we find the drivers for the difference in cost between these scenarios?

It really comes down to the installation cost of outside plant access network elements and the related inside plant termination along with the multiplying effect of node split actions that are needed in each case over the time period.

To further explain the cost conclusions above let us examine the 10-year transformation activity and its footprint impact as shown by Jibe.

In the table below, each row represents a scenario and shows the footprint view of node Raleigh North_111 along with its transformation activities over the 10-year period necessary to serve the 90 new greenfield HHP.

<table>
<tr>
<td>
</td>
<td><u>Baseline scenario</u>

Q3 2022: 2way split of Raleigh North_111
Q3 2024: childnodes are further split into 5 childnodes each and upgraded to RPD digital nodes.</td>
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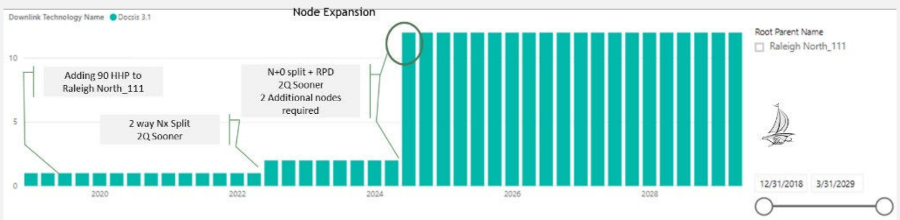
<td>
</td>
<td><u>Node Expansion</u>

Q2 2019: addition and coax cable construction for 90 new homes
Q1 2022: 2way split of Raleigh North_111.
2 quarters before baseline
Q1 2024: childnodes are further split into 6 childnodes each and upgraded to RPD digital nodes. 2 quarters before baseline and 2 additional deep fiber nodes required.</td>
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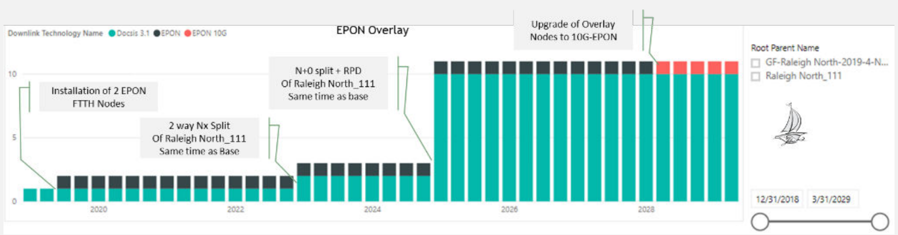
<tr>
<td>
</td>
<td><u>EPON Overlay</u>

Q2 2019: installation of EPON OLT with feeder fiber construcion and fiber construction for 90 new homes
Q1 2022: 2 way split of Raleigh North_111.
Q1 2024: childnodes are further split into 6 childnodes each and upgraded to RPD digital nodes
Q4 2027: 90 homes connected to OLT are upgraded to 10G EPON</td>
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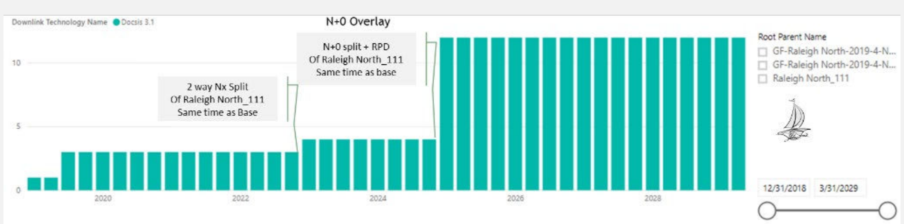
<td>
</td>
<td><u>N+0 Overlay</u>

Q2 2019: installation of 2 N+0 Deep fiber RPD nodes with feeder fiber construcion and Coax construction for 90 new homes
Q1 2022: 2 way split of Raleigh North_111.
Q1 2024: childnodes are further split into 5 childnodes each and upgraded to RPD digital nodes</td>
</tr>
</table>

Appendix B: Long term predicative greenfield planning example

This example use case shows the process of creating a 10-year predictive integrate network expansion plan with Jibe that includes the residential greenfield expansion plan as well as an expansion of the business only overlay network. The calculated integrated network plan will include brownfield transformation, greenfield deployment and transformation, as well as business network deployment and transformation.

As mentioned in section "Predictive macro level greenfield planning", the key to successfully tackle the predictive greenfield transformation challenge is to rely heavily on the brownfield network information.

The overall process can be broken down into 6 steps:

1. Create brownfield network input and transformation plan. (summary in adjacent box)
2. Identify urban morphologies and create matching network element node profiles for residential greenfield and business.
3. Define yearly expansion schedule.
4. Create network expansion detailed topology information.
5. Run integrated network plan
6. Visualize and interpret results.

Brownfield Network Assumptions

- Hypothetical brownfield network of 10000 access network elements in the state of North Carolina
  - 3 Markets
  - 45 Facilities
  - ~3.8M HHP
- Transformation strategy assumptions:
  - Includes: DOCSIS, FTTH and Fixed Wireless areas
  - Realistic House Holds Passed (HHP) and network element utilization Numbers
  - Geographic and Demographic utilization growth profiles
  - Validated cost and resource definitions
  - Piedmont market FTTH strategic introduction plan
    - Form 2021 all business or MDU dense requiring upgrade will transition to FTTH (stop all 2 way and N+0 splits)
    - From 2022 all nodes requiring N+0 split will be upgraded to FTTH instead
- Time-scope is 10-year quarterly

Step 1: Create transformation plan

The iterative process of building a network transformation plan with Jibe is out of the scope of this paper and not outlined here. The selected plan is kept very basic in order to clearly focus on greenfield transformation and integration process.

Step 2: Morphology identification and node profile creation

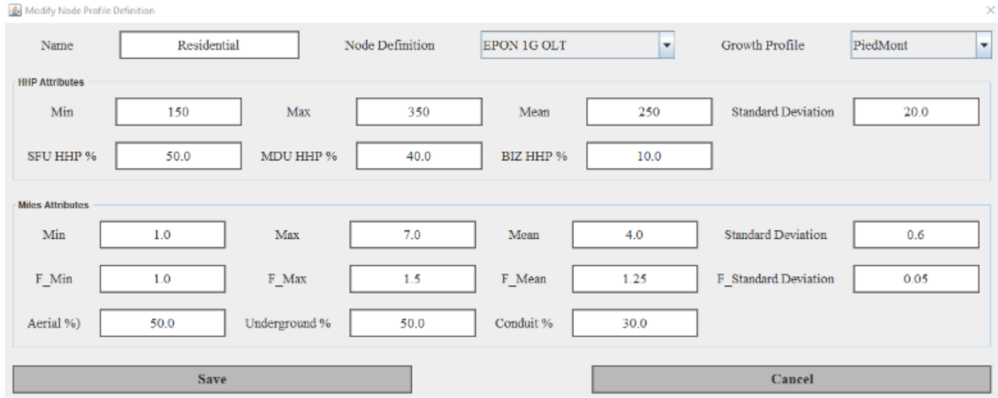
For the sake of simplicity, we assumed a single morphology for the residential as well as the business network across the entire footprint.

The morphology definition itself is not the key to solving the puzzle of creating a network expansion topology. The key is the realization that network elements belonging to the same morphology share the same node characteristics. Hence, the key real step is the definition of the node characteristics representative of the morphology, or in this exercise, the network.

The key morphology dependent node characteristics are:

- **The size of the node**: How many households passed per node. For the purpose of creating representative nodes we assume that nodes sizes in morphology are normally distributed between minimum and maximum values.
- **The type service endpoints connected to the node**: What percentage of endpoints are Single Family Homes, Multi Dwelling units, or are business locations.
- **The distance of the node to the service end-points**: defines the total number of miles of cable to be constructed from the node to reach all the service endpoints including percentage of aerial, underground, and conduit miles.
- **The distance from central location to the node**: defined number of miles to be constructed to reach new node including percentage of aerial, underground, and conduit miles.

To make this information usable for creating greenfield nodes, the operator needs to specify the type of nodes that would be deployed based on their expansion strategy.



A node definition consists of network facing and user facing interfaces and ports along with the technology used.

In the Jibe topology creation tool, all the necessary node information is capture in a node profile as shown in the picture on the right.

For this example, we created 4 Node profiles:

1. **Residential**: Year 1-3 nodes will be EPON OLTs with residential morphology characteristics
2. **Residential 4-10**: Year 4-10 nodes will be 10G-EPON OLTs with residential morphology characteristics
3. **Business**: Year 1-3 nodes will be Active Ethernet switches (1G) with business morphology characteristics
4. **Business 4-10**: Year 4-10 nodes will be Active Ethernet switches (10G) with business morphology characteristics

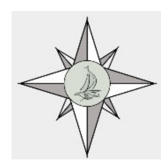
Step 3: Define yearly expansion schedule

The operator typically has a high-level view of the number of service endpoints that are going to be added to his network in future year. Since in this exercise we are introducing both residential expansion and expansion of the overlay business network, we include separate numbers for both.

The only thing left to do is to bring the high-level plan together with the node profiles schedule view as shown in the picture below.

Name	Market	Facility	Node Profile	year1	year2	year3	year4	year5	year6	year7	year8	year9	year10
P Resi 1-3	PiedMont	ALL	Residential	60000	60000	60000	0	0	0	0	0	0	0
P Business 1-3	PiedMont	ALL	Business	30000	30000	30000	0	0	0	0	0	0	0
P Resi 4-10	PiedMont	ALL	Residential 4-10	0	0	0	60000	60000	60000	60000	60000	60000	60000
P Business 4-10	PiedMont	ALL	Business 4-10	0	0	0	30000	30000	30000	30000	30000	30000	30000
M Resi 1-3	Mountains	ALL	Residential	5000	5000	5000	0	0	0	0	0	0	0
M Resi 4-10	Mountains	ALL	Residential 4-10	0	0	0	5000	5000	5000	5000	5000	5000	5000
C Resi 1-3	Coastal	ALL	Residential	5000	5000	5000	0	0	0	0	0	0	0
C Resi 4-10	Coastal	ALL	Residential 4-10	0	0	0	5000	5000	5000	5000	5000	5000	5000

Step 4 & Step 5: Create network expansion topology information. Run integrated network plan



With the Jibe toolset both these steps are nothing more than a literal click of a button.

Step 6: Visualize and interpret results

To begin with, lets look at the plan summary statistics generated by Jibe as shown in the table on the right. You can quickly see the contribution of greenfield expansion on the overall network transformation budget requirement.

	Brownfield Only	Integrated
Total Cost	$4,381,840,283	$6,246,366,565
Total Cost - PV (12% discount rate)	$2,437,404,201	$3,582,891,327
Input nodes	10,000	10,000
Greenfield nodes	0	6,634
Final Node Count	51,932	58,566

One of the very first insights available from the network transformation plan is the evolution of your network footprint - both in terms of deployed technologies, as well is in the number of access nodes (examples of both in graphs below).

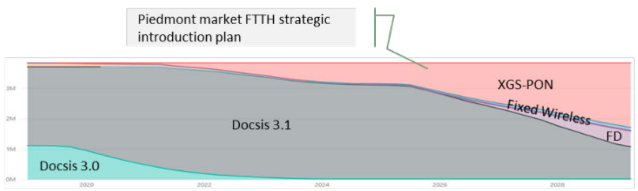
The first area we want to zoom into is technologies deployed as shown in the chart below representing technology per HHP.

In the brownfield case you see the clear impact of the corporate strategy to migrate nodes to FTTH anytime a node needs and upgrade action.

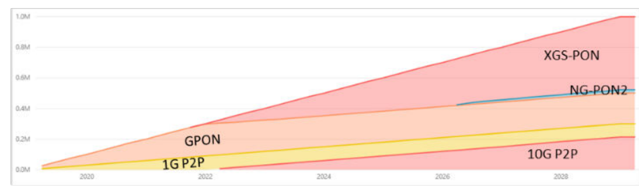
In the greenfield case the graph shows obviously the introduction of the new service endpoints, but a more interesting observation is that there are only very limited technology upgrades for the installed FTTH nodes. This indicates that there is a lot of capacity headroom even for GPON and 1G p2p nodes, giving you the option of delaying the switch to 10G deployments.

The fourth graph in the picture shows the evolution of access network elements in the network starting from 10K to ~60 K. Only ~6k new nodes are introduces because of greenfield expansion. The majority of them are due to HFC node split actions.

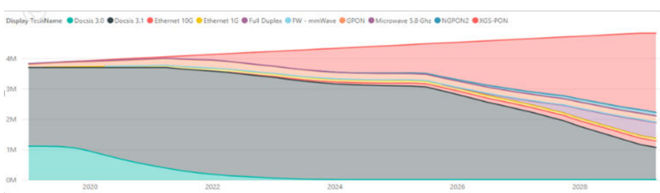
One key observation is that once an area moves to FTTH, the only footprint changes are technology upgrades. This explains why the growth curve is flattening towards the end.

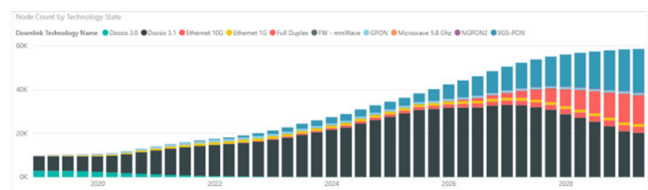


Brownfield technology per HHP



Greenfield technology per HHP


Integrated technology per HHP

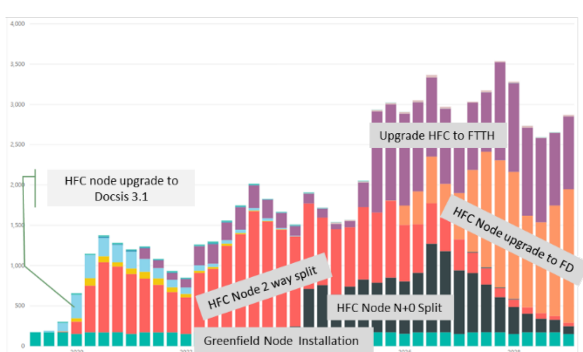

Integrated Node Count per Technology

Another way to understand the impact of a network transformation plan is to look at the number of node upgrade actions that are need for that scenario.

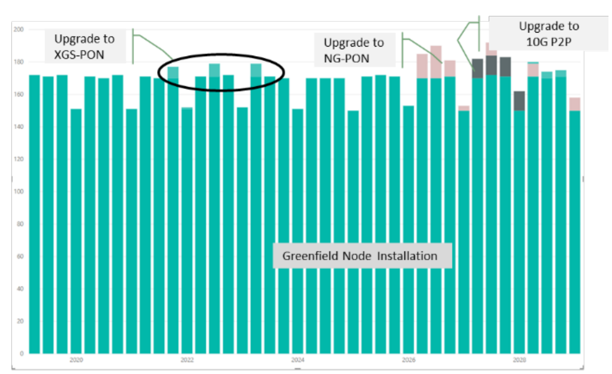
First observation from looking at the integrated activity view is that the number of greenfield activities is barely noticible in comparison to the number of brownfield upgrade actions. But, as we will see in other views, the construction effort associated with these greenfield actions is very significant.

A second observation is that the number of HFC upgrade actions stay significant throughout the complete timeframe. Investigating further will reveal that HFC nodes go through multiple upgrade actions.

A third observation, as illustrated by both the greenfield view and the integtrated view, is the low frequency of FTTH node upgrades.



Integrated activity view

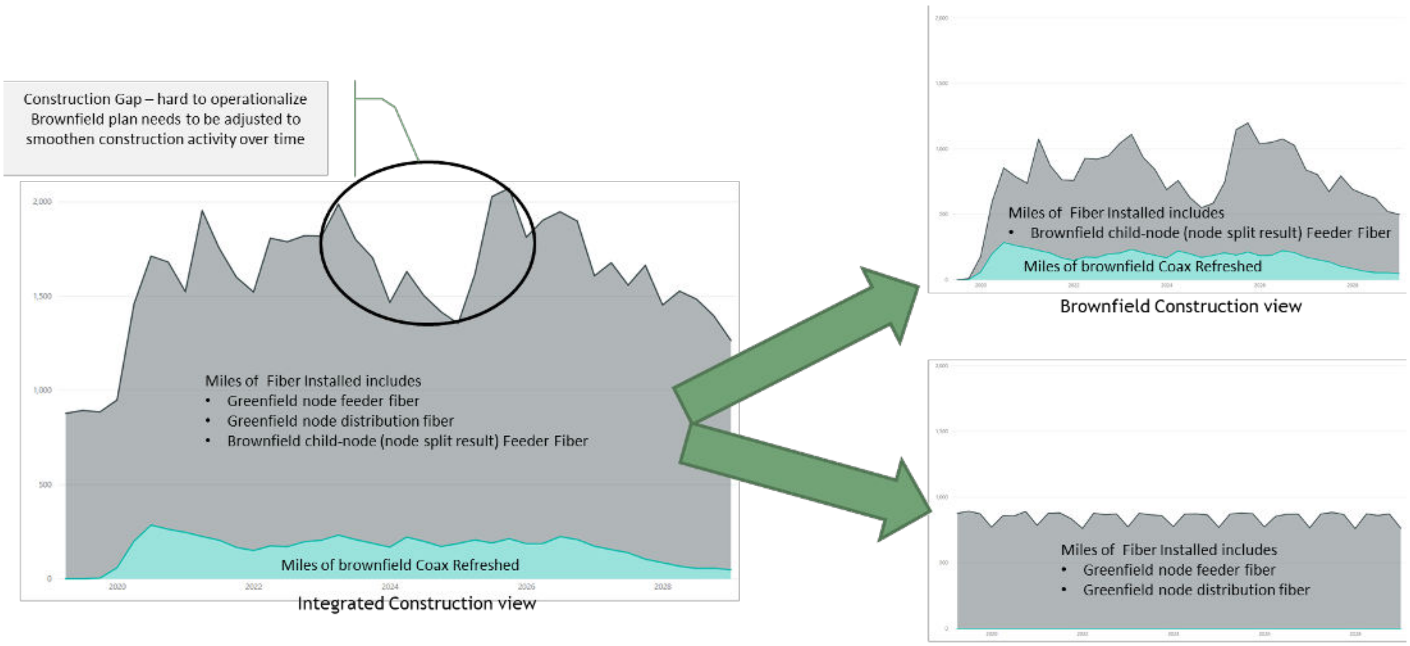


Greenfield activity view

The next set of graphs shows the integrated, brownfield and greenfield view on the outside plant cable construction activities in miles.

This is the view that best shows the impact of footprint expansion on your resource needs. Even though the number of greenfield installation activities per quarter is dwarfed by brownfield activities, the new cable miles that need to be installled accounts for close to 50% of the overall installation activity.

One additional point that can be derived from the greenfield construction view is that once installed, no new construction is required for future upgrades.

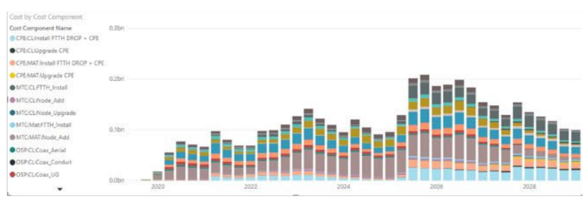


Integrated Construction view

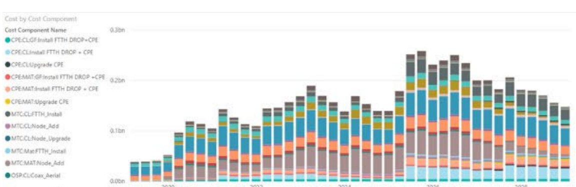
Brownfield Construction view

Greenfield Construction view

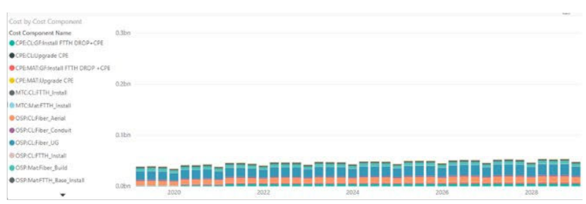
Finally, the charts below show a view of the total cost per cost component per quarter integrated and separated by greenfield and brownfield activities. In real life, a significant effort will go into understanding these charts in great detail. We will cover that in a future whitepaper.



Brownfield Cost component view



Integrated Cost component view



Greenfield Cost component view

JIBE - AN ACCESS TRANSFORMATION TOOLSET

REVOLUTIONARY SOLUTION FOR NETWORK PLANNING

Jibe is a breakthrough interactive tool to create and analyze multi-year access network transformation plans that fulfill your growth requirements, strategic objectives, and resource constraints. Jibe enables you to create the optimal strategy for 90% of your yearly capital investment.

Jibe Capabilities

GUI Driven Planning

- XML Based Topology Input
- Flexible Technology Option Configuration
- Centralized and Distributed Access Definition

Node Level Forecasting

- Granular Activity and Mileage Forecast
- Detailed Resource and Material Forecast
- Comprehensive Cost Forecast

Detailed What-if Analysis

- In-depth Scenario Creation
- Exhaustive Trigger and Constraint Configuration
- Enables Comparing Different Scenarios

Informative Visualization

- Power BI, Tableau Visualization
- Deep Dive to Node Level Forecast
- Highly Capable Metric Generation Tools

Why Jibe?

Too many technologies:
- Node Splits?
-Fiber Deep?
-FTTH?
-Fixed Wireless?
Jibe gives you tools to plan it out

Should I run different deployment strategies for MDU, Business and SFU customers?
Jibe will help you

How in the world am I going to operationalize this plan?
Jibe will help you forecast resources, material etc.

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