An access domain methodology for network transformation

(Republished from ISE November 2019 magazine)

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New service requirements, increased competition and access network convergence drive the complexity and frequency of access network upgrades. A comprehensive methodology is necessary to create a viable access transformation plan and avoid regrettable investment.

What is unique about access network transformation

Access network architectures, designed to funnel data from very many end points to a convergence point, are fundamentally different from any other network architecture. Moreover, while demand growth is the key transformation driver for most of the network it is only one of the factors triggering change in the access network.

The service that can be offered to a subscriber is directly related to the capabilities of the access link connecting the subscriber (e.g. if you want to increase the maximum bandwidth tier from 100 Mbps to 1 Gbps, the access link needs to be able to peak up to 1 Gbps even though the change may only have a minor impact on the average bandwidth consumption and thus not impact the rest of the network). Hence any corporate decision to change service offerings or customer connectivity options (e.g. corporate decision to connect all Multi-Dwelling-Units with fiber for competitive reasons) directly impacts the access network and drives frequent sometimes non-linear1 upgrades. Add-in the continuous need for new access links to serve greenfield areas, new subscribers or new service end-points and you understand why the access network needs constant attention.

Clearly access transformation planning is much more than a simple growth-based upgrade optimization exercise. Given the number of triggers for change and the uncertainty of all inputs [1], tackling the access network transformation challenge can only be successful by evaluating and comparing a significant number of transformation alternative. For this to be feasible in a short amount of time, an access domain specific methodology is needed to automate the heavy lifting of creating an access network transformation plan. This article lays out the high-level steps in an access domain network planning methodology.

What is the problem?

Linear upgrade strategies in a single technology domain are no longer sufficient to keep up with growing service demand and complexity. Building a comprehensive transformation strategy requires deep understanding of the impact of both linear and non-linear upgrade paths. The current tools to build transformation plans are not capable of handling the increased level of complexity.

Key Takeaways

Building tools on this new innovative methodology solves the complexity of identifying viable upgrade paths satisfying all types of upgrade triggers.

Additional benefits can be realized enabling:

- Understanding impact of new technology options.
- Integrated greenfield and brownfield planning.
- Increase insights through what-ifs

Step 1: Understand how access networks can evolve [2]

For any access technology the link capacity per subscriber is defined by 3 components: spectrum bandwidth, spectral efficiency and how many endpoint (subscribers) share the capacity. In access networks only 3 types of upgrade actions are used to improve on one or more components:

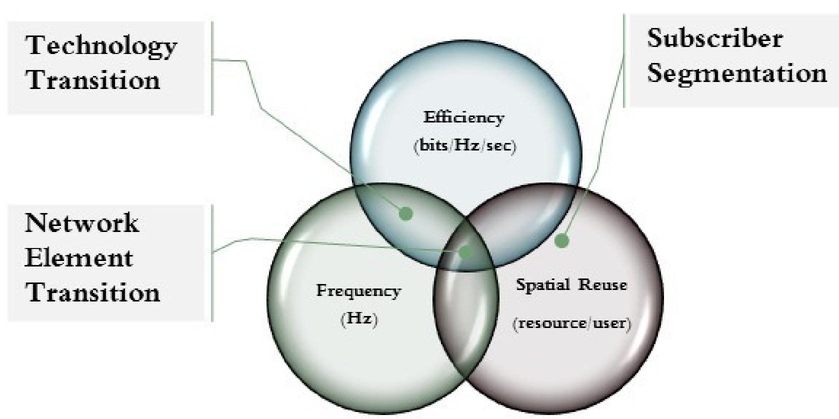


Figure 1: Transformation action basics

Technology transitions = Upgrading the technology of a link to a newer member in the technology family (e.g. ADSL to ADSL2): typically improves the available spectrum as well as the spectral efficiency.

Subscriber Segmentation = Redistribute subscribers on more access links" resulting in more bandwidth per subscriber.

Network element transition = Move subscribers to a different access network element. This is typically done for one of the following reasons:

Shorter distance: Using higher spectrum bands on the access link can negatively affect the distance the signal can reliably propagate forcing the active access network element to be placed closer to the subscriber.

Redistribute subscribers: Segmenting shared media often goes hand in hand with moving subscribers to new smaller network elements typically place closer to the subscriber.

Move subscribers to a new technology family: For instance, changing subscribers for a copper to fiber access technology.

Step 2: Model upgrade paths, triggers and constraints

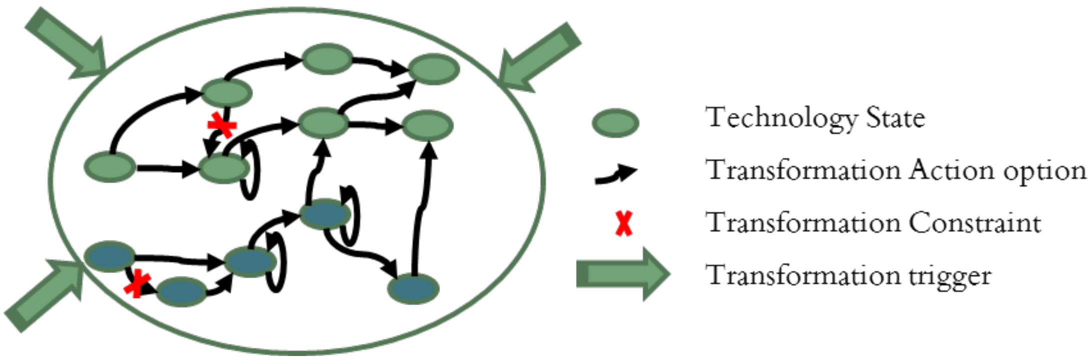


Figure 2: Modelling transformation behavior

From step 1 it is clear that increasing bandwidth capacity of an access link comes down to making changes to the access network element the subscriber is connected to. At any given point in time the access links of a network element are in a specific technology state (e.g. "GPON state"). Therefore, modelling all potential upgrade paths for an access network can be simplified to identifying the upgrade options for each technology state unlocking to key to a straightforward automation algorithm. Ter illustration: instead of specifying complete paths such as: ADSL-> ADSL2 -> FTTN VDSL -> Sealed remote VDSL2 -> ..., and ADSL -> ADSL2 -> GPON -> XGS-PON -> ... simply specify options for each state e.g. ADSL2: option 1 FTTN VDSL, option 2: GPON.

The second part is to model when network elements need to upgrade out of a technology state. A network element is triggered for upgrade either by running out of capacity because of user demand growth or to accommodate policy and service decisions. Growth triggers can be easily modeled by creating profiles defining how subscriber demand is growing year over year. This allows an execution engine to calculate the predicted demand at any point in time and trigger an upgrade if a threshold percentage of technology capacity is exceeded. Policy and service trigger modelling simply comes down to defining when and under what condition an upgrade action will be forced (e.g. in 2020 force fiber to the building for all MDU customer).

Lastly to really have full flexibility in modelling transformation behavior, constraints can be added to the model specifying conditions when potential upgrade options are not available (e.g. In market "A" prevent copper-based upgrade options in Q2 2021)

Step 3: Calculate transformation actions

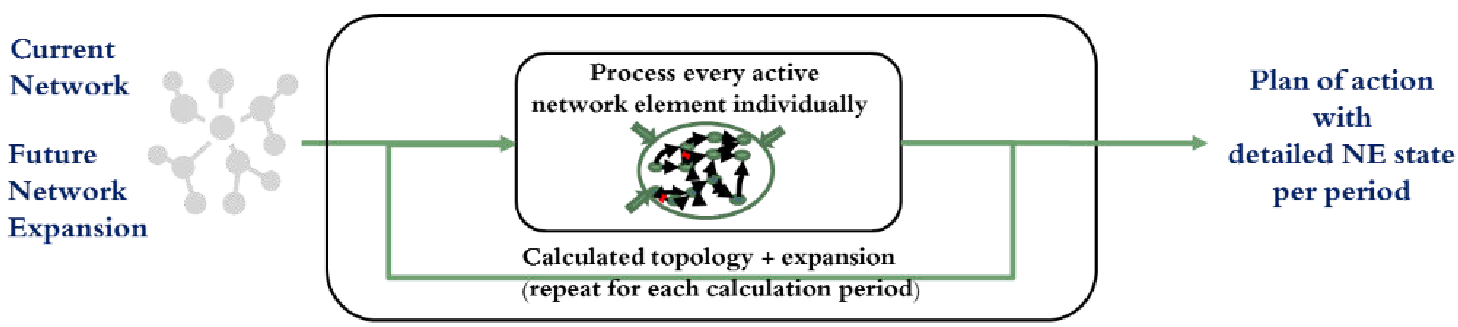


Figure 3: Transformation calculation

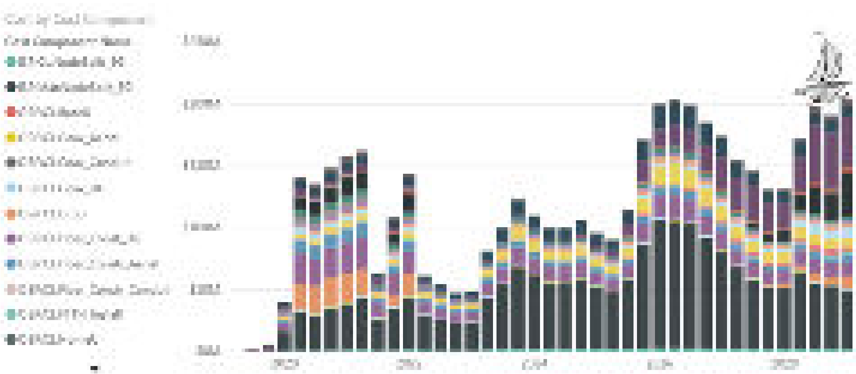
With the upgrade behavior for a network element at a given point in time modelled in step 2, the algorithm to calculate all transformation actions required to keep the access network compliant for an arbitrary time-scope (e.g. 10 years quarterly, 5 years monthly) becomes trivial. Simply start with the current state of the network elements to be analyzed (use either details of real brownfield network or a made-up representative architecture if details are not available). For every calculation period execute follow actions:

add new network elements needed for network expansion (see [4] to understand how to define network expansion with or without details available.)

1. for all active network elements follow the behavior rules (Figure 2) to calculate resulting state or new network elements.
2. use resulting network state as input for next calculation period and repeat.
3. The result of this process will include a detailed view of the network state over time and all transformation actions at the individual network element level.

Step 4: It all comes together

Step 3 completes the methodology to calculate an access network transformation plan for a set of assumptions. That is great unfortunately not very useful. To assess the value of a plan, understand if the plan is implementable, and be able to compare and contrast different plans, much more information is needed. Additional information that any planning method should provide includes at a minimum detailed cost over time, labor and material resource requirements over time, construction activity over time and much more.



Luckily all this information can be defined for each type of upgrade action. With the methodology already calculating individual actions for specific network element at defined points in time all the required details can be easily calculated from the upgrade action definition combined with network element attributes such as household passed, household connected, access and feeder miles etc.

OK, but what about costs that are not related to upgrade activity such as network operations cost. OPEX cost is typically linked to active subscriber count and the access technology used. Since the methodology already identifies the technology state and subscriber count of all access network elements and any point in time, OPEX calculation becomes a straightforward addition.

Almost there, this methodology for even a medium size access network will create millions of data points. To turn all this date into useful decision driving information the results need to be presented in a visualization tool with a template giving immediate enterprise level insights with the ability to zoom in down to the individual network element, specific period and individual component.

Is it worth the effort?

Obviously reducing network transformation analysis time from weeks to hours is in itself a large value. More importantly the benefit of not being limited by the amount or complexity of access transformation alternatives that can be analyzed in a timely manner is immeasurable.

And there is more, once a framework based on this methodology is in place for a network, it makes answering the smaller questions that come up all the time trivial. Some examples:

- What technology/ architecture should I use for a new greenfield area? Run your scenarios for the greenfield footprint and in minutes you will have the best future safe option.
- Competition is rolling out 1Gbps service in city X, what will it take for me to counter? Add the rule to all your scenarios and run for city X to get your best option.
- Do I have the budget and resource to roll out fiber to all MDU customers in market Y?
- What if …? Answer all of them timely with minimal effort.

Finally, not having all the details on your current network architecture is not a showstopper. The methodology can be used to understand the impact of new technology options and/or strategic directions starting from a high-level characterization of the existing network. The latter makes the methodology indispensable in all phases of the access network transformation decision making process.

Intrigued

Find detailed background at First Principle Innovations (**www.fpinno.com)** and check out AP-Jibe a fully flexible access network transformation toolset that implements this methodology and much more.

References

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

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