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Having the Whole Company in a Bag

Mediacom's Real-World Use of Automated Access Network Design and Optimization Technology

A Technical Paper prepared for SCTE by

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1. Introduction

This paper presents findings and insights from Mediacom Communications' application of automated design and optimization (ADO) technology to its access network strategy and planning activities, and to its business-as-usual network design and implementation efforts. Mediacom's decision to adopt ADO technology is discussed in the context of having to make decisions on major capital investments in an environment that requires considering multiple, evolving network technologies and architectures as well as serving a variety of markets ranging from urban to rural, while having too little time to perform the necessary analyses using traditional manual methods.

This paper further describes Mediacom's strategic approach to managing such challenges and how it sees the use of ADO technology being transformative to its operations. The benefits of having 'the whole company in a bag' are discussed in detail. Such benefits include having the ability to ask and answer billion-dollar, footprint-wide questions in hours, as well as the ability to quickly react to network utilization issues and implement solutions on a node-by-node basis that are consistent with Mediacom's network evolution plan. The distinction between the use of actual network designs, as opposed to costing models and rules-of-thumb, in generating bills-of-materials and capital cost estimates, is described in terms of concrete benefits to the capital planning and budgeting process, as well as to construction planning and execution activities.

This paper also describes a unique situation in which Mediacom entered into a competitive bidding process to serve a mid-size US city with symmetrical Gigabit service and, using ADO technology, was able to quickly and confidently evaluate multiple N+X network architectures in terms of technical feasibility and capital cost. Finally, this paper presents and discusses the technical and operational path taken by Mediacom in evaluating and deploying ADO technology.

2. Business and Operational Challenges

Mediacom's network engineering group is constantly working to answer the deceptively simple sounding question: What must we spend on improvements to the access network to ensure it consistently satisfies our customers? Coming up with an answer to that question is fraught with challenges including:

- New and forthcoming transmission technologies that simultaneously offer excellent performance but complicate the capital expenditure decision-making process
- A network footprint that comprises relatively dense urban, medium-density suburban, and low-density rural environments, each presenting unique service requirements and design considerations
- The need to design, budget, approve and deploy network improvements in the shortest possible time to maximize the return on capital and to avoid losing customers to competitors
- Making the highest and best use of the capital funding available for network improvements, regardless of the challenges noted above
- Very long lead times for delivery of equipment and materials which is causing, and is expected to continue to cause, painful delays in network deployments
- The requirement to regularly (semi-annually) review and modify the long-term (5-year) network technology and architecture strategy to keep up with evolving transmission technology, growing customer demand, and competitive threats.

Mediacom, as a profit-making business, also must satisfy its investors that capital investments in the access network have been well planned and accurately budgeted. Similarly, as a telecommunications service provider to the public, Mediacom must satisfy its respective franchising authorities that, in fact, the access network will continue to reliably meet the service requirements of its customers.

3. Adoption of Automated Design and Optimization Technology

3.1. Pilot Project

In early 2020, Mediacom embarked on a program to determine and, over several years, deploy a new network architecture across its entire footprint. At that time, it was expected that most of the network would be upgraded to an N+2 architecture, though N+0 and FTTH architectures would be considered where customer demand warrants. Since then, Mediacom has adopted a network architecture strategy, dubbed Fiber-Deep, that does not call for a fixed maximum cascade length of 2 active devices, instead specifies a range of homes-passed per CMTS port – or Fiber-Deep node – as the determining factor for cascade length.

At that time, Mediacom undertook an evaluation of an ADO technology to determine if that technology could deliver:

- preliminary designs for N+2 architecture access network in accordance with Mediacom's design rules and equipment specifications
- optimization of locations of all new nodes to minimize node count
- fully calculated, technically valid RF plant design
- optimal routing of new fiber cable as required to connect new nodes to the existing fiber plant
- integration with Mediacom's existing plant engineering platform
- amplification of the effectiveness and productivity of Mediacom's existing network planning team
- savings of time and cost relative to manual planning and design methods

The results of the pilot project demonstrated that all of Mediacom's requirements were, or could be, satisfied by the ADO technology under evaluation. Mediacom subsequently decided to implement the ADO technology, commencing in early 2021 and continuing through Q3 of 2021.

3.2. Overview of ADO Platform

The ADO environment comprises three main components and two primary results, as shown in Figure 1. The three main components and the two primary results are:

- Mediacom's existing geo-spatial information GIS/network engineering database containing a complete model of the as-built access network
- a set of network design rules, one for each network architecture that Mediacom wishes to consider, which are created and maintained within the ADO platform, and
- the ADO engine itself, which reads in the as-built access network from the GIS/network engineering database and applies the design rules for a selected new architecture to the as-built network, resulting in
- preliminary designs and cost estimates for the new network architecture.

Mediacom initially utilized ADO to apply network design rules for its 'Fiber-Deep' architecture to its entire network footprint, which resulted in Mediacom having 'The Whole Company in a Bag'.

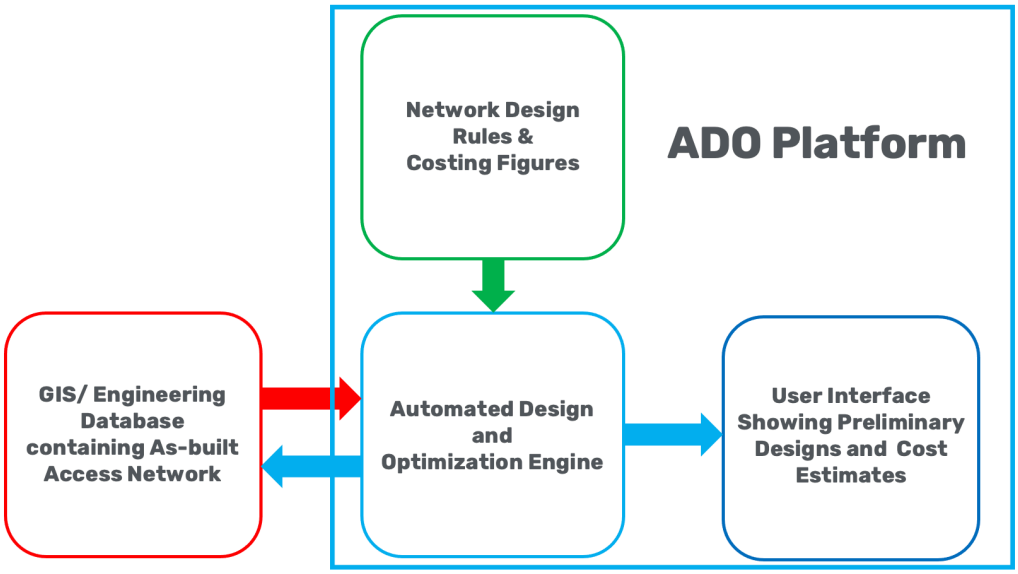

Figure 1 – Overview of ADO Environment and Platform

It is fundamental that the GIS/network engineering database be complete and accurate, otherwise the resulting preliminary designs and cost estimates will be incomplete and inaccurate. Mediacom, along with most major operators, has invested significant time and money in recent years in ensuring that its GIS/network engineering database is complete and accurate and, with the availability of ADO, is seeing a return on that investment beyond its previous expectations.

By serving as the repository for all of design rules for multiple network architectures, the ADO platform allows Mediacom to centrally develop, easily deploy and automatically enforce corporate design standards. This results in all preliminary designs and cost estimates being compliant with corporate standards, thus eliminating the typical variations that occur when multiple planners and network designers are each producing preliminary designs manually. The design rule sets in the ADO platform can be configured to allow the individual planner or designer to adjust certain design parameters, such as the use of express coaxial cable, and execute multiple designs runs to arrive at a preliminary network design that incorporates the insight of the planner or designer while remaining compliant with corporate standards.

The resulting preliminary designs can be viewed in the ADO user-interface in map view (geographically on a scaled land-base, including a satellite photo base) and schematically (in a simplified view that shows user-selected technical details, such as signal levels, active device cascade lengths, and cable lengths). The network designs are stored in the ADO platform's internal database for as long as required, which is typically until a new network architecture is decided upon and preliminary designs are then produced accordingly, or until a network deployment is decided upon and the preliminary designs are exported from the ADO platform to the GIS/network engineering database to be the basis for production of final design and construction drawings.

The cost estimates (and underlying bills-of-materials) are similarly stored in the ADO platform's internal database and are viewable in multiple formats via the user interface. They can also be exported for use by other software platforms within the network engineering group and within other groups in Mediacom.

3.3. Designs Versus Models

Traditionally, the operator's network planning personnel estimate access network deployment costs by manually producing a costing model whereby preliminary designs are developed for a relatively small portion of the network footprint in question, cost estimates are tabulated based on those few designs, then those cost estimates are extrapolated across the network footprint. Typically, the costing figures in the cost model are over-estimated by a significant amount to ensure that they do not prove to be unmanageably low. While this approach allows network planning personnel to provide information to support senior management in a timely manner, the cost model is necessarily subject to an undesirable degree of uncertainty, which in turn leaves the planners and senior management having to make major capital decisions with less-than-ideal information at hand.

The application of ADO technology offers the operator the opportunity to develop preliminary designs and cost estimates for multiple network architectures across the entire network footprint in the same, or less, time than required to manually develop sample designs and to extrapolate a cost estimate. By virtue of the speed of the ADO processing engine and of every single foot of the access network being processed to develop preliminary designs for a new architecture, there is no modelling required to develop the corresponding cost estimates. Rather, the ADO processing engine applies the operator's standard equipment, cable, and installation costing figures to the bills-of-materials for the preliminary designs to provide costing for every item of new equipment and cable, and for the construction labor to install same.

While it is understood that the preliminary designs, and resulting cost estimates, are subject to change during field validation and construction, that degree of change – or uncertainty – is much less and more easily managed than is the case with manually produced design and costing models.

Further, by having legitimate preliminary designs for the entirety of the network footprint in question, any questions as to the validity of the preliminary designs and the corresponding cost estimates can be very quickly addressed because all of the designs can be viewed on-demand both in map view (geographically on a scaled land-base) and schematically (in a simplified view that shows user-selected technical details, such as signal levels, active device cascade lengths, and cable lengths).

Ultimately, Mediacom expects that the application of ADO will simplify and expedite capital planning for access network upgrades by making better quality network planning information more accessible than previously possible.

4. Whole Company in a Bag and Why That's a Good Thing

Planning and budgeting for access network upgrades is more complex than ever before and has become a costly, full-time activity given the rate of development of new transmission technologies, competitive threats, and increasing customer demands. At Mediacom, the 5-year plan is updated semi-annually, which has required a significant allocation of personnel to carry out using traditional manual processes. The application of ADO to produce the Whole Company in a Bag, that is: A set of preliminary designs and cost estimates for Mediacom's current standard Fiber-Deep architecture, has given Mediacom a comprehensive and accurate baseline for use in planning and budgeting of access network upgrades - for the entire network footprint. Importantly, this capability obviates the need to invest time and money in manual production of preliminary designs which are often superseded by changes in technology by the time a given portion of the footprint is scheduled for upgrade.

Furthermore, by being able to produce, on demand, preliminary designs and cost estimates for alternative network architectures, Mediacom can quickly evaluate and compare each alternative network architecture in terms of equipment and cable quantities, and construction costs. This allows Mediacom to very quickly:

- update its long-term planning and budgeting by processing the entire footprint when needed, which satisfies the need of senior management for long-term planning information, and
- select and deploy the ideal network architecture for any portion the network footprint in question, which is particularly important given Mediacom's mix of urban and rural serving areas.

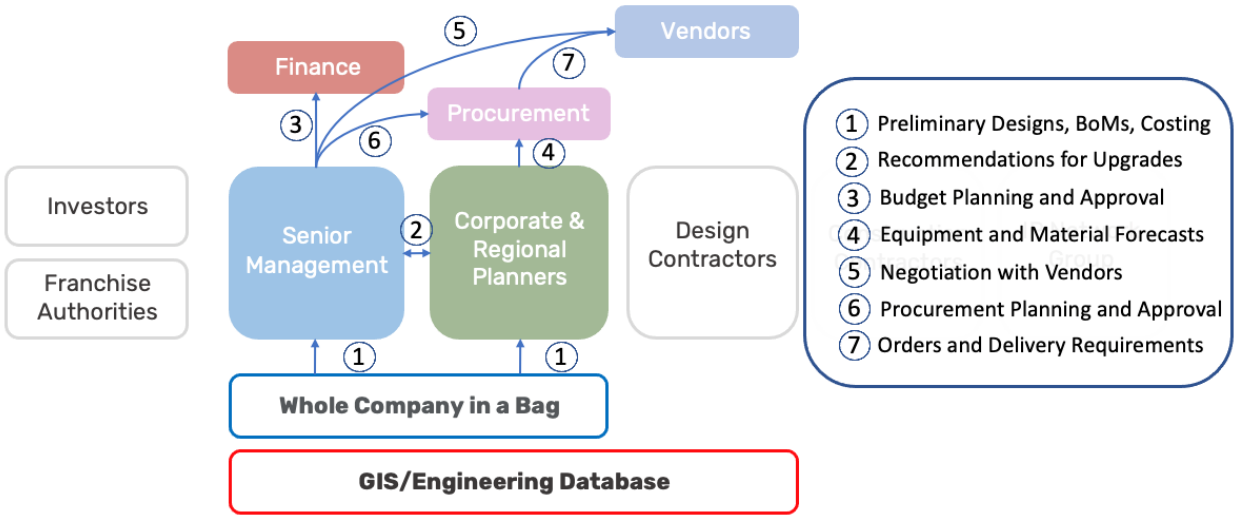

Figure 2 – Long Term Planning Activities

Traditionally, Mediacom has identified and upgraded single nodes to address congestion or other service issues. This approach has allowed Mediacom to keep up with customer demand but doesn't allow for any consideration of a more comprehensive and cost-effective approach to improving the surrounding larger portion of the network footprint.

The use of ADO allows Mediacom to do exactly that. For example, the entire serving area of a hub can be processed by the ADO platform practically as quickly as one or two nodes, allowing Mediacom to

identify opportunities to not only immediately upgrade problem areas, but to do so in a way that supports the eventual upgrade of the larger surrounding area and affords time and cost savings.

Mediacom expects this capability to become even more important when considered deployment of a Distributed Access Architecture (DAA) because the equipment complement in a hub will be reduced as DAA nodes are deployed in the access network. By using ADO to produce DAA preliminary designs for an entire hub serving area, Mediacom's access network planners can give their colleagues responsible for inside plant systems and technical facilities the information they need for their planning and deployment efforts. Similarly, Mediacom can then identify costs (and ideally overall cost savings) across its technical facilities, inside plant systems, and the access network when planning a DAA deployment.

An immediate benefit of having the Whole Company in a Bag is that serving areas that are well out of compliance with any current Mediacom network architectures can be easily identified when processed by the ADO platform against Mediacom's Fiber-Deep design rules (or, any other current architecture design rules) because the resulting cost estimates are higher than the average cost per node. This allows Mediacom to prioritize those network serving areas for upgrade or, if required, immediate maintenance work.

As noted in Section 3.2, the preliminary designs can be viewed in the ADO platform's user-interface in:

- map view, geographically on a scaled land-base, including a satellite photo base, and
- schematically, which is a simplified view that shows user-selected technical details, such as signal levels, active device cascade lengths, and cable lengths.

The various views allow Mediacom personnel to intuitively grasp the fundamental design characteristics of the proposed network itself and, by being able to see the network on a satellite photo base, assess its suitability to the physical topology of the serving area and distribution of the customer premises therein.

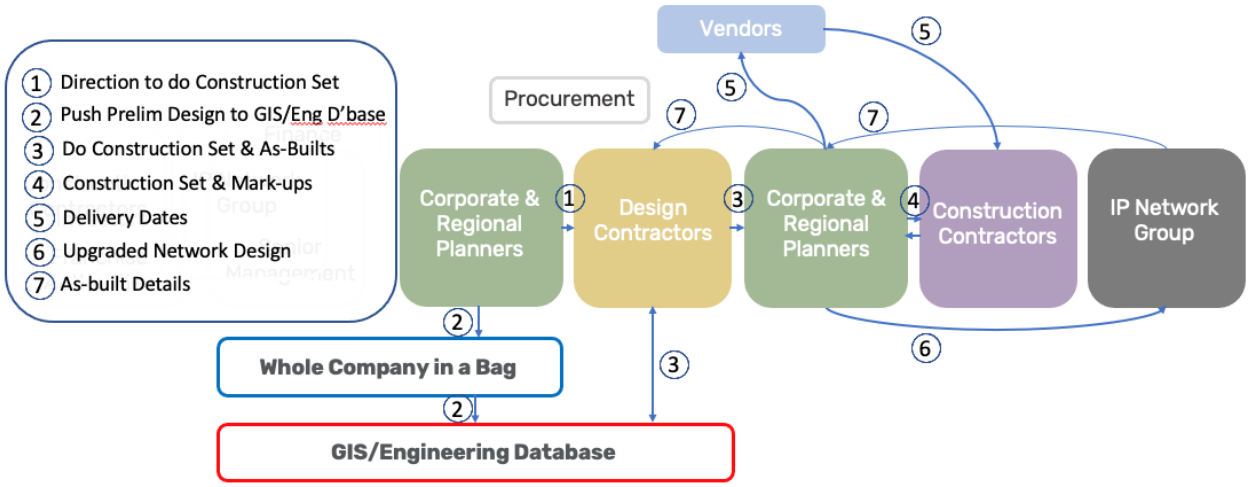

Figure 3 – Network Planning and Deployment Activities

Overall, Mediacom has seen a reduction in time for approval of network design for any area to be upgraded of two to four weeks. This is primarily due to having pre-approved preliminary designs for the entire footprint already 'in the bag'. Also, network planners at corporate and in the regions can see exactly the same designs at the same time, allowing them to collaborate very effectively to arrive at an agreement on exactly what network architecture to deploy by using the ADO platform.

It is noted that the aforementioned time savings do not include any time savings in the production of construction drawings expected by having the preliminary design from the ADO platform as an advanced starting point.

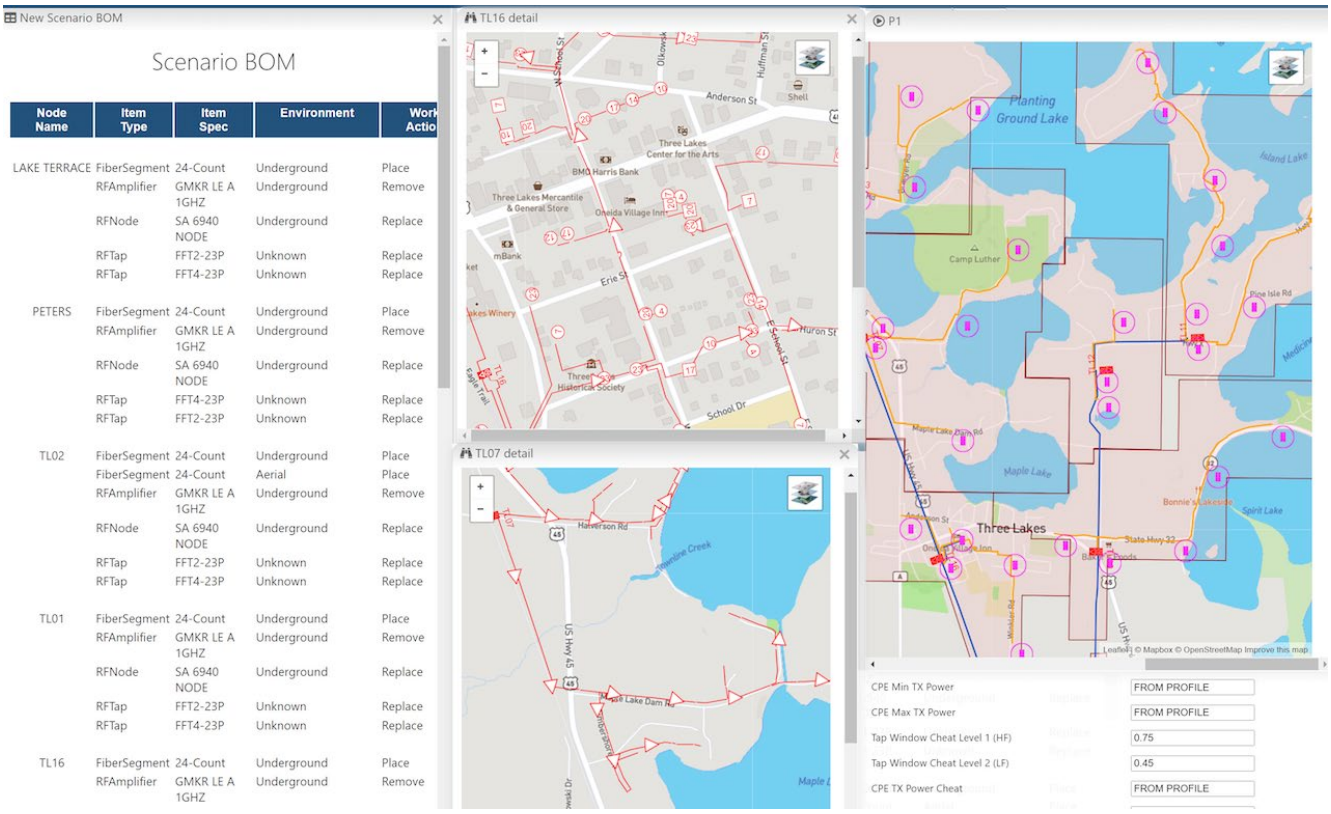

Figure 4 – Screenshot of User Interface – Network Map View

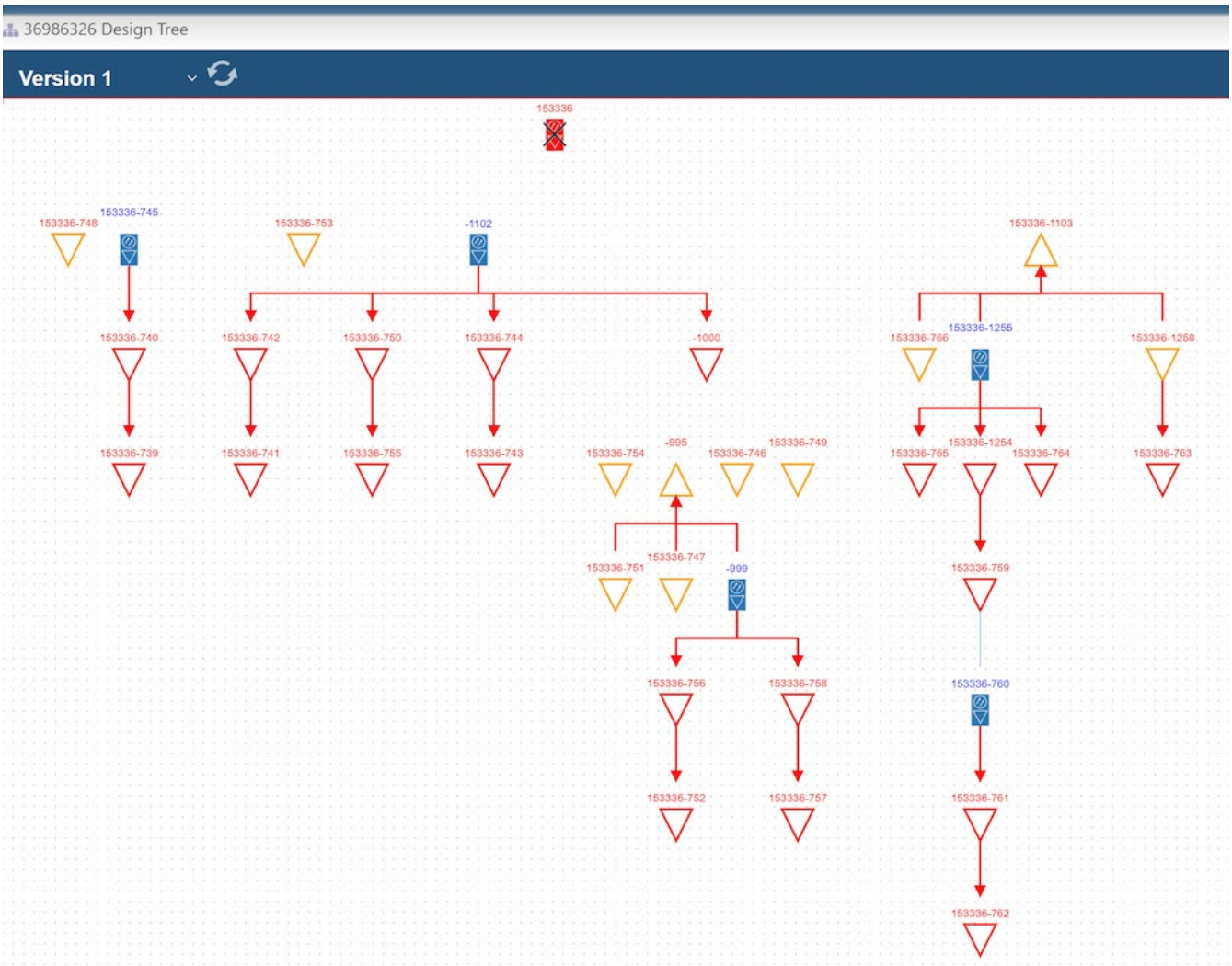

Figure 5 – Screenshot of User Interface – Network Schematic View

As much as Mediacom dedicates a great deal of time and money to ensuring its customers are very happy with their services, Mediacom must also ensure that its investors and its franchise authorities are confident that Mediacom is fulfilling the company's respective commitments.

By being able to provide investors with comprehensive insight into the company's capital expenditure and network upgrade plans, Mediacom can best maintain the confidence of the investor community, which is fundamental to ensuring access to capital funding.

Similarly, the franchise authorities must be confident that Mediacom is going to fulfill its obligations under the respective franchise agreements. Using ADO, Mediacom's ability to demonstrate (at an appropriate level of detail) its network upgrade plans and to, as a normal course of business, move increasingly quickly to maintain and improve the quality of the network.

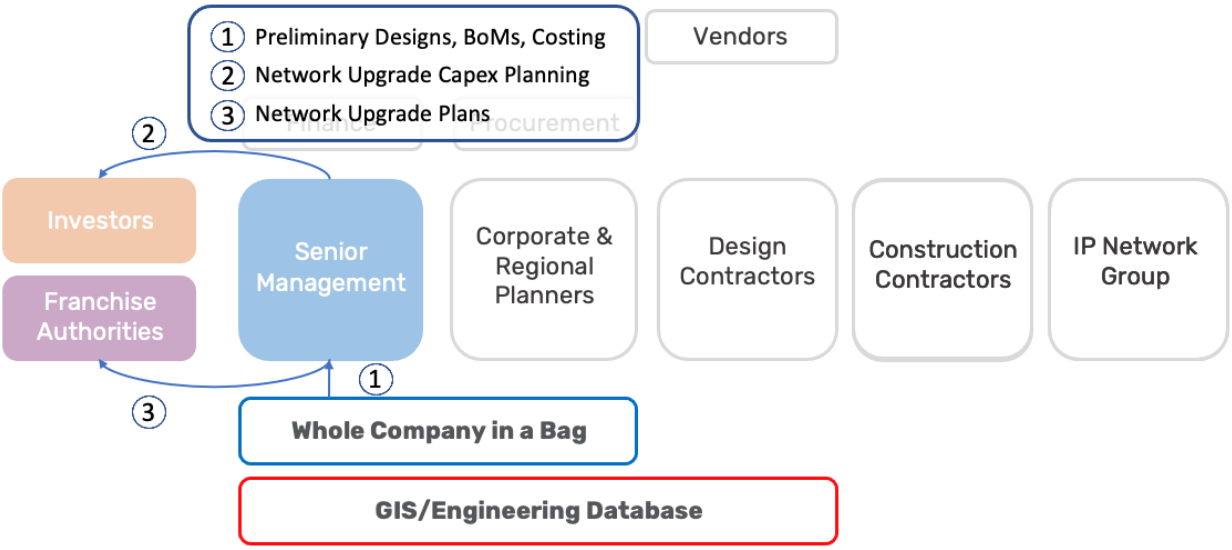

Figure 6 – Relations with Investors and Franchise Authorities

5. N+0 Planning – A Real World Example

In early 2021, Mediacom participated in a competitive bidding process that was set out by a mid-sized city wherein Mediacom is the incumbent service provider. The city solicited proposals from several service providers with regard to obtaining the highest possible bandwidth connectivity for all of the city's residents and businesses.

For the purposes of meeting the city's deadline for submitting its proposal, Mediacom utilized traditional network planning and cost estimation techniques for a N+0 network architecture. Subsequently, Mediacom utilized ADO to obtain more detailed and comprehensive designs and cost estimates in order to prepare for negotiations with the city. This was important given that the city was proposing to contribute funding to the network deployment effort. As a result, Mediacom was required to clearly demonstrate that its proposal would provide the most technically advanced service to its customers at the lowest possible cost.

In utilizing ADO, Mediacom was able to:

- quickly develop proposals for several different service levels, corresponding architectures, and respective costs thereby providing the city with a comprehensive range of options, instead of only one
- confidently compare (lower) capital costs of HFC upgrade options with the cost of building and FTTH network (as proposed by others)
- demonstrate that the deployment of its proposed network architectures would be much less physically disruptive to the community by virtue of maximizing the use of its existing access network
- be highly responsive to the city's requirements and strengthen the working relationship between itself and the responsible city officials.

Mediacom's application of ADO to the competitive proposal process demonstrated that having network designs and cost estimates for the entire access network footprint in the city, as opposed to only sample designs of parts of the footprint and costs extrapolated therefrom, allowed it to manage a significant competitive threat more effectively and confidently.

As noted previously, Mediacom operates under numerous franchises granted by the respective franchise authorities, which can prove challenging at times. In this situation, Mediacom was able to demonstrate a high degree of responsiveness to the franchise authority by providing a very detailed and well considered proposal which can only have a positive effect on Mediacom's working relationship with the franchise authority's personnel.

6. Deployment of ADO

Mediacom undertook a phased approach to the deployment of the ADO platform, with Phase 1 being to obtain 'the whole company in a bag' to support senior management in capital planning and other corporate-level activities, and Phase 2 being to implement ADO functionality for business-as-usual planning and design to support corporate and regional planning, design, and construction activities.

Phase 1 involved a number of activities including:

- development of Design Rules for Mediacom's Fiber-Deep architecture, which is Mediacom's default, or baseline, network architecture for purposes of corporate-wide capital planning and for considering any particular network area for upgrade,
- processing of Mediacom's by the ADO vendor of Mediacom's GIS/engineering database of the as-built network to produce Fiber-Deep preliminary designs and cost estimates for the entire network footprint, which were stored within the ADO platform's internal database,
- definition of Mediacom's requirements for querying the Fiber-Deep database, which were then implemented as functions within the user interface, and
- delivery of the user interface as a web-based portal into the Fiber-Deep database maintained on a server within the ADO vendor's IT infrastructure.

By pioneering the use of ADO technology, Mediacom was able to exert significant influence over the functionality and general design of the user interface and the Fiber-Deep database queries during the deployment process. This allowed Mediacom's senior management to obtain value from the ADO platform relatively early in the deployment process.

Phase 2, being focused on business-as-usual activities, involved:

- significant interaction with Mediacom's network planners at the corporate level and in the regions to ensure that the functionality provided by the ADO platform was truly useful in terms of time and cost savings in their day-to-day activities,
- implementation of an interface between the ADO platform and Mediacom's GIS/engineering platform so that the ADO platform
    - had on-demand access to the data therein describing the as-built access network configuration, thereby ensuring that any preliminary design produced in the ADO platform would be based on the best available information, and
    - can export selected preliminary designs to the GIS/engineering database so that network planners and design contractors could use those designs as the basis for completing detailed designs and construction drawing packages, thus saving a significant amount of time and effort in that process.

As with any major deployment of new technology, there were a few interesting, and some critical, factors to the successful implementation of the ADO platform, including:

- having to invest some time and expense to process the legacy computer-aided design (CAD) data within the existing GIS/engineering platform database into fully modelled data to ensure that the ADO platform could function optimally, which work was carried out in 2020 on the expectation that the ADO platform deployment would occur in 2021,
- working with the vendor of the GIS/engineering database to implement the interface between that system and the ADO platform so that the GIS/engineering database vendor could ensure that the ADO platform could read from and write to that database with no risk of data corruption,

- dedicating a reasonable amount of time on the part of a few senior Mediacom personnel on a weekly basis to working meetings and technical discussions to, most importantly, convey Mediacom's technical and operational requirements to the ADO platform vendor,
- revising the deployment plan at the kick-off meeting to include the N+0 planning work (christened Phase 0) described in Section 5 above, which involved developing N+0 Design Rules and applying them to the as-built network in the city in question to produce two sets of preliminary designs and cost estimates within 90 days
- engaging in regular discussion within Mediacom and with the ADO platform vendor to develop a working understanding of how Mediacom's internal processes will be improved, and
- communicating process changes to Mediacom personnel not originally involved in the deployment of the ADO platform but, nonetheless, affected by its deployment and adoption.

Phase 0, the N+0 planning work was executed in Q1 of 2021 while Phase 1 was executed in Q2/Q3 and Phase 2 in Q3.

Mediacom anticipates continued expansion of the ADO platform in terms of network design capability, e.g., FTTH, and supporting a broader group of users that would benefit by having access to the ADO platform. It will certainly take some time and effort to bring the broader user group onto the ADO platform, if only because people are naturally reticent to change the way they do their jobs, but the benefits to be gained by using ADO technology are expected to far outweigh the adoption costs.

7. Summary and Conclusions

Mediacom has found that the adoption of ADO technology does enable evaluation of the technical and capital costs characteristics of access network designs much more comprehensively and quickly than was previously possible.

While it was expected from the outset that ADO technology would immediately benefit those directly involved in network planning and engineering. It became increasingly apparent that the use of ADO technology – specifically, the data within the preliminary designs and cost estimates it produces so rapidly – has conferred benefits on practically every group within Mediacom involved in the funding, design, construction, and operation of the access network.

The increase in confidence and the saving of time afforded by having easy access to preliminary designs and cost estimates for multiple network architectures for network areas as small as a single node and as large as the entire footprint has allowed Mediacom to execute its access network upgrade strategy significantly more efficiently and effectively.

Interestingly, Mediacom's ability to work with external groups – investors, franchise authorities, and vendors – has also been enhanced by being able to provide clearly and consistently each of those groups with information they need to best understand and support Mediacom's access network upgrade strategy.

As Mediacom gains more experience with ADO technology, it is anticipating opportunities for automation of the design of power distribution for HFC networks and of FTTH networks.

Finally, it seems that, whereas 'having the whole company in a bag' was coined to refer to having at hand designs covering all of Mediacom's access network footprint, it more accurately means having designs for entire footprint in one place AND having everybody in the company who cares about the access network working together better than ever.

Abbreviations

ADO	automated design and optimization
CAD	Computer-aided design
CMTS	cable modem termination system
FTTH	fiber to the Home
GIS	geospatial information system
IP	internet protocol
IT	information technology
N+0	node plus zero active RF devices in cascade on a single coaxial cable leg of access network
N+2	node plus 2 or less active RF devices in cascade on a single coaxial cable leg of access network
N+X	node plus 0 or more active RF devices in cascade on a single coaxial cable leg of access network
RF	radio frequency
Q1	first quarter of calendar year
Q2	second quarter of calendar year
Q3	third quarter of calendar year
Q4	fourth quarter of calendar year