Arttu Purmonen, Vice President

INTELLIGENT TOOLS TO INCREASE UPTIME IN THE HFC PLANT

This white paper is of primary interest to the Cable Executive who is looking for practical tools in their toolbox to cut costs, extend the life of their network and increase customer satisfaction.

TELESTE

Winter 2000, Northern Finland

Although it was the best season to observe northern lights, this was not cheering up a cable television technician who tried to locate the source of ingress. A layer of snow over 3 feet deep crowned the street cabinet, and it took an hour to shovel the snow away. Sweat poured into the eyes of the technician when he placed a return-path attenuator into the RF port. A call to the Network Operating Center personnel was short; it was the wrong cabinet. The cabinet stayed behind when the technician started to navigate towards the next street cabinet.

Summer 2000, South Finland

Teleste's R&D heard what operators in Northern Finland and in Switzerland were experiencing in two sporadic cases. The dots were connected. These operators wanted to eliminate truck rolls, or at least reduce them by over 50%. After gallons of Finnish coffee, in the country known as a number one coffee consumer in the world, the first compact fiber nodes with transponders were sketched. But the story had just begun.

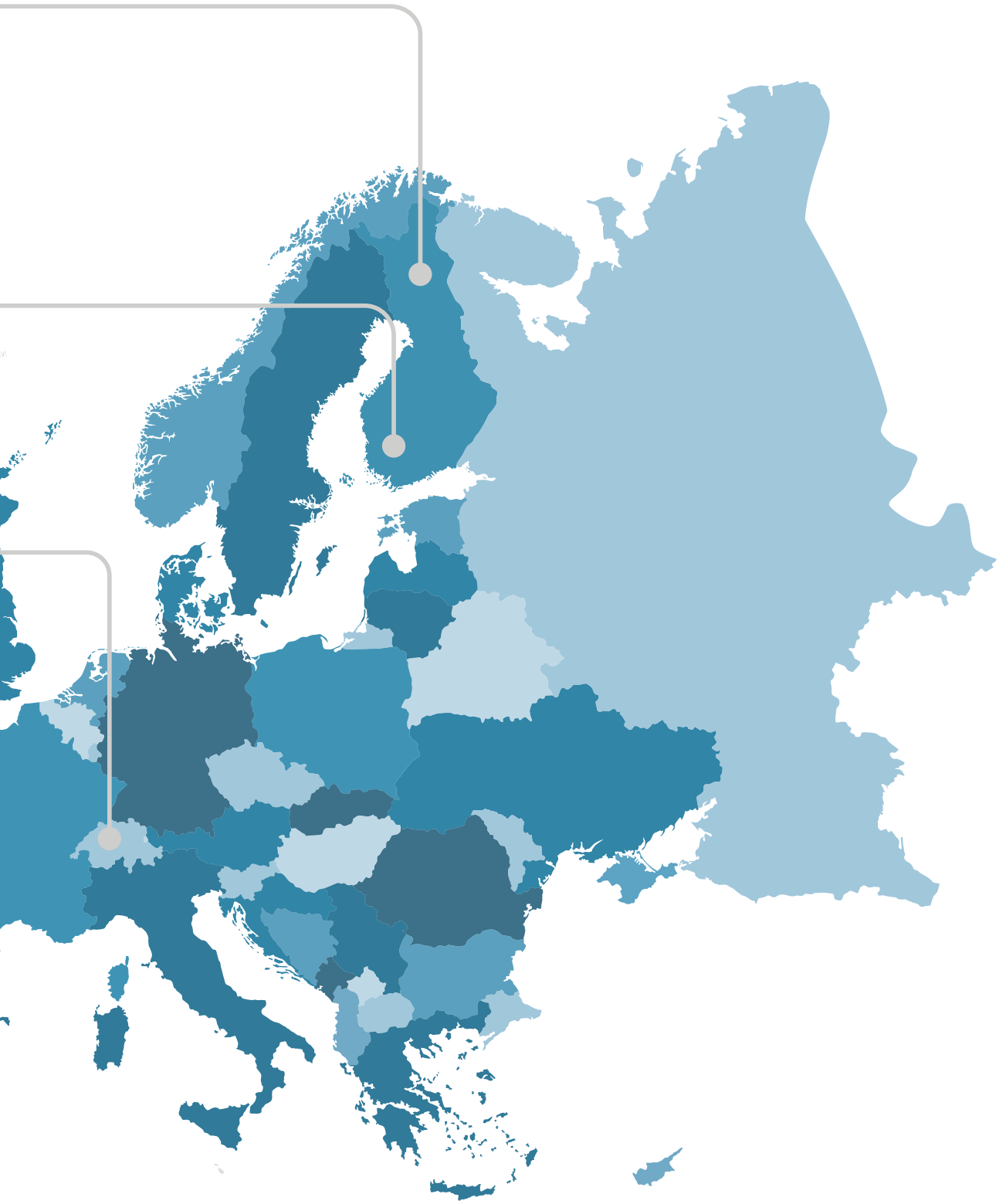
Spring 2000, Switzerland, Zurich

A cable television operator was struggling. It was forbidden to drive in certain luxurious areas during the nighttime. Truck rolls were simply not allowed, although consumers in these areas expected short repair times.

From 2000 Onwards

The first compact fiber nodes entered European cable television space in 2001. Now operators had intelligent substrates in their network and new use cases for them continued to grow. Some wanted to have remotely controlled ingress switches and attenuators, some wanted to see downstream spectrum, some were keener to solve upstream issues, some wanted to automate all adjustments, and some wanted to automate all configuration and alignment work. Every operator wanted to solve problems before end customers called the helpdesk and tickets were created.

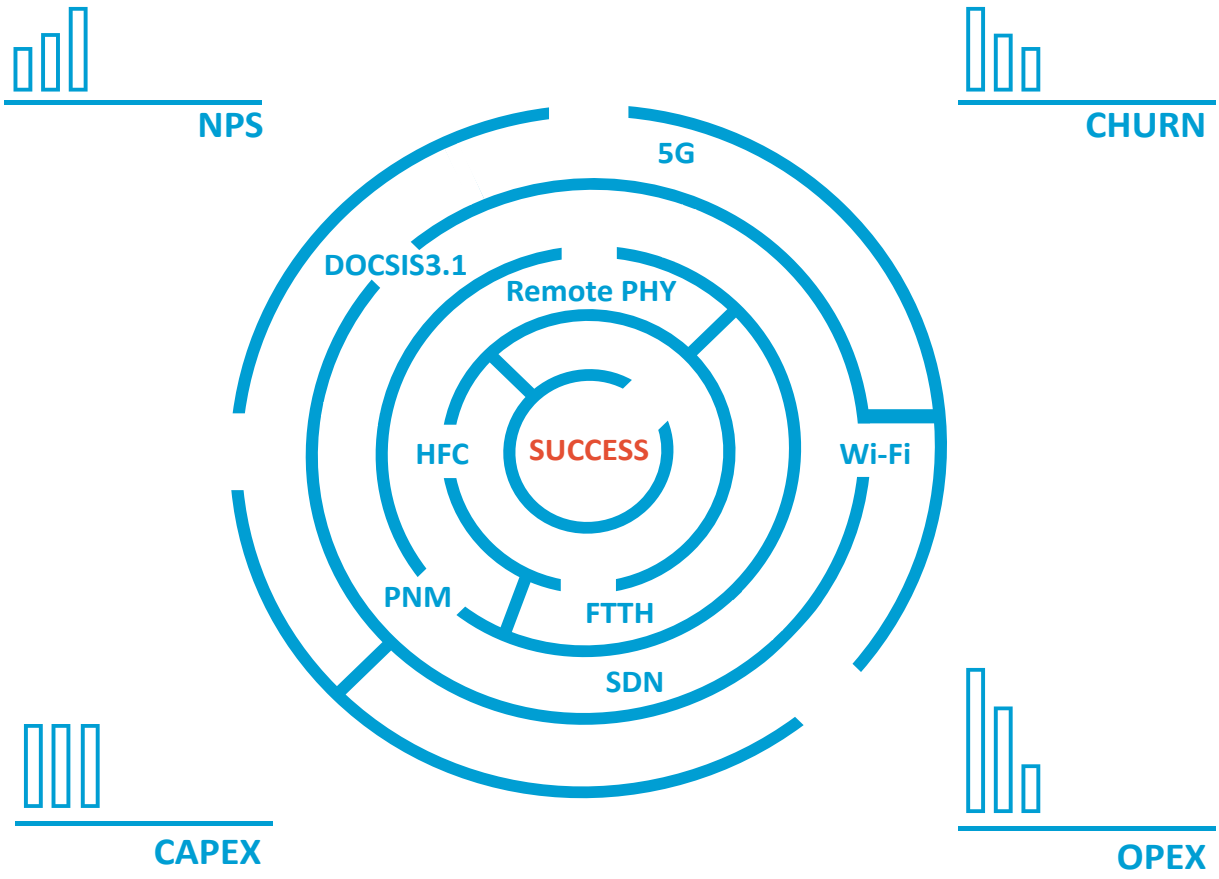
Today, Teleste's intelligent fiber nodes are found in almost every European country, used by the biggest operators and their peers [1] – [11]. Why? Only some European countries have a thick snow cover in winter, and only some cities have luxurious areas forbidding truck rolls. Because futile truck rolls are expensive, even if snow doesn't exist, because OPEX and customer satisfaction are discussed by executives of all operators. Next, we will discuss these pivotal challenges, namely OPEX and the loyalty of an operator's customers. What kinds of tools exist to vanquish them? How have scholars and industry practitioners addressed these issues?



ABSTRACT

Managing churn and operational expenditures (OPEX) forms a focal challenge for cable television operators in an increasingly competitive environment with FTTH being deployed and 5G wireless services on the horizon. Technical Operations Management and Senior Executives are looking for tools to decrease impairments in the HFC plant to increase service uptime. In spite of an ever-increasing need for service uptime, the operators need to find new ways to reduce OPEX of their HFC Outside Plant infrastructure. Although these challenges may be seen as contradictory, the cable executives are paradoxically forced to solve them both, due to a rapidly changing market and technology space. Solving the paradox requires increased productivity through automated self-learning solutions. Marshaling all future options, such as Proactive Network Maintenance (PNM), DOCSIS 3.1, FTTH, Remote PHY, Wi-Fi and software-defined networking (SDN), is an exceedingly complex task.

This white paper is of primary interest to the Cable Executive who is looking for those extra tools in their toolbox to cut costs, extend the life of their network, and increase customer satisfaction. It should also be of primary interest to the Technical Operations Management and Network Maintenance personnel who are looking to understand how Intelligent Network solutions can close the gap on understanding and controlling Outside Plant issues as they occur. We will conduct a literature review as a means of discussing how existing articles consider network OPEX, customer churn, PNM, and software-defined networking. A plethora of identified research gaps and missing empirical evidence is briefly discussed, but our focus is on offering concrete tools. The tools can, as the empirical evidence proofs, solve many identified issues today.



Marshaling all future options is an exceedingly complex task.

REDUCING THE OPEX OF FIXED LINE TELECOM OPERATORS, AN UN-ANSWERED QUESTION

A general model for the operational expenditures (OPEX) of Telecom operators was described in 2005, but the model did not quantify the impact of new technology [12]. Later research considered this gap by asking 'How Can a Mobile Service Provider Reduce Costs with Software-Defined Networking?' [13]. In this study, the reduced manual configuration work and better testing abilities ahead of service rollout were found to be the key reasons why operative expenditures were lower [13]. Unfortunately, scholars have not studied how operators, besides Mobile Service Providers, can reduce OPEX. Could it be that fixed line operators have not shown interest, and academia is unaware that operators are interested in reducing OPEX?

Actually, this is not the case, as a 2009 survey has already pointed out [14]. While some respondents in the survey were pure mobile operators, operators operating fixed lines also participated. In one part of the survey, all operator answers were divided into two general streams, indicating their Operational Support Systems (OSS) motivations.

Two-thirds of the responses belonged to this category:

'Motivations are the desire to decrease time-to-repair, decrease OPEX, and improve customer satisfaction by quicker response to new requirements and customer complaints.'

One-third belonged to this category:

'These operators felt that OSS would be outsourced. The out-sourcing scenario was partly motivated by internal failures and a desire to give the problem to someone else.'

As the same survey concludes:

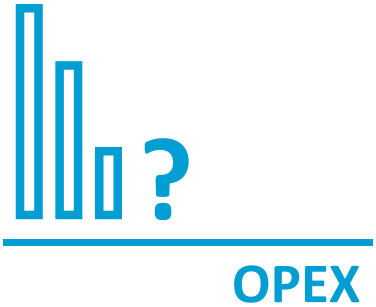
'The most important conclusion is probably that there is a great potential to further network management research by working closer with service providers. There is a gap between the current research efforts which typically focus on new software architectures and protocols and the telecom companies that have other priorities.'

Did this survey embolden scholars to close the gap? It did, but only partly in 2012, when network management was rethought [15]. Unfortunately, once again, mobile service providers stole the show:

'We studied an alarm and trouble-ticket database from a mobile service provider in order to understand the first level of the taxonomy.'

Today, to the best of our knowledge, the question 'How can fixed line operators reduce OPEX?' remains unanswered. Perhaps certain studies lightly touch on the subject, giving guidelines regarding the scale benefits [19], energy efficiency [20], and overall performance [21].

Obviously, many industry practitioners have asked this question behind closed doors, but due to their confidential nature, these studies are not generally available. Global management consulting companies have published some OPEX-related studies lightly touching on the subject; typically, the last page of these studies gives contact details, motivations for this can be speculated [16] [17] [18].



Summary:
Existing, publicly available material does not properly answer the question on how fixed line operators can reduce OPEX.

REDUCING CHURN THROUGH NETWORK RELIABILITY

Customer satisfaction and churn

A straightforward and perhaps brutal way to measure customer satisfaction is to measure churn instead of customer satisfaction; therefore, we will next elaborate on the churn. The actual churn rates of cable television operators are discussed less frequently. Still, some operators share this information publicly, and some operators share background information that can be used to calculate churn rates [22] [23] [24]. Based on publicly available information, we can state that the churn rate of triple-play customers seems to be lower than the churn rate of single-play customers. This statement is in line with the findings of scholars who report a remarkable correlation between the churn rate and service bundles, i.e. bundling does reduce churn [25] [26] [27]. An important factor impacting the churn rate is the customer switching cost, meaning the cost that consumers encounter when switching service providers [28]. The switching cost in the cable television industry varies, but one study found it to be approximately $109 [29]. The annual churn rates in the cable television industry are seldom reported, but the few reported churn rates range between 10% and 32% [22] [23] [24]. The large variation between churn rates, especially between the churn rates discussed publicly, can partly be explained by the unclear terminology. When a cable television customer stops ordering broadcast television services but continues ordering broadband data services, the customer might be called a churner, a service churner or a 'cord cutter'.

Network reliability and churn

A study focusing on internet service providers (ISPs) revealed that network service reliability explains 64% of the variability in customer retention rates [30]. However, service reliability is an experienced measure if quality exceeds customers' expectations, and the expectations are partly set by the service providers [31]. The experienced service reliability might also be low due to the fact that some consumers do not know how different applications should be used. Unfortunately, it does not matter why customer departures happen; when people experiencing low internet speeds due to faulty Wi-Fi settings are churning, they are still churners, even though the lack of wireless 'fidelity' is caused by the way in which they themselves configured the settings.

Another study addressed network reliability to a certain extent: researchers interviewed 22 churners via telephone, most of the participants were over 60 years of age [32]. The study might indicate who normally answers telephone interviews, but generalizing from such results to cover younger customers would be bold. The most practical guidelines have been reported in a study discussing pre-churn events in the US, although the report fails to provide enough information to evaluate its validity, such as how many customers were interviewed [33]. According to one study, the network reliability is the single-most influential factor causing dissatisfaction in the cable television industry [34].

Summary:
While bundling reduces churn, the poor network reliability is the single-most influential factor causing dissatisfaction in the cable television industry.

VANQUISHING OPEX AND CHURN

DOCSIS 3.1 & Proactive network maintenance

The DOCSIS 3.1 specifications and guidelines discuss enhanced diagnostic tools enabling proactive network maintenance (PNM) [35, 36]. The needed Big Data for proactive actions is gathered by cable modems (CM) and cable modem termination systems (CMTS). PNM tools are expected to equip operative people to reduce churn remarkably through increased network uptime. But is this assumption correct? Do DOCSIS 3.1 cable modems and CMTS's offer enough visibility to locate and isolate network problems quickly?

Unfortunately, PNM capabilities are limited by the fact that one CMTS port is serving many cable modems. Big fiber node segment sizes and long amplifier cascades bring granularity to the holistic network view, although the last drops can be investigated if micro reflections occur. It would be convenient if all network problems could be fixed proactively. However, this is not the case. Real network data from European cable television networks shows that roughly one-third of the helpdesk calls can be prevented proactively. How do we know this?

Many European cable television operators are using intelligent HFC fiber nodes and amplifiers [1] – [11]. These intelligent devices include features such as a full capture spectrum analyzer. By using these intelligent access devices many Network Operating Centers (NOC) have performed proactive actions since 2001. Based on the real-field data, roughly one-third of the calls can be avoided, the remaining two-thirds of the helpdesk calls should be managed reactively. Even PNM tool vendors, in their marketing material [37], report figures close to our findings: 'A Major MSO has experienced a 25% drop in customer complaints by using their own PNM system.'

Can operators use PNM tools to solve problems reactively when customers call? Yes, but even in the best case, the PNM tools will only speed up the process. PNM solves network problems by sending the network technicians to roughly the right locations. This leads to the question if PNM framework is all we have and possibilities to increase customer satisfaction and overall efficiency through higher network uptime will reach saturation point once cable operators have deployed the best in class PNM solutions? We do not believe in this prophecy.

Summary:
While the proactive actions will increase customer satisfaction, the share of these actions is unfortunately small in comparison to the share of the reactive actions. PNM tools will speed up reactive actions through more accurate location awareness, but the tools are faint when it comes to fixing or segregating the root causes and their multiplier effects.

Software-defined networking

Software-Defined Networking (SDN) is an emerging paradigm that has successfully managed to pave the way towards next-generation networking [38]. The goal is to provide effective communications and services where network, data, and computation are fused into a service architecture [39]. SDN will contribute to this vision of future communications; however, significant issues must be addressed in order to meet expectations, and the potential for application-driven networks might lead us to wonder whether SDN, as currently envisioned, is even sufficient [39]. An inspiring study 'Where is the Debugger for my Software-Defined Network?'[40] provoked us to ask:

Should we record the path taken by a world traveler from the real-time data reported by customs or from the postcards they send home?

We believe in both alternatives. When postcards do not arrive, it would be interesting to know if they were even sent, was the sender reminded to send, or was the sender's trip interrupted. In cable television networks, the cable modems can 'send postcards' but intelligent access network devices, such as nodes, can report on why the postcards have not arrived.

As the same study puts it: 'As a community, we should explore whether to augment hardware or whether to use software workarounds with caveats.'

Our question is this: does it matter if you can select both alternatives?

Summary:

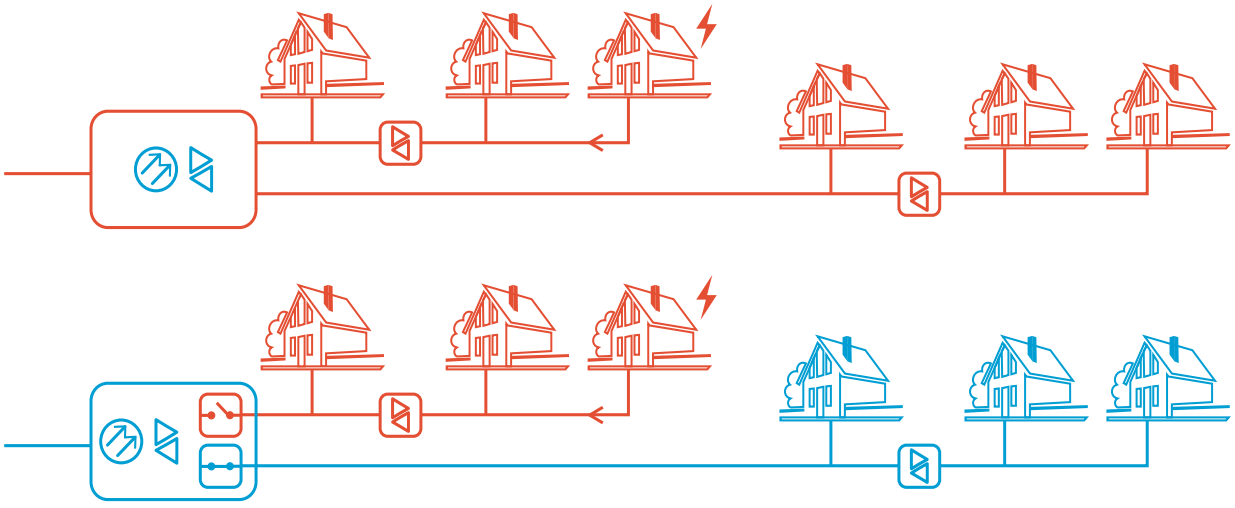
SDN will be an interesting ingredient in communication network implementation strategies. However, significant issues must be addressed in order to meet expectations. Although augmenting hardware and software workarounds are seen to be alternatives, we don't believe they need to be mutually exclusive.

From theory to practice

In earlier chapters, we have recognized the following challenges:

1. Operators have the desire to decrease time-to-repair, decrease OPEX, and improve customer satisfaction by a quicker response to new requirements and customer complaints.
2. According to the studies, the network reliability is the single-most influential factor causing dissatisfaction in the cable television industry.
3. While the proactive actions will increase customer satisfaction, the share of these actions is small in comparison to the share of the reactive actions. PNM tools will speed up reactive actions through more accurate location awareness, but the tools are faint when it comes to fixing or segregating the root causes and their multiplier effects.

The tool to confront these challenges is described in the next chapter.



The failing segments can be segregated with ingress switches.

Intelligence is the ability to adapt to change.

Stephen Hawking

The proposal, intelligent optical nodes

Intelligent optical nodes are 24/7 probes in the cable television network. They do not make PNM tools and full-capture cable modems useless, rather they complement them. All data collected by cable modems and CMTSs becomes exponentially useful when data, produced by optical nodes, is analyzed simultaneously. RF impairments can and do occur sporadically based upon environmental, electrical and mechanical issues that impact customer experience and contribute to churn. NOC personnel need all possible data to find correlations and to guide network technicians. While CMTS may see upstream ingress or common path distortion, the intelligent optical nodes can be used to find out where these disturbances enter the network. By remotely attenuating incoming signals in the optical node ports, the NOC personnel is able to see which coax branch is generating the ingress. This process can be further automated by a smart remote ingress switching (Smart RIS) toolset. The Smart RIS can find ingress sources through automatic manipulation of ingress switches and empowers Technical Operations team to perform the root cause analysis.

The fast root cause analysis is useful, but sometimes the return path ingress disables even healthy coax branches, an obvious but negative consequence in cable television networks that are combiners for the upstream. The fix requires a truck roll, even though tools to locate the failing network segments may exist. However, an anodyne works; the failing segments can be segregated with ingress switches, integrated in the optical nodes, until the segment has been fixed. Therefore, a number of homes contaminated by the ingress can be limited while the problems are displayed on a real-world map. As previous studies have shown, network problems initiate the journey that leads to churn if dissatisfaction is fostered by negative interactions with the helpdesk [34]. Hereby, it becomes of utmost importance that the helpdesk knows what is ongoing in the network. This information can be produced by the intelligent optical nodes, whereas the ubiquitous network management tools can display the information in a meaningful manner.

Very few people question the benefits of automatic transmission in cars. Cars are tools to move from place A to place B. Why would you complicate the driving experience by using manual transmission? Optical nodes are tools to receive and transmit signals. Why would you complicate the user experience by using manual adjustments? This thought has led to automatically aligning and adjusting fiber nodes. They perform tasks leading to results that only very few cable television technicians can manually beat. Many operators have used this feature during large network upgrades, when skilled CATV field technicians wear thin and deadlines are getting closer. By pushing a single button, even non-CATV experts can install optical nodes. Many of these features are enabled by electrical controls that replace traditional plug-in modules. The electrical controls also eliminate all logistic hassles caused by wrong plug-in modules in the van.

THE IMPACT

Our customers have discussed the following concrete benefits that a shift to intelligent CATV networks can bring.

1. Up to 60% less truck rolls
2. The ingress and CPD problems are repaired 30 minutes faster on average.
3. Severe node area breaks are 150 minutes shorter on average.
4. 30% of all customer calls and tickets can be avoided because of preventive actions and improved network reliability.
5. 100% of seasonal network maintenance visits can be avoided.

The monetary benefits of Intelligent Networks are remarkable. According to our research in Europe, moving to intelligent network architecture in a medium sized network of 120,000 users can amount to operational savings of close to 10 million euros ($11.5 Million) over 15 years, reducing the accumulated total cost to less than 50%. For a large network of 1.2 million users, this means savings of almost 100 million euros ($115 Million) over 15 years. In the US these numbers could be higher because of lower subscriber density and more prevalent truck rolls in most parts of the country.

DOCSIS 3.1 introduces new modulation methods and advanced constellations. Older cable television networks have been pampered with lower order QAM constellations that left enough of a carrier-to-noise ratio (CNR) margin to be wasted. For instance, seasonal network visits, due to lower/higher temperatures, might have been futile. The new advanced constellations, such as the 4K QAM require higher CNR, even when OFDM and more sophisticated forward error correction mitigate challenges. To avoid these seasonal network visits and costly truck rolls, the intelligent optical nodes are able to reconfigure themselves and keep all adjustments precise. Therefore, e.g. temperature changes do not impact the network performance, and consumers can enjoy robust broadband speeds.

Less maintenance work

100% of seasonal maintenance visits can be avoided.

Less calls

30% of all customer calls can be avoided because of preventive actions and improved network reliability.

Less truck rolls

Up to **60%** less truck rolls.

Tremendous time savings and higher network uptime

The ingress and CPD problems are repaired faster in average. **30 mins**

Severe node area breaks are shorter in average. **150 mins**

In Europe HFC outside plant devices are mainly in street cabinets, thus the devices are easier to access than in regions where HFC devices are strand mounted. The figures could be higher in the US.

Excellent customer satisfaction

"Excellent customer satisfaction comes from fast and stable connectivity that answers each customer's needs – whether they wish to check emails, or watch online video and TV content that require high data transmission capacity. Working with Teleste, we have been able to improve the reliability of our network during the past years; and now, we are pleased to continue our previous cooperation in upgrading our network to meet the growing capacity requirements for years to come."

Ole Fruekilde, CEO of Stofa, 30.05.2017

Customers can enjoy smooth Internet video services

"We are focused on ensuring that our customers can enjoy smooth Internet video services, also in live environments; delivering fast and reliable network connections is an elemental part of meeting the target. Teleste has provided us with intelligent access products that can reduce truck rolls and help us to offer fixed broadband connections that meet consumers' service expectations today, as well as in the future."

Mikko Nurmi, Director, Cable Networks, DNA 10.10.2017

Comprehensive and focused tool for the job

"After experimenting with several network management systems, we found Teleste software the most comprehensive and focused tool for the job. We have been managing our networks with CATVisor software the past 10 years and we've been very pleased how it has enabled us to keep everything under control. We are excited about the new version and can't wait to benefit of the new features."

Alf Pedersen, Manager of Technical Department at Stofa A/S, Denmark.

LIMITATIONS AND AVENUES FOR FUTURE RESEARCH

Operators who have started to use intelligent network products [1] – [11], such as optical nodes, are constantly improving their offering and service packages. Cable modems and set-top-boxes are changed and upgraded, promotional offers are launched. It becomes impossible to accurately calculate the correlation between lower OPEX or churn rate and shift to intelligent cable television networks. Experimental designs, evaluating the impact of one variable, cannot be performed in real cable television networks serving millions of subscribers.

The gap between the current academic research efforts and the priorities of the telecom companies is massive. While the leading technology vendors are offering tools to reduce OPEX and churn, their statements will be judged to be biased by commercial interests. As the vendors appreciate customer privacy, many facts behind figures remain confidential. Therefore, the indestructible causality between the identified problems and improvement suggestions yearn transparency.

However, we can point out interesting research gaps and questions that scholars could credibly close and answer.

1. Empirical evidence on how ubiquitous network intelligence impacts OPEX and customer satisfaction would serve many telecom executives.
2. SDN will be an interesting ingredient in communication network implementation strategies. However, significant issues must be addressed in order to meet expectations. Ongoing research activities are very theoretical, and more practical managerial suggestions could serve telecom executives who must make pragmatic decisions.
3. For some reason, academia is more interested in offering novel information to mobile operators. Many developments, such as predicting the customer churn for fixed-line communication services, require more variables in order to obtain more accurate results [41]. Research covering the challenges of fixed-line communications remains sparse. Just recently, Comcast implemented a machine-learning program that the company said can accurately predict whether it needs to dispatch a technician to a customer's home in order to fix connectivity problems [42]. While tremendous operators can perform such research on their own, the smaller cable operators would surely welcome the findings of scholars.

ABOUT THE AUTHOR

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Before devoting his efforts to technical marketing, Arttu served as business director, product manager and an engineer at Teleste Corporation. Arttu is an active content producer, and his interest lies in the latest network and video processing technologies. Understanding the customer perspective has always motivated Arttu, and his latest research work focuses on consumer retention rates, especially on the question of how operators can use intelligent network products to prevent pre-churn and churn. Arttu joined Teleste in 1997 and holds an MSc in technology; he is currently performing complementary studies at Turku School of Economics prior to post graduate marketing studies.

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Jouni Karlsson (illustrations)
Päivi Vuori (editor)

About Teleste

Teleste offers an integrated product and service portfolio that makes it possible to build and run a better networked society. Our solutions bring television and broadband services to your home, secure your safety in public places and guide your use of public transport. With solid industry experience and drive for innovations, we are a leading international company in broadband, security and information technologies and related services. We connect with our customers through a global network of offices and partners. In 2016, Teleste's net sales reached EUR 260 (USD 310) million and the company employed over 1500 people. Teleste is listed on Nasdaq Helsinki. For more information see www.teleste.com and follow @telestecorp on Twitter.

About Teleste Intercept

Teleste Intercept is a joint venture formed by Teleste Corporation and Antronix in 2017. We provide best-of-breed intelligent access network platforms for the North American broadband market. Our technologies offer innovative, viable options for driving a customer-oriented business and fulfilling consumers' expectations for increased speed and service uptime. With our portfolio, you can manage networks remotely, and scale them efficiently and cost-effectively to meet customer data and video demands. Visit www.telesteintercept.com and follow us on Twitter and LinkedIn for more information about us and our products.

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