Pairing IoT and AI to Reduce Network Maintenance Costs

A Technical Paper prepared for SCTE by

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1. Introduction

The most fundamental component of a cable service provider's products is the network. The networks we provide are ubiquitous in the lives of our customers. Any network disruption causes inconvenience, but as more people work from home, run businesses over the network, or manage critical services online, an outage can increasingly have a serious financial effect or even put people's lives at risk.

It is imperative that our networks provide the features, quality, and reliability our customers have come to expect. There are many obstacles to maintaining quality and reliability: Data is frequently erroneous or arrives too late to be of significant value; finding qualified employees for a more complex portfolio of products and getting those people to the right place at the right time to fix problems is increasingly difficult and expensive; diagnosing problems is often a matter of experience that is isolated to a few experts. It is expensive to send people to fix plant problems, and the prescribed fix may not always be effective.

One possible solution is to provide the necessary technical capability to the technicians to cut through complexity and reduce cost, while allowing the network to self-diagnose and in many cases repair problems without the need to roll a truck. Such tools are built on the concept of the Internet of Things (IoT). This includes sensors and actuators in the network and Artificial Intelligence (AI) algorithms to interpret and correctly diagnose or even automatically repair network problems.

While instrumenting the network is an up-front capital cost, it can pay for itself by providing an accurate real-time view of the status of the network. AI can interpret the collected data and use that data to provide an accurate diagnosis of the problem, isolate a precise location for the fix, then potentially reroute traffic while a repair is made and even automatically make the repair. This results in a more reliable network that can be maintained at a lower cost.

In this paper, we will explore existing and potential IoT solutions that can be installed in the network, and how IoT and AI can be combined to build network infrastructure that is simpler and less expensive to maintain. We will frame this as a progressively improving solution from a reactive response, to planned upgrades, then moving to proactive prevention and finally to a predictive solution that anticipates and resolves problems before they happen. This approach migrates the network from a resource that exhibits frequent downtime into a resource that is rarely down while being less expensive to maintain.

2. Network Maintenance Challenges

2.1. Network Maintenance Program Evoution

Traditionally, Cable Operators have tried to evolve their network maintenance program from a reactive to more proactive maintenance, with predicative being the elusive goal. Figure 1 illustrates a common view into the evolution of network maintenance programs.

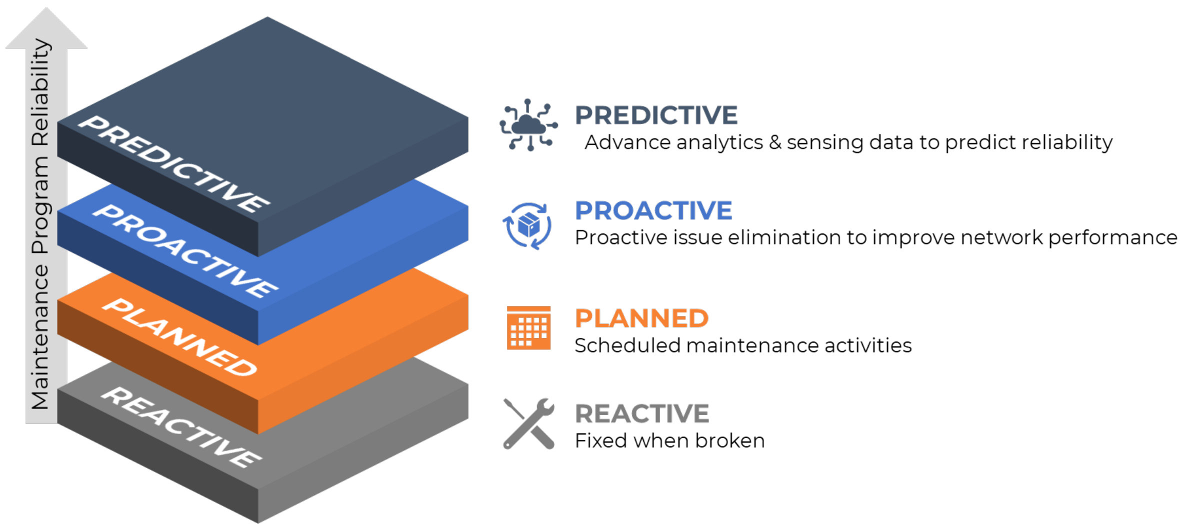

Figure 1: Network Maintenance Program Evolution

- **Reactive Maintenance** – Allowing parts to run to failure.
  As the least technologically advanced and most common level of network maintenance, reactive maintenance involves repairing or remediating parts or equipment only after they have broken down or have been run to the point of failure. Reactive maintenance relies on people and using existing tools and components to their limits. However, this can lead to catastrophic machine damage as humans make mistakes and network components get damaged due to vibration, overheating, potentially causing unknown damage to network assets beyond the failed parts.

- **Planned Maintenance** – Attempt to prevent problems before they occur.
  A planned, time-based preventative maintenance approach can help avoid broken network assets and decrease downtime by replacing parts at regular, pre-planned intervals. While planned maintenance may be more cost-effective than reactive strategies, it also can be more difficult to justify as the parts are replaced before they have reached their end-of-life and requires an inventory of spares to be managed. These can also result in greater planned downtime.

- **Proactive Maintenance** – Treating the root case, not the symptom.
  Proactive maintenance strives to identify and address the problems that can lead to those breakdowns in the first place, such as configuration misalignment and, environmental conditions. By identifying and addressing the root causes of many component failures, proactive maintenance typically helps to prevent the wear and tear that leads to equipment failure, ultimately decreasing failures and downtime. This can also help in improving operational efficiency by reducing unnecessary repairs and improving the lifespan of network assets. Proactive maintenance requires organizational support to be successful and often requires more extensive training and robust change management practices.

- **Predictive Maintenance** – Fix issues before failure (analyze trends, predict failures)
  Predictive Maintenance can help break the inefficient cycles of older strategies by enabling cable operators to maximize the useful life of their network assets while avoiding *both planned and unplanned* downtime, reducing cost and increasing operational efficiency. On a very high level, Predictive Maintenance analyzes operators' network data collected from the connected equipment to predict when a network asset needs maintenance or replacement. But simply gathering the information from sensors and systems is not enough to yield the benefits of Predictive Maintenance; the ability to aggregate and then analyze data can be crucial to predicting malfunctions. This often requires new capabilities for creating, handling, and making use of data.

2.2. Network Maintenance Program Challenges

According to a McKinsey Report [2], Network maintenance and service operations account for 60 to 70 percent of most telcos' operating budgets. The industry has already faced a decade-plus of increasing cost pressure, and the returns on necessary infrastructure investments are barely outpacing the cost of capital. To stay ahead, operators will need to make critical investments in network maintenance programs to offer efficient and effective processes to drive costs down while improving customer and employee experience. With the evolution of network maintenance programs, there has been an addition of complexity in the forms of modern technology, new services and delivering the services in a reliable manner. This scaling of the network and complex environment comes with considerable challenges that inhibits cable operators' ability to exit the reactive maintenance world (scale of reactive items challenging their ability to resolve). What ends up happening is the teams have very little remaining capacity to deal with proactive/predictive items. In Figure 2, below we highlight some of the key challenges that cable operators face on daily basis which can be resolved with the help of AI and IoT as the key technology enablers -

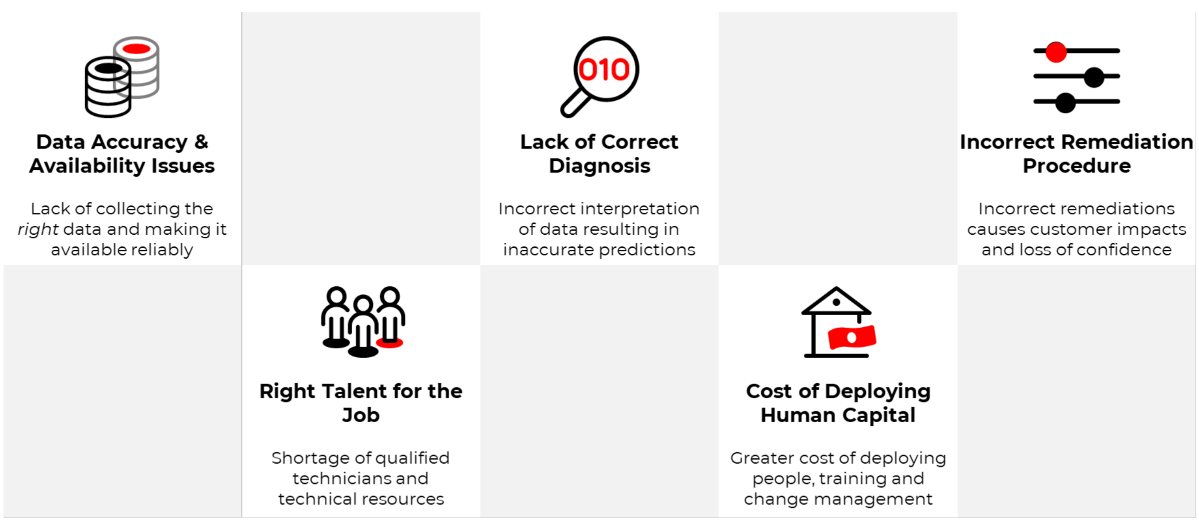

Figure 2: Network Maintenance Program Challenges

- **Data Accuracy & Availability Issues –**
  In the past, network maintenance often required time-consuming manual data crunching and resource intensive processing to generate insights from data being collected. The strategies relied heavily on having in-depth knowledge of the data and expectations that the data is accurate and

available to the users when needed. The decreasing cost of sensors, computing power, and bandwidth, coupled with increasing technological advancements, has enabled us to capture more data, more often. Data accuracy, integrity, real-time data flow and data availability have been challenges with which cable operators struggle as networks increase in complexity necessitating more sophistication in network maintenance.

- **Lack of Correct Diagnosis** –
  Simply gathering the data / telemetry from sensors and connected devices is not enough to yield the benefits of proactive / predictive network maintenance. One should be able to aggregate, analyze data and predict diagnosis with a high degree of confidence. Building trust in the process and models doing the predications takes time and effort – developing validation scenario and test cases – and may require novel approaches until the space matures with open-source and vendor-supported models.

- **Incorrect Remediation Procedures** –
  After gathering the data and being able to correctly predict correct diagnosis – not guesses (false positives) – about network assets and health, the next step is to provide the right remediation steps (manual or automated) to drive optimal efficiency for network maintenance. Remediation processes require a much deeper knowledge of the network and customer dynamics, so that remediation not only happens on the right network asset but also at the right time considering customer experience impacts. Remediation also involves proactive communication of impacts to customers and paths to resolution. Coalescing with the ubiquity of networks and the unpredictability of customer usage patterns, Cable Operators have been challenged in balancing network remediations with customer experience.

- **Right Talent for the Job** –
  As the network becomes more complex, Cable Operators are challenged with shortage of right talent for the job (e.g., right network technicians for remediation, or skilled technical resource required for the data synthesis and analysis, cloud native technologists), coming into competition with the *hyperscalers* (e.g., AWS, Azure) and other core technology companies. Some of the operators are viewing network maintenance as a technology problem but talent, process and organizational change are equally if not more important. Reducing the requirement for specialized talent and replacing it with accurate and effective automation can help.

- **Cost of Deploying Human Capital** -
  Operationally lean and efficient network operations and maintenance is what Cable Operators have been striving for. The cost of deploying human capital to manage the network complexity has been on a constantly increasing curve and is, in a capital-strapped ecosystem, one of the key challenges being faced by the network operators.

In the subsequent sections we will discuss how the strategic use of IoT and AI can help Cable Operators to overcome some of these challenges and to be able to run lean network operations supported by proactive and predictive network maintenance.

3. Key Use Cases for Network Maintenance Improvements

In the telecommunications industry, network operations and maintenance are often said to be one of the most complex aspects of the business. Historically, most successful telcos tend to outperform at this task with close coordination across business units. It might sound simple but is a herculean task and requires expensive manpower and resources. We present below a sample of the key use cases that cable operators face in detecting flaws in the network, network security, network optimization, while offering real-time improvements in managing day-to-day network operations. Central to these use cases are the more efficient resolution of issues and providing enhanced customer service and satisfaction.

- **Fault Detection, Prediction and Resolution**
  Service impairments and faults are inevitable in a Cable Operator's network. Operations primary consideration is maintaining a functioning network and that faults do not result in large costs, whether through maintenance costs themselves or penalties for breaching SLAs. Given these concerns, three areas emerge for measuring fault detection, prediction, and resolution:
  1. **Customer experience**: how can the cable operator limit the customer impact radius and be able to provide a highly confident estimate of restoration of the services.
  2. **Human capital cost**: The cost of network engineers fixing the problem, as well as those customer-facing roles dealing with complaints.
  3. **Speed**: How quickly the Cable Operator can identify the problem and therefore solve it; measured as Mean Time to Repair (MTTR)

- **Network Optimization**
  Network optimization is about how to route traffic and balance workloads across the available infrastructure and assets to try and deliver the highest quality of most cost-effective service. It is possible to optimize the network manually, but with tens of thousands of nodes, headends and hub sites this would mean the whole team of network engineers doing nothing but re-optimizing the network. With the high cost of staffing network operations, manual network optimization is not practical. There is a need for self-optimizing network which can provide real-time, event-based network traffic balancing. Measurements for the success of self-optimizing network fall under the following areas:
  1. **Cost Optimization**: Maximize the use of existing network assets; predicting and optimizing network traffic that would otherwise incur higher costs.
  2. **Quality of Service**: Service prioritization during demand peaks or disruptions and reverting to default when the event is over; prioritizing firmware updates to provide least services disruption to customers.

- **Network Planning and Upgrades**
  Predicting / forecasting customer demands for products and services to assist cable operators in rolling out network upgrades that are designed to enable new services by using the right deployment model between mid/high-splits, DOCSIS 4.0, FTTP overbuilds. Proactive network optimization and upgrade planning can help operators switch from site-centric rollout planning - based on engineering guidelines - to a customer value-centric rollout that identifies priority sites using technical needs, customer experience metrics, and financial data, factoring in regulatory-approval timelines and local vendor delays.

These are only a subset of numerous compelling use cases that can be leveraged by Cable Operators to stay competitive in an increasingly challenging market. In the subsequent sections we will discuss how, by investing in AI and IoT and adopting best practices, Cable Operators can future proof their operations and remain competitive in the years to come.

4. How can IoT and AI help Cable Operators?

AI and IoT has the potential to revolutionize the Cable industry. The integration of Artificial Intelligence (AI) in Internet of Things (IoT) introduces new dimensions of efficiency, automation, and intelligence to our daily lives. IoT provides the interface between the computing power of AI and the real world. It allows reality to be accurately measured in real-time, then uses actuators to allow changes to be affected in the real world. Artificial intelligence has revolutionized the way machines learn, reason, and make decisions. When combined, Artificial Intelligence and Internet of Things opens a realm of possibilities, enabling intelligent, autonomous systems that can analyze vast amounts of data and take actions based on their insights.

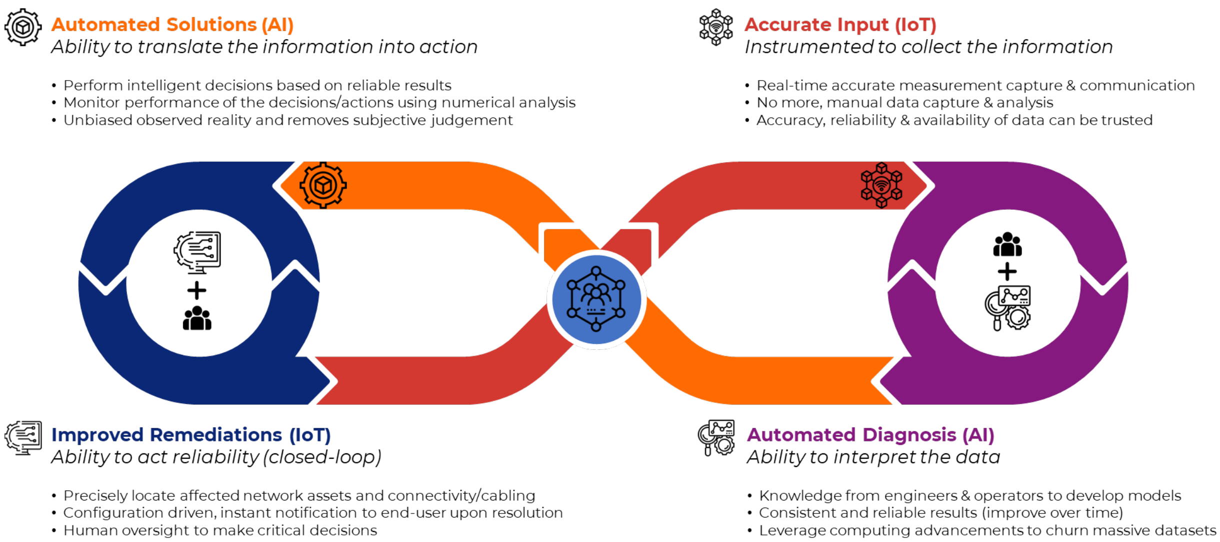

Figure 3: Cable Operator's Integration Approach for AI and IoT

4.1. Accurate Input (IoT)

The Internet of Things (IoT) is the universe of networked sensors and actuators. One of the most important aspects of IoT is its ability to take accurate direct measurements and communicate those measurements immediately. Before the advent of the IoT, measurements were often made by bulky analog instruments, data was transcribed by hand or automated in batches and analyzed later. There were many ways to introduce errors or lose important real-time context. IoT sensors, on the other hand, can be tiny, digital, and numerous. Their accuracy, reliability, and instantaneity mean the data can be trusted and evaluated in real-time and used to make instant decisions.

4.2. Automated Diagnosis (AI)

Instant decisions can only be trusted if the data is accurate, and the decisions are reliable. AI gives us the techniques we need to make decisions based on enormous amounts of data and verified results. Machine Learning (ML) is one form of AI that is based on statistical analysis. It identifies patterns in input data and observes results. When the data consistently produces reliable results, making decisions on the data seems "intelligent." Often, the sheer amount of data is too much for humans to process, but this is where computing power shines. The ability to train, verify and optimize models on sheer volume of data substitutes for experience and the expected results can be relied upon with a measurable level of confidence.

4.3. Automated Solutions (AI)

There are many AI techniques beyond ML. These techniques can be individually used on the same reliable data to draw different conclusions. The reliability of each of these techniques can also be assigned a numerical probability; correlations between techniques can be automatically verified. This analysis can be used to further increase confidence in proposed solutions. This algorithmic approach leverages unbiased observed reality and removes subjective judgement. While mistakes can be made, the consequences of possible mistakes can also be assessed – humans in the loop can make critical decisions based on objective numerical analysis.

4.4. Improved Remediation (IoT)

Better information (more accurate, timelier, and in greater volume) leads to improved remediation opportunities. Better AI allows us to clearly see the various remediation solutions and objectively evaluate them.

4.4.1. Fix Problems via Actuators

With innovative actuators in the network (*which can be an IoT device or code that can make configuration changes*), solutions can sometimes be automatically and immediately applied. One simple example is signal amplification. It is relatively simple to design amplifiers that can be remotely adjusted. Similarly, wave frequency can be adjusted remotely to affect the efficiency of the network or compensate for cable defects. If there is redundant equipment in the network, new equipment can be switched on to resolve some problems and faulty equipment simply switched off until it can be replaced.

4.4.2. Precisely Locate Affected Equipment and Cabling

Frequently, understanding the location of the problem is as important as understanding the problem itself. Signal reflection analysis and other techniques can be used to precisely find the location of a cable cut or kink. Network mapping and analysis can precisely locate a faulty piece of networking equipment.

4.4.3. Reroute Traffic Around the Problem

Sometimes, a truck roll is required to fix the problem. However, the "fix" is often not immediately necessary. It may be acceptable to temporarily avoid the problem until a complete fix can be made. Customers are more likely to be satisfied with partially degraded service for a short time than with a completely disabled service, even if the outage is short.

4.4.4. Instantly Update Configuration and Inform Affected Customers When Network Restored

When problems occur, one of the biggest frustrations for customers is the lack of information. Understanding the likely duration of the problem, which areas are affected and timely notifications when service is restored are all critical in customer satisfaction. Customers are often more forgiving when you keep them informed. IoT and AI can be valuable tools here too. Automated calls or messages to customers when service is restored can reduce the time to inform customers and avoid the time and trouble it would take for people to make those contacts.

4.4.5. Anticipation

While it is good to solve observed network problems quickly and correctly, it would be even better to anticipate problems. IoT can provide valuable information for planning the network. Signal levels can be observed in real time. Equipment loads can be identified. AI can be used to suggest where problems are likely to occur. Redundant equipment can be installed or located strategically. Technicians can be on call when weather is predicted to be a problem. Good managers already do this, but if real-time sensors are used, managers can have better information about potential threats and be more strategic about preparations.

4.4.6. Avoidance

The corollary is that while responding quickly and accurately to network problems is great, avoiding problems is generally a better customer solution and cheaper for the operator. IoT and AI are critical components required for achieving this goal. A constant stream of data from IoT sensors provides a real-time view of the network. AI can monitor this data and identify early warning signs of potential problems. Then these worrisome signs can be addressed as regularly scheduled network maintenance during regular hours. The problems can potentially be avoided. Furthermore, this maintenance can be publicized to customers and used as a tool to retain existing customers or attract new ones.

5. What Do Telco Technology Leaders Need To Do To Start Their AI/IoT Transformation Journey?

As we have discussed so far, the fusion of Artificial Intelligence and the Internet of Things can help Cable Operators optimize their networks by automatically adjusting network settings and configurations to improve performance and reduce costs. AI algorithms can further be used to analyze vast amounts of data generated by telecommunication networks, providing valuable insights into network performance, and helping to identify and resolve issues in real-time. This can significantly improve network reliability and reduce downtime, ultimately leading to enhanced customer satisfaction. All of this is easier said than done. In this section we will discuss as a Cable Operator AI leader some of the lessons learned, best practices that must be followed and the challenges / limitations that will be faced. We will also discuss the collaborative governance process that will help us define the new ways of working with using AI/IoT as part of our existing process.

5.1. Lessons Learned

In recent years, several Cable Operators and telcos have invested in AI and IoT. Most have launched limited proof-of-concept experiments to address pockets of problems and broadly these experiments or proofs-of-concept are done in silos. The toughest challenge most operators face is scaling the initial trials to create operational visibility, improve network reliability and generate financial impact. Here are some of the key lessons learned for technology leaders in the telecommunications industry.

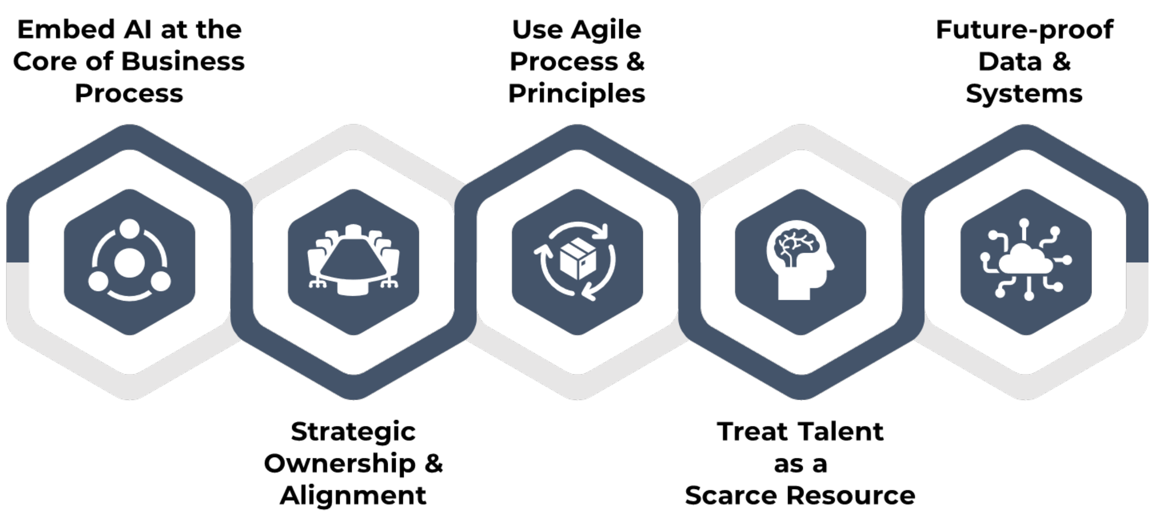

Figure 4: Key Lessons Learned

5.1.1. *Embed AI at the Core of Business Processes*

The early winners in the telecom industry have reinvented themselves by embedding AI at the very heart of not just their products, but their key processes. Cable operators must first identify priorities in consultation with business visions and goals to determine where AI will create the highest value. They should roll out use cases end-to-end in those priority areas so that they can optimize their processes and provide more value to customers. One huge benefit of embedding AI as part of the core business process is the training & upkeeping of the AI model i.e., the model can be quickly adapted to real life situations and complexity changes. Operators who have tried approaching AI as a niche process and introduced separate implementation programs have seldom been successful.

5.1.2. Strategic Ownership and Alignment

Using AI at scale requires a new employee mindset and culture; it is important to prepare people for change. To do that, getting the C-Suite to own the AI deployment process is critical. One way of ensuring AI ownership at the top is to make the company's executive committee members accountable for delivering outcomes and value throughout the AI journey.

5.1.3. Use Agile Process and Principles

Agile methods of working are a catalyst, if not a prerequisite, for Cable Operators to unlock AI's power. Agile allows the adoption of a flexible and value-driven approach and enables working across functions – capabilities that are necessary to scale AI. Cable Operators must build cross-functional, agile teams focused on tangible AI-driven products or processes. They can scale up/down the teams as they do AI usage to ensure that they have sufficient resources for both along the way thus catalyzing the rapid adoption of AI in the organization.

5.1.4. Treat Talent as a Scarce Resource

Cable Operators must attempt to attract and retain digital talent in competition with the tech sector globally. To become more attractive workplaces, some Operators have rewritten their employee value propositions, revised their HR and promotion policies, and made work more flexible. Additionally, Operators must invest heavily in communications, skill building, and on-the-job training for employees and managers. Operators can also look at as AI for leveling up its employees, performing the function of an assistant by offering advice and guidance which will improve the effectiveness and performance.

5.1.5. Future-Proof Data and Systems

Operators must ensure that their data and technology assets are ready for AI. That requires two elements: Establishing a data governance structure that will ensure the data is usable, consistent, and valuable; and, revamping the IT architecture to make it more flexible and robust. That will enable AI-driven Operators to break down the siloed complexity of legacy IT systems and scale their AI applications.

5.2. Technology Best Practices

Legacy operational practices are not fit for purpose in modern cloud-native networks, whose increased complexity means that network engineers will be unable to have full knowledge of all the network stacks. For network operators to overcome these challenges, we present below a list of key AI technology-related best practices.

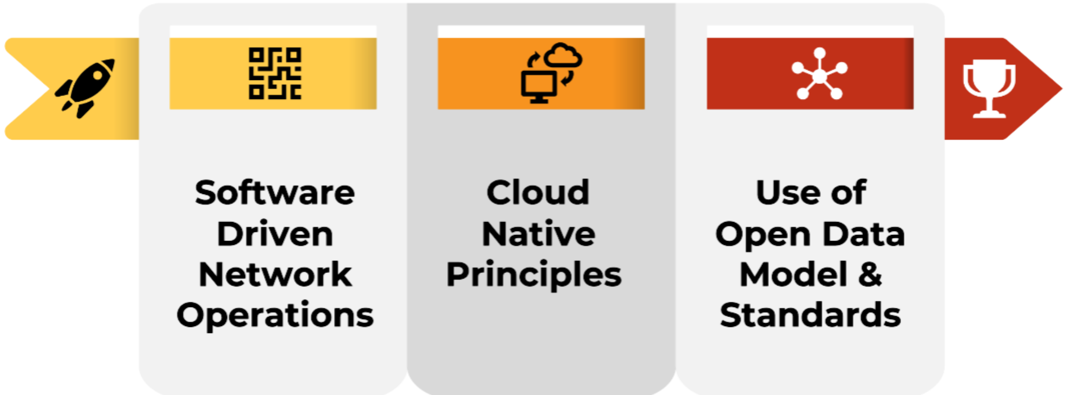

Figure 5: Key Technology Best Practices

5.2.1. *Software Driven Network Operations*

Software-driven network (SDN) operations must be employed, where intent-based automation replaces the current manual approaches in managing networks. The application of Artificial Intelligence to operations (AIOps) is the key to making installation, deployment, and operation part of an automated lifecycle management. The use of AI and IoT will be essential for analyzing network data, identifying network issues, and optimizing network performance. It will help take preventive action and fix network issues before they cause service disruption or downtime.

5.2.2. *Cloud Native Principles*

Cloud-native principles and technology have proven to be an effective accelerator in building and continuously operating the largest networks in the world. Using 12-Factor design principles [1], many telcos have realized operational effectiveness and business value with portability and scalability, simplified hand-offs between network engineering and operations and seamless continuous deployments.

5.2.3. *Use of Open Data Model and Standards*

Another prerequisite for the successful transformation of telco operations is the adoption of a common, open data model for network data based on industry standards, building open integration points for more uniform automation across the network stack.

5.3. Challenges and limitations

While the integration of Artificial Intelligence in Internet of Things offers numerous advantages, it also presents certain challenges and limitations. It is important to understand and address these issues to ensure the successful deployment and utilization of AI in IoT systems.

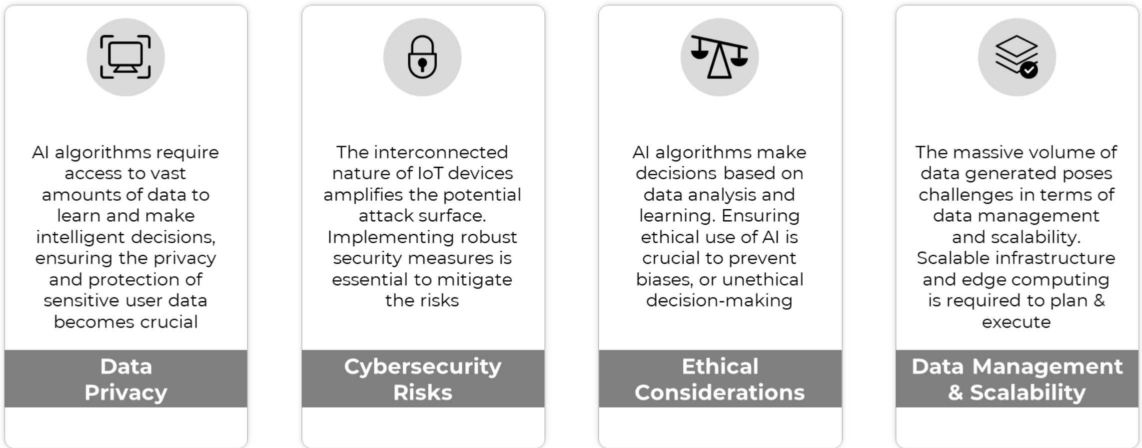

Figure 6: Key Challenges & Limitations

5.3.1. *Data Privacy*

AI algorithms require access to vast amounts of data to learn and make intelligent decisions. However, ensuring the privacy and protection of sensitive user data becomes crucial. Organizations must implement robust data encryption, secure data transmission protocols, and stringent access control mechanisms to safeguard user information and prevent unauthorized access.

5.3.2. *Cybersecurity Risks*

The interconnected nature of IoT devices increase the potential attack surface for cybercriminals and amplifies the risks of breaches. AI-enabled IoT systems can become targets for malicious activities, such as data breaches, unauthorized access, or manipulation of critical operations. Implementing robust security measures, including intrusion detection systems, encryption, and regular security updates, is essential to mitigate these risks, minimize the area of attack, minimize data exposure and exfiltration.

5.3.3. *Ethical Considerations*

AI algorithms in IoT devices make decisions based on data analysis and learning. However, ensuring ethical use of AI becomes crucial to prevent biases, discrimination, or unethical decision-making. Organizations must adhere to ethical guidelines, fairness principles, and transparent AI practices to avoid unintended consequences and maintain trust among users. Additionally, aspects of human-machine interactions, poses some key challenges –

- **Transparency and Explainability** - AI algorithms can be complex and difficult to interpret, resulting in challenges in understanding how an individual result was arrived at. A 1979 presentation slide attributed to IBM said, “computers can never be held accountable... therefore a computer must never make a management decision.” Ensuring transparency and explainability of AI-driven decisions in IoT systems is crucial for user trust and accountability. Organizations must strive to develop AI models that provide clear explanations for their decisions.
- **Human-machine collaboration** - As AI becomes more integrated into IoT systems, striking the right balance between human control and AI autonomy becomes essential. Organizations must design interfaces and interactions that facilitate effective collaboration

between humans and AI-powered IoT devices. This involves understanding user needs, preferences, and the ability to override or intervene when necessary.

5.3.4. Data Management and Scalability

The massive volume of data generated by IoT devices poses challenges in terms of data management and scalability. Consider the following challenges:

- **Data storage and processing -** AI algorithms require substantial computational power and storage capacity to process and analyze IoT-generated data. As the number of connected devices increases, managing the sheer volume of data becomes a daunting task. Organizations must invest in scalable infrastructure and efficient data storage solutions to handle the ever-growing data streams.
- **Bandwidth and network limitations -** Transferring large volumes of IoT data to the cloud for AI processing can strain network bandwidth and lead to latency issues; in some situations, this can aggravate strained network conditions into cascading failures. This becomes particularly challenging in scenarios where real-time decision-making is required. Edge computing, where AI computations are performed closer to the data source, can help alleviate bandwidth constraints and reduce latency.
- **Integration with legacy systems -** Integrating AI capabilities into existing IoT systems or legacy infrastructure can be complex. Legacy systems may lack the necessary compatibility or processing power to handle AI algorithms effectively. Organizations must carefully plan and execute integration strategies, ensuring seamless interoperability between AI-driven IoT systems and legacy infrastructure.

5.4. Collabrative Governance Approach

Networks are the new utility – ubiquitous, pervasive, and critical. Like any other utility, customers expect it to be available whenever needed and to be operationally reliable. A utility that is performing as expected is essentially invisible. The goal should be zero down time and operational excellence. This high standard is possible with Next-Gen Operations Management. To operationalize this structure and successfully integrate AI and IoT into the business, it is important to consider current operations. A well-considered transition that minimizes current operational disruption would produce better, more sustainable results.

Figure 7: Next Gen Network Operations Management

Introducing IoT and AI into operations management is a critical change that will achieve the goals identified above, but it is important that we do not abandon process and governance. IoT and AI are not replacements for these critical operational elements. Rather they should be leveraged to ensure that the efficiencies anticipated can be realized. Good process is important when deciding where IoT and AI can best be used. Good governance helps keep critical corporate goals in sight and ensures that progress toward those goals is measured. Governance also helps ensure that data is protected and used appropriately.

Communication and collaboration are essential. Adoption of a new technology cannot be accomplished without the buy-in and assistance of Network Operations (end-users, those who will be using the system). Operations must understand the motivation and must be consulted every step of the way. A proof-of-concept (PoC) trial may be advisable to verify the details of how the technology will be installed, integrate with existing process, how will the end-user experience look like and how will the success of AI/IoT be measured.

6. Conclusion

In this paper, we have attempted to make a case for migrating from a manually maintained network to a Next-Gen Operations Management approach based on IoT and AI. We believe such an approach improves reliability, reduces downtime, and lowers network maintenance costs. One of the unique opportunities that cable operators can use to incorporate IoT and AI as the people and process enabler in their network is DOCSIS 4.0 (D4.0). Most of the cable operators will need to rebuild their network to a certain degree to support D4.0, this provides a great opportunity to embed as much IoT and AI capability as possible as part of the network design. This decision needs to happen now as most of the cable operators are working with vendors to define the specifications of new generation network equipment. While this strategy requires additional capital investment to instrument the network and install the AI/ML platform, the anticipated benefits are enormous and something that cannot be underestimated.

The network strategy can migrate from a reactive response to customer-reported problems to an automated predictive system that can anticipate and prevent problems before they are noticed by customers. Between these two extremes, steps can be taken to simplify the transition. Initially, reactive responses can be migrated to planned improvements and proactive maintenance.

Taking the correct steps can be guided by an IoT platform that allows accurate and instantaneous measurement of key network parameters. Current knowledge of the network is key to an accurate and effective response. AI / ML techniques take this accurate data and provide automated, effective, and validated actions that can resolve network problems. Once the network is relatively stable, these same tools can be used to prioritize proactive network maintenance, then proactively identify network conditions that may predict future problems.

This automation allows a limited human work force to work more effectively and efficiently while being able to correctly resolve issues (a.k.a. first time right) that they may not have personally encountered in the past. All of this can be accomplished while lowering network maintenance costs over time.

IoT and AI can be combined to provide the most reliable network for our customers while reducing costs, time, and people necessary to solve problems. Additionally, the core IoT and AI platforms used to improve operational maintenance can be used to improve other internal processes or as new revenue generating services for our customers.

Abbreviations

3GPP	3rd Generation Partnership Project
AI	Artificial Intelligence
AIOps	Artificial Intelligence Operations
DOCSIS	Data Over Cable Service Interface Specification
FTTP	Fiber to the Premises
HR	Human Resources
IT	Information Technology
IoT	Internet of Things
MTTR	Mean Time to Repair
OpenRAN	Open Radio Access Network
SDN	Software Driven Network
SLA	Service Level Agreement

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