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**Review Article**

# Telecom Innovation in Action Modernizing Spectrum Mobile for Growth and Compliance

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## Abstract

Spectrum Mobile became a large provider of mobile services in the US after being acquired by charter communications. The speed with which a company can grow increases the complexity of its system, which in turn leads to new challenges. Spectrum Mobile faced a number of challenges: inconsistent releases, delays in testing changes, etc. To overcome these challenges, the QA/DevOps team started working on four key elements within their overall testing procedure: compliance, resiliency, automation, and modernization. Several key initiatives were started as part of this new initiative including the implementation of CI/CD pipelines in the cloud to automate the customer experience; the creation of a "hotfix" lane for addressing critical issues in real time. New technologies such as Blue/Green deployments and service virtualization were utilized to address middleware instability and scalability issues within the company. By leveraging new technology, Spectrum Mobile was able to enhance the speed with which it releases new products and services to customers, improve the availability of their systems, and create a 50% increase in its number of subscribers and protect a large amount of revenue. This case study also illustrates how the modernization of legacy systems will continue to be necessary to maintain competitive advantage in the telecommunications industry. In addition, the case study indicates how cloud-based and AI-based technological advancements will enable Spectrum Mobile to develop automated and scalable architectures in the future. Spectrum Mobile will continue to explore the potential of artificial intelligence (AI), predictive analytics, and sustainable networks to support the evolving needs of society through technology.

**Keywords:** Spectrum Mobile, Charter Communications, Service Virtualization, Artificial Intelligence (AI), Predictive Analytics, Sustainable Networks.



## INTRODUCTION

Telecommunications are a combination of technology and service that allow for the movement of information over long distances by way of wired and/or wireless networks. The telecommunications industry is now an integral part of connecting people globally, building digital networks and providing business tools, connecting globally with others, and enabling the new digital economy to exist. The invention of the telephone and the telegraph more than 150 years ago was the starting point for the evolution of telecommunications to today's technology, which now consists of: radio, television, broadband, mobile networks of the late 1970's and beyond. Telecommunications companies offer many types of essential communication products and services to their customers, including: voice calling, text messaging, internet access, and value-added services such as cloud storage and video conferencing. The telecommunications industry consists of three main segments: Network Operations, Service Provision, Equipment Manufacturing. Many advances in telecommunications technology can be attributed to fiber-optic, 5G wireless technologies and satellite communications. New developments such as the Internet of Things (IoT) and artificial intelligence (AI) will create new opportunities for future telecommunication technologies. There are many service providers in the United States competing in the highly competitive telecommunications market, which is regulated to ensure fair competition and maintain the quality of service provided. Telecommunications services are an important part of everyday life for both individuals and businesses, allowing people to communicate with each other easily, provide a platform for instant communication and

provide the tools necessary to run today's digital businesses. [1]

In the United States, the national mobile platform being discussed will become a major driver of growth for one of the largest mobile telecom providers, accounting for millions of mobile customers in the wireless segment. The platform will be responsible for enabling all critical telecommunications functions through its customers, including number portability, SMS activation, account setup changes, billing (recurring and usage-based), managing the life cycle of devices, and more while communicating with a number of partner networks. The accuracy and reliability of services is critical to the success of a wireless subscriber's experience as a result of real-time operations such as plan upgrades, phone number transfers or new active phone numbers are determined by the timing of these operations. Reliability, speed of number portability, billing accuracy, and consistency in performance are the foundations of a brand's reputation within the marketplace. A telecom platform must be both effective and trustworthy in order to build customer loyalty and encourage continued growth and investment from all areas of the telecom industry.

Telecom is a fundamental component of modern communication, allowing people around the world to communicate seamlessly with each other, as well as with their devices (e.g., mobile phones). Telecommunications comprises many different types of technology including basic telephone service, broadband services such as cable modem access or high-speed internet service via satellites, Webcams for video conferencing, as well as real-time data transfer capabilities based on Internet Protocol (IP) from one location to another around the globe. In this way, telecommunications enables individuals to communicate with each other from anywhere in the world through various digital means, thereby allowing them to stay connected to family and friends who may live thousands of miles away from one another. The rapid growth of the telecommunications marketplace has made it possible for almost everyone to stay connected at all times regardless of location. As well as enhancing people's ability to work, it allows them to develop and innovate within their respective industries (e.g., banking, health care, education). In addition, the telecom industry serves as the foundation of the digital ecosystem, allowing various geographic regions to connect and contribute to the growth of the world economy and social progress [2].

Through millions of users and their ability to access reliable cellular service statewide, the telecom platform provides an essential mobile service in the US telecom marketplace. With the growing volume of traffic being transmitted through its extensive network of infrastructure, the platform is becoming increasingly popular with individual customers as well as business clients. The delivery of service, network efficiency, customer service, and network accessibility are all being positively influenced by the mobile platform, which is driving innovation in all aspects of the telecom industry and growing the wireless sector. The mobile platform is key to the US telecom marketplace by providing reliable cellular services to millions of customers and providing statewide coverage for all customers.

A vast user base would benefit from the platform's high level of connectivity, allowing individual and business users to gain access to services with a much greater level of speed and availability. By using a highly optimized infrastructure for both service delivery and network efficiency, this service creates a new level of customer experience for subscribers across the nation and drives innovation in digital communication not only through improved connectivity, but also through evolving trends for digital communications. The wireless sector has benefitted from the creation of digital platforms like this, as they are helping to further the growth of the wireless sector through this platform's influence on the way we connect. As a result of all of this, it is safe to say that the benefits of using this platform extend well beyond the level of connectivity offered to subscribers [3].

Subscriber experience is enhanced in real time via the platform's features. Instant SIM card activation allows new customers to access and utilize their mobile plans almost immediately, and thus allows for enhanced levels of customer satisfaction and lower rates of customer churn. Number portability is critical in that it allows for users to change carriers while still keeping their phone numbers intact, which can be particularly important during promotional periods or when a user is looking for lower priced plans. Additionally, the plan management feature allows customers to add or change service packages when they want to; for example, upgrading to a larger data package for travel. Real time billing systems allow for quicker invoices and thus reduces the chance of disputes or misunderstandings; as a result, this builds greater trust with customers, especially while traveling internationally and incurring roaming charges. Device upgrade features provide customers with the ability to quickly and easily access current technology; thus, there are no delays when upgrading to the newest devices. Finally, partnerships with other networks allow users to maintain continuous connectivity when traveling internationally, and thus all of these features allow the platform to provide reliable, fast, and customer-focused wireless services [4].

In the telecommunications business, service delivery has been dramatically improved through the use of digital platforms, including live dashboards, automatic job assignment systems, and integrated systems that provide real-time visibility and operational control. The combination of all of these capabilities has resulted in quicker fault resolution times and improved customer experiences. AI-enabled architectures allow network

professionals to retrieve real-time incident information and thus improve network response times. For example, integration platforms such as ZigiOps allow real-time visibility, enhance collaboration between cross-functional teams, automate workflows, and reduce issue resolution times by 25%. As a result of these benefits, customer service representatives have experienced significant reductions in average handle times as a result of real-time automation in contact centers, and their customers have been able to eliminate the need to perform after-call activities in order to better meet their customer satisfaction goals. Finally, AI solutions like Nokia's AVA 5G Cognitive Operations can predict when outages will occur and result in a reduction of customer complaints of up to 20% and a reduction of on-location maintenance visits. Thus, millions of users can maintain uninterrupted connectivity because of all of the benefits that these innovative digital service platforms offer [5].

Digital platforms and legislative support for number portability are creating new opportunities for cellular customers to easily compare carriers and switch between carriers without significant effort. Once customers experience service issues such as service interruptions, billing problems, or upgrade errors, they will typically move to a competitor offering better service. Thus, any missed opportunities to upgrade to a higher service offering in real time will typically lead to immediate customer loss and/or negative social media posts. Customers expect that their current service will meet or exceed any new promotion from a competing carrier, and when a carrier does not quickly respond to updates or resolve issues, the carrier will likely lose customers, particularly in urban areas with overlapping wireless coverage. This emphasizes the need for seamless, real-time services to maintain market share and trust in today's very competitive electronic marketplace.

**Related Work**

This list of sources includes all elements of customer abandonment, how companies operate in the present moment, and the impact of competition on telecommunications. It discusses how the use of real-time technology (including AI) has helped improve customer service and satisfaction through real time visibility/automation and how this technology can be used to enhance the reliability of networks and users' experiences. The use of integration platforms by companies provides a clear business process and allows customers to have confidence in the company they provide them with services. This list of sources provides more detail on the improvement of customer satisfaction and handling duration through the implementation of real-time technology in contact centres. There are also studies on how the use of predictive maintenance, through AI, has helped improve customers' connections and, consequently, reduced the number of complaints made by customers. Collectively, these references support the discussion of improving customer satisfaction, operational efficiencies, and competitive advantages within the telecoms industry [6].

The telecoms industry is facing numerous challenges, including accurately capturing and retaining data, automating legacy systems, and maintaining consistent service levels across its networks. While businesses, such as Lepton Software and Global Technology, are using AI, real-time Dashboards and other capabilities to increase customer satisfaction, improve operational efficiencies and response times, and decrease the need to send responses, they also face several challenges, such as needing to invest large amounts of capital to implement these technologies, and they may potentially lose jobs as a result of the introduction of these technologies. ZigiWave's partnership with Dynatrace highlights both the advantages of using real-time integration platforms and improving visibility and collaboration among team members. The integration of both companies also demonstrates the ongoing need to monitor usage of the platform and its accompanying features. The average handling time of Uniphore has improved with the introduction of new software but its customers have stated they are concerned about a reduction in customer service representatives due to technology use [7-9].

SmartDev stresses the importance of ensuring the integrity of the customer data used by AI application models while MindTitan suggests that continued investment will be necessary for success in the telecom business using AI technologies. Additionally, examples from Orion Inc. show that there is a benefit for companies investing into AI tech.While examining the impact of real-time telecommunications operations, as well as the use of artificial intelligence in those operations within the Telecommunications industry, some of the key improvements are to increase customer support systems and address quality assurance or personalization service issues through improved operational performance and efficiency. However, using Real-time Operation and Artificial Intelligence does present challenges for businesses and their service providers within the telecommunications industry. These Insights have highlighted the importance of using both Real-Time Operations and Artificial Intelligence to allow users to receive more accurate and timely information about their services [10].

While there is a number of benefits to the modernization of Older Telecommunications Systems, there are challenges associated with modernizing these Old Systems. Improvements that can be achieved include Streamlining Processes, Minimizing Service Downtime, Improved Security and Compliance, as well as increased Long-Term cost savings as a result of Reduced Maintenance, greater Scalability and Agility, Easier Integration with New Technology, Enhanced User Experiences through an Improved User Interface that Reduces Errors and Training requirements.

The Challenges Associated with Modernizing Old Telecommunications Systems include the Complexity of, and Dependencies on, the Legacy Systems of Telecommunications Providers that may complicate Upgrade Efforts and cause business interruptions when upgrading. Additionally, there is the risk of Data Loss during Migration/Conversion and Performance Disruption after the migration/conversion. In addition, finding and retaining skilled employees to perform the conversion is often difficult due to the need for employees to have knowledge of both Legacy and Modern Telecommunications Technologies; this presents a risk of implementation failure. Furthermore, the Initial Expenses of Training Employees to Support or Use the New System and Management of Change require companies to continue to evaluate the Security and Compliance of the New System [11,12].

Modernization should be pursued in a manner that minimizes Downtime and maintains Operational Effectiveness and Business Continuity. Older applications can be moved easily and quickly to new modernized environments with very little effort using the lift-and-shift application modernization strategy. Another strategy for moving modernizing older applications is called phased or incremental or stepwise application migration, where an application will be migrated progressively over time through each of the phases into the next phase of the modernization process while at the same time providing an improvement to the foundational database(s) at the end of every phase, thereby significantly improving the risk of moving too many applications at once through a phased method of continuing to upgrade existing applications progressively over time. Another type of approach to modernize applications is rehosting, which allows migrating existing applications to a new modern infrastructure without the expense of rewriting the application code, which allows rehosting applications to easily migrate [13].

Hybrid cloud technology allows organizations to have the best of both worlds, with the opportunity to use the existing on-premise server (ONS) resources while also being able to take advantage of additional high-performance computing capabilities available in a public cloud to help ensure business continuity during upgrades and modernization efforts. Bluegreen deployments are created when an organization builds two identical (or near identical) servers (typically referred to as blue and green), and during the initial period of implementation between the two servers, either the blue or green server can be utilized during upgrades without downtime for the applications being transitioned. The dual O&M strategy for a phased or incremental modernization also provides the organization with a real-time method to validate the application's data and business processes since both the legacy and new versions of an application will be operational on a single set of resources at the same time. Best practices and methodologies from Agile development and the DevOps philosophy also will allow organizations to modernize at a quicker pace while reducing the negative impact to both their consumers and end-users as a result of modernization. All the strategies mentioned above enable the success of an organization's modernization effort while providing minimal risk to its consumers and end-users as a result of modernization efforts [14].

**System Architecture**

A platform built for connected devices that connects users (customers, employees, etc.) with their mobile devices (smartphones, tablets, etc.) to a public mobile network. Spectrum Mobile's platform utilizes modern technology and automation to provide solutions that were difficult to achieve with its previous manual processing approach. The platform's original middleware design using SOAP caused challenges such as downtime, uncertainty with respect to compliance risk resulting from the manual processing activities associated with the platform, and an inability to scale to meet the demands of large subscriber bases during peak usage periods. Today, the Spectrum Mobile platform is being hosted on AWS EKS, which has enabled the use of cloud-based architecture and continuous integration/continuous deployment pipelines to automatically deploy software to the platform without having to experience any downtime. Automated testing frameworks have also enabled the Spectrum Mobile platform to perform complete automated testing of subscriber journey product requests and identify and fix bottlenecks through performance testing and dynamic scaling. The Spectrum Mobile platform has been designed to be highly available with an uptime of 99.9% when deploying new products and has implemented a hot-fix lane to quickly address urgent issues and significantly reduce turnaround times for these types of requests.

Key software developments at The Company include the use of a Blue/Green Deployment model to help facilitate seamless transitions from old to new platform components, Virtualization of services to support continued testing of platform capabilities throughout the development lifecycle, Feature-Flagged Roll-Outs of features to gradually expose features to end consumers, and the incorporation of ChatOps as a means of supporting real-time communication and collaboration between product development teams. With Synthetic Data Generation tools, product testing may occur without compromising Subscriber Privacy. The ongoing modernization of the Spectrum Mobile Platform continues to yield significant improvements such as reducing Release Cycles; increasing responsiveness to Hot-Fixes; improving availability/scale; increasing Subscribers; and generating a Significant amount of Company Revenue Protection, thus demonstrating that Spectrum Mobile is continuing to evolve its Product Delivery Pipeline toward a more automated, compliant, and efficient manner. Mobile Device Tier: The Mobile

Device Tier serves as a connection point from consumers' end-user devices (i.e., smartphones and tablets) to Public Networks for the purpose of accessing Mobile Services.

The Public Network Tier facilitates secure communication between end-user devices and the Cloud Infrastructure that houses the Cloud-Native CI/CD Pipeline(s) utilized to automatically deploy to AWS EKS Clusters. The Kubernetes Orchestration platform leverages Microservices Architecture versus Traditional Middleware (e.g., SIM Activation, Billing, Secondary Administration) to allow for rolling updates and dynamic scaling for the availability of sites. Service Virtualization utilises Emulation of APIs to support Testing, while Feature Flags allow for StManage user devices (UEs) through Control Plane, which manages sessions and device connections. Manage UE's data sessions through routing packets through User Plane. Automated monitoring for compliance & security, and Synthesized Data Generation. Use ChatOps for collaboration and provide real-time feedback to teams dealing with issues regarding the management/release of issues.

The 5G architecture consists of multiple parts working together to deliver better connectivity/services. Smart devices (smartphones/tablets/IOT devices) are examples of UEs, while the RAN consists of gNodeBs (gNBs) and utilizes advanced technologies like beamforming and massive MIMO (Multiple-Input, Multiple-Output) to increase capacity and coverage. To optimize the utilization of resources, gNBs are coordinated by the Next Generation RAN (NG-RAN) system. The Network Core (5GC) acts as a centralized point for all of the access, mobility, session management, and traffic to/from user devices. Important functions in the 5GC are the Access and Mobility Management Function (AMF), which authenticates and authorizes users to access the network; the Session Management Function (SMF), which manages user sessions and quality of service; and the User Plane Function (UPF), which manages users' data traffic. Other components of 5GC that support functions like network slicing and service orchestration are the Network Repository Function (NRF) and the Authentication Server Function (AUSF) (to verify that a device is authorized to connect to the network). The Network Slice Selection Function (NSSF) allows providers to choose an appropriate network slice for an application, while the Network Data Analytics Function (NWDAF) collects data and provides information for improving user experience and network performance. In order to maintain a reliable flow of information between sites, the Service Communication Proxy (SCP) supports establishing reliable flows for a worker's information.

The NG (Next Generation) Interface is the means of communication between the Access and Core Network, and the Xn (Cross-network) Interface is used to synchronize two or more gNodeBs. This design uses a modular and scalable approach to deploying components based on detailed services through industry standard APIs. Due to this architectural framework, providers are able to deliver on the demand for the following features of 5G: ultra-low latency, ultra-high device density (very large numbers of User Equipment), and the ability to create separate network "slices" for many different applications, enabling the delivery of a highly functional and reliable 5G network. To view the key steps involved in Updating Spectrum Mobile, see Figure 1 below.

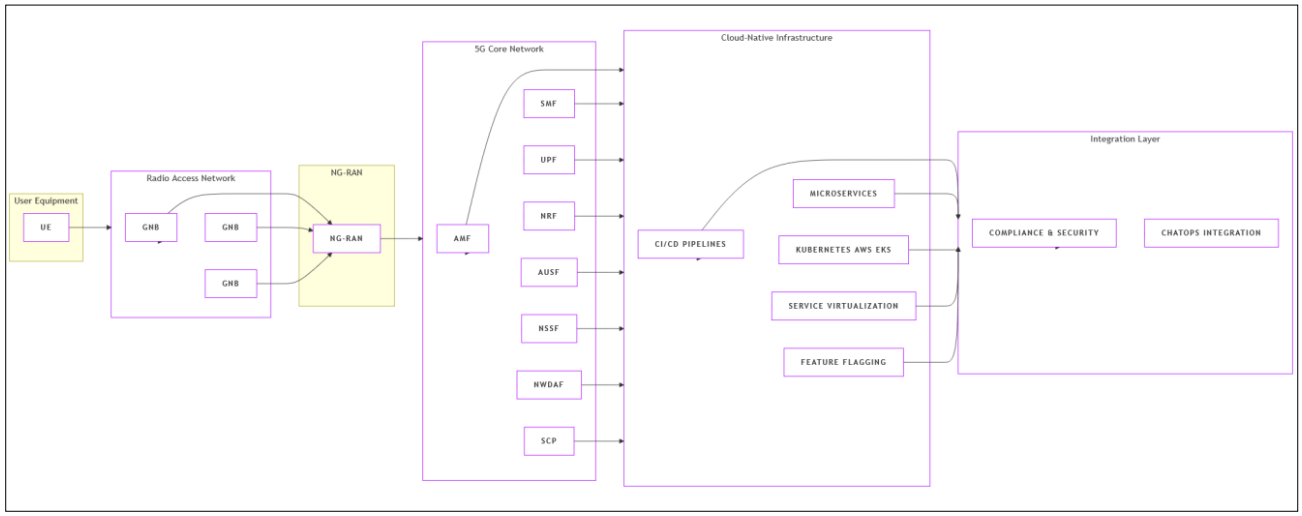


**Figure 1: Modernized Spectrum Mobile Architecture**

1. User Layer:
   - User Equipment (UE) describes tablets, smartphones, and IoT devices. This is done by connecting a device wirelessly to a Radio Access Network (RAN). The UE will connect via 5G or LTE connections.

2. Radio Access Network (RAN):
   - gNB (Next Generation NodeB) is a base station that connects to UE to support wireless communications.
   - NG-RAN connects multiple gNBs and provides links between them.
   - The direction of the data flow is shown by arrows pointing from the UE to both gNBs and NG-RAN.

3. 5GC Core Network:
   - The AMF (Access and Mobility Management Function) provides access control, session mobility, authentication, and UE mobility services.
   - The SMF (Session Management Function) is responsible for managing UE sessions, IP address distribution and QoS management for each UE, and routing of UP packets.
   - The UPF (User Plane Function) routes, forwards, and optimizes traffic, and manages the flow of user data across the network.
   - The NRF (NF Repository Function) stores information on each network function in a central location within the network.
   - The AUSF (Authentication Server Function) provides secure authentication of users.
   - The NSSF (Network Slicing Selection Function) chooses the appropriate network for a specific UE.
   - The NWDAF (Network Data Analytics Function) collects and analyzes network data.
   - The SCP (Service Communication Proxy) sends each type of service message to the proper destination.
   - Data flow between the NG-RAN and network functions is represented by arrows.

4. Cloud-Native Infrastructure:
   - CI/CD Pipelines automate the GitLab and Jenkins processes of deploying new microservice deployments.
   - Microservices supply device management, SIM activation, billing and number portability functions.
   - Kubernetes (AWS EKS) is used for rolling updates and scaling up and down based on demand, and for implementing health probes.
   - Service Virtualization provides a way to emulate the APIs of partner systems. - Gradual Ramp-up of New Feature Rollout Via Feature Flagging
   - Arrows Show Data Flow Between Cloud-Native Infrastructure and Network Service Providers

5. Layer of Integration for Compliance & Security:
   - It includes Synthetic Data Generator, Automated Evidence Gatherings, and Surveillance.
   - Layer of Integration for ChatOps Integration; includes ability to provide real-time communications/status updates via Teams/Slack.
   - Arrows Show Data Flow Between ChatOps Integration Components & Cloud-Native Infrastructure.

Multiple metrics are utilized to assess the level of modernization of a telecom infrastructure (i.e. Spectrum Mobile). There are multiple classifications of metric significance that focus on the performance, dependability, & user experience. Accessibility metrics would consist of call setup success rate and registration success rate. Retainability metrics would consist of drop call rate and handover success rate. Integrity metrics would consist of throughput, latency, packet error rate. Capacity of network is assessed using spectral efficiency, resource block utilization, maximum user throughput. Reliable and available indicators of availability & dependability of the system are uptime & mean time between failures. User experience metric comprises of service quality & customer satisfaction score. Operational efficiency is used to gauge release cycle time & turnaround time for hotfixes.

Security and Compliance Metrics are automated test compliance success rates & incident response times. These metrics provide an extensive framework to ensure Telecom Infrastructure is able to meet both Technical & Commercial Objectives.When you are evaluating and improving the architecture of a telecommunications company, a number of key considerations are important. One important metric to assess when evaluating and improving the architecture of a telecommunications company is to evaluate how well it scales, or what capacity it has to support more users and handle larger traffic volumes during peak hours of use. Another important metric to evaluate is the degree of automation available in the architecture's systems. It is essential to identify how many manual processes have been automated to improve the reliability and speed of the release process. Evaluating the success of the simulations created by partner application programming interfaces using service virtualization will evaluate the efficiency and reliability of testing and the identification of defects prior to the launch of new releases.

Tracking the adoption of feature flags will provide an understanding of the impact feature flags have on the reduction of customer-impacting incidents. A measurement of the average incident recovery time will provide insights into the resilience of the system. A measurement of the efficiency of resource utilization will provide insight into the cost and performance optimization of infrastructure resources. Subscriber

growth rates will indicate the ability of the platform to attract new subscribers. The linking of improvements to the architecture with the resulting improved financial results resulting from revenue protection will quantify the value of the improvements made to the architecture. By evaluating these metrics and metrics relating to the functionality, technology, and the overall business impact, continuous improvement can be obtained, and the overall value of the architecture can be justified.

The modernization of Spectrum Mobile has positively impacted many areas of the organization's performance. Prior to the modernization, release cycles were measured in days. Post-modernization, hotfix reversals are completed within 6 hours on average. Previous to modernization, the systems encountered frequent outages with limited access. Now, it is estimated that systems have achieved a 99.9% uptime percentage during deployments. Scalability of the architecture has been corrected and now has sustained triple the normal volume of use without failure. Previous constraints on subscriber growth were due to the architecture's constraints but now can support an increase of 50% in subscribers with minimal incidents. Additionally, enhancements have reduced the amount of lost revenue from erroneous billing and failed activations, resulting in millions of dollars in revenue that would have otherwise been lost. Automated testing has drastically reduced the time needed to detect defects compared to prior methods of manual testing. The evaluation and implementation include deployment strategies and the evaluation of shortcomings relating to lengthy holds and the use of manual scripts. New approaches such as blue/green deployments and CI/CD pipelines will increase the efficiency of deploying upgrades to the architectures. Furthermore, one of the challenges identified in the table below (Table 1) is the problem associated with middleware (i.e., systems that provide a communication mechanism between disparate systems), which often cause brittle systems.

**Table 1: Key Innovations and Their Impact**

| Innovation | Description | Impact |
|---|---|---|
| Blue/Green Deployments | Zero-downtime cutover strategy | Seamless releases, no customer impact |
| Service Virtualization | Simulated partner APIs for testing | Continuous testing, no dependency on external systems |
| Feature Flagging | Gradual rollout of new features | Minimized customer impact, easy rollback |
| ChatOps Integration | Real-time release status in Teams/Slack | Enhanced collaboration and transparency |
| Synthetic Data Generation | Simulated realistic telecom transactions | Secure testing, compliance without exposing PII |

Numerous innovations introduced during the modernization of Spectrum Mobile improve both its operation and overall customer experience. The most notable improvements include green/blue deployments, which enable deployments to happen without downtime, as well the virtualization of our services which allows us to continuously test our services while relying on no third-party dependencies. The phased approach to rolling out new features provides minimal disruption to customers and makes roll-backs easier should we need to revert back. ChatOps also provides improved cross-team collaboration and transparency, while synthetic data allows for accurately simulating compliance-testing and security-testing scenarios without exposing personal information.

The modernization of Spectrum Mobile faced its share of difficulties, which included issues caused by "fragile" middleware, and concerns within the corporate culture regarding the introduction of automation. As a result of virtualizing applications and the use of feature flags, the team has increased its ability to be resilient. Automating aspects of Shadow Mode is an emerging solution that is expected to translate into increased automation adoption across teams. The use of synthetic data as well as performance evaluation models greatly increases our ability to predict, increasing our readiness and compliance via automated collection of evidence.

Before modernization, Spectrum Mobile operated with long release cycles and lengthy hotfix reversals, limited subscriber growth, and inconsistent uptime. After the upgrade, our release cycle times are shorter, hotfix reversals occur much more rapidly, our infrastructure scales more easily, and we have vast amount of error-protection revenue. For comparison, the dataset below includes various metrics for evaluating telecommunications architecture: Call Setup Success Rates, Registration Success Rates, Drop-call Rate, and Handover Success Rates.

The report provides specific details about average uplink and downlink data speed, round trip time of data packet and signal loss percentage. It also provides information about availability and efficiency of spectrum resources at peak usage time, maximum user throughput and percentage of system uptime and service outages. Many of these metrics, such as MTBF, quality scores, customer satisfaction scores, and compliance audit readiness have been previously captured. The report shows that a considerable amount of manual processes have been automated resulting in faster incident recovery times and greater operational efficiencies. In addition to these metrics, subscriber growth and the fiscal effect of revenue protection measures are highlighted. There are a variety of ways this report can be presented through visual means i.e. pie, bar and line charts, which can help

to communicate the effectiveness and effect of the telecom architecture.

Telecom architectural performance indicators have dramatically changed from the previous standard due to shifting operational need, customer expectations and technological advances. Network availability is now striving to achieve "5 nines" availability (i.e. 99.999%) due to the growing importance of mobile connectivity. Latency has decreased to less than 10 ms, and throughput capacity has increased to hundreds of Mbps and in some cases Gbps with the introduction of 5G. Modern day networks are now engineered using cloud-native and tiered platforms, which provide greater agility and scalability compared to the previous generation of rigid systems. The establishment of standardized APIs allows for seamless integration with 3rd party services, enabling customer-centric innovative ideas. Additionally, AI has revolutionized operations through improved automation and predictive maintenance, resulting in greater reliability and decreased cost associated with running a telecom network. Energy efficiency is now a priority and represents the increased amount of data traffic flowing through a network and is one of the major industries to begin exploring quantum computing for future optimization and growth opportunities. Overall, <INSERT GREATER CONTEXT> represents the move towards intelligent, adaptable, and automated networks creating significant improvements in user experience and performance as shown in Figure 2 below.

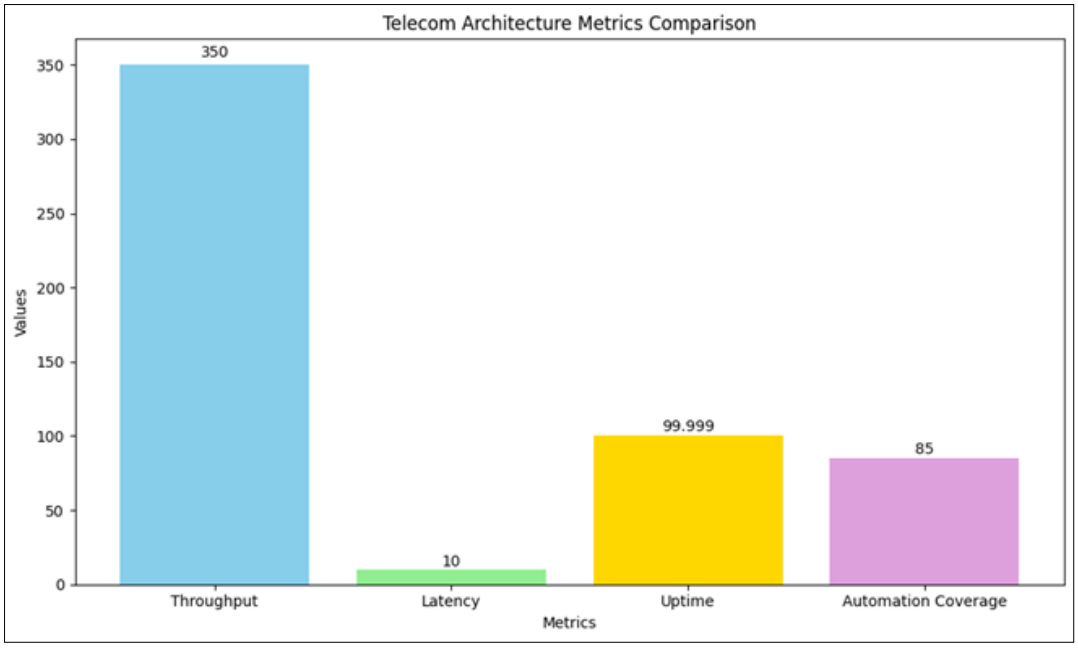


**Figure 2: Telecom Architecture Metrics Comparison**

## CONCLUSION

The telecom industry has made significant progress over the last ten years in terms of design performance, reliability and operating effectiveness. This progress has resulted in many telecom providers adopting new business models and processes, such as cloud-native and microservices architecture, as well as utilizing AI for the automation of many business processes, thereby enabling delivery of faster, more reliable and more scalable services. In addition to these new business models, the telecom industry continues to measure its performance using new metrics, including throughputs, latencies, uptimes and automation coverage, as well as leveraging these metrics as guides for continuously improving service delivery to meet the increasing demands of both customers and markets. By utilizing AI and machine learning for automation and predictive analytics, as well as introducing new technologies such as quantum computing and advanced network slicing, the telecom industry will continue to see a rapid evolution of its technology. The telecom industry will see a growing emphasis on balancing the need for sustainable development and energy efficiency with corporate goals in designing and constructing networks in the next several years. Telecom companies will increasingly need to invest in R&D, as well as developing employee skill sets, to remain competitive and offer value within the growing interconnected global economy.

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