SUMMARY

Three forces are at work that will greatly increase the operational complexity of the 5G access network, requiring that operations be automated to an unprecedented degree: densification, disaggregation, and virtualization.

5G Access = (4G Access x Densification x Bandwidth) x (Disaggregation + Virtualization)

These forces will increase the operational complexity of the 5G access network by over an order of magnitude by escalating the complexity and number of radio sites, vendors, and access network elements, and virtualizing some of the network elements by simulating their functions on distributed standard data center or open source network computing hardware.

Mobile network operators (MNO) will need to bring automation in the operation of these networks to keep quality high and operational expenses low, as will their suppliers that will provide the access technologies to connect their radio towers to their mobile networks. Cable MSOs, fixed wireless operators, and fixed wireline operators will all be supplying access bandwidth and will share in the operations complexity.

FRINX provides an automation platform that can be configured to be a network domain controller, a cross-domain orchestrator or even applied to any general network or business automation and orchestration problem. It has process automation components, a full-function inventory system, and configuration capabilities for network elements or any other system with an API or CLI. It is composed of pure open-source software, delivered together with the FRINX components as a cloud-native implementation and can be extended and configured by CSPs, SIs, and vendors to the use cases needed.

The time to automate is now and into the future. Choose your automation platform wisely.

INTRODUCTION

Mobile operators have long indicated a desire to expand their supplier ecosystems to speed innovation and lower the cost of the most expensive element in their mobile networks: the radio access network. However, adding suppliers increases complexity and cost to the network. 5G emerges as the most complex standards effort ever undertaken by the telco industry. Automation is the key to solving this problem.

Operators clearly understand the scope of the problem and the solution. ACG conducted a poll of the top 20 operators globally, and 89% of operators said automation is critical to operation of a 5G network, with 78% also saying it is very important to the operation of their 4G networks[1].

However, integration complexity concerns are compounded by adding more vendors into the solution, especially new vendors that are not well integrated into the operators' preferred management system via open interfaces that may or may not fully support the analytics on which operators rely to measure performance.

SCALING 5G DEPLOYMENTS REQUIRES A NEW ENVIRONMENT

Deploying 5G networks at scale will necessitate a new architecture framework based on virtualization and a new operating paradigm.

5G Networks: Denser and More Complex

Not just another G when it comes to mobile technology, 5G networks are fundamentally different from 4G networks. 5G benefits from using a wider range of spectrum for transmission than 4G networks, has more extensive performance requirements than 4G particularly for Virtual and Open RAN, and is up to 100x more complex in features and architecture than 4G. The virtualization of 5G network elements adds more vendors to the solution architecture, which presents configuration, management, and performance optimization challenges.

The new spectrum bands, primarily above 2GHz, have 5x−10x the capacity of standard 4G spectrum channels but cover a shorter distance. The use of massive MIMO (MMIMO) compounds the capacity issue by supporting up to 4,096 5G antennas where 16 4G antennas used to function. For users to benefit from the higher speeds and capacities of high-band 5G, operators are densifying their networks to provide increased coverage.

Densification is occurring in several specific ways, including small cells and fixed wireless access (FWA), and these new sites require 3−10x times the backhaul bandwidth compared to 4G. Open RAN solutions promise to lower the cost of mobile network deployment by opening the RAN to alternative players, all requiring operations support.

[1] The Open RAN Alliance and the emergence of the Open RAN ecosystem with over 100 vendors won the battle in getting the proprietary interfaces opened, presenting the mobile operators the potential to expand their RAN supplier ecosystem.

Disaggregation and Virtualization Drive Complexity

Network operators are transforming their networks and operating environments at an unprecedented rate. The traditional monolithic, closed, purpose-built hardware-based systems of recent years are being extended by virtualized cloud-native solutions and disaggregated network elements running on general-purpose platforms that often use open-source software. At the same time, networks are being distributed and disaggregated to optimize performance, improve agility, and reduce cost. Although the benefits of these initiatives in terms of service velocity, agility, elasticity, speed of innovation, and improved customer experience are undeniable, they introduce a staggering amount of complexity as modular components from various vendors need to be integrated, operated, and modified continuously and dynamically.

Last-mile operators are positioned to play a major role in backhauling 5G traffic, given their extensive footprints and the presence of power in the last mile where small-cell densification is most problematic. 5G requires significantly more cell sites than 4G. For 28GHz mmWave, a site plan can require more than 10x the number of cell sites with each requiring power and backhaul connectivity to the mobile core. The major last-mile technologies, DOCSIS and PON, enable operators to support 5G backhaul.

5G Densification Challenge

Given the significant need for small cells in the access network, a number of access technologies are being considered. However, they all face challenges in meeting the scale required for 5G.

Hybrid fiber coax networks: well suited for 5G densification

Cable MSOs are well positioned to be major players in providing 5G backhaul if certain technical challenges of latency can be overcome[2]. Given the significantly larger numbers of cells needed in 5G and the need to locate them very closely to subscribers, using fiber to backhaul this greater number of cells is very expensive and operationally more complex to deploy because it requires pulling fiber very deep into the access network and providing power, which requires permits and construction. Therefore, DOCSIS has emerged as an attractive alternative given its wide footprint (it passes 93% of US homes according to NCTA), its penetration in areas where densification is needed, and the presence of power deep in the access network.

However, deploying a massive number of small cells to meet 5G densification is beyond the existing operational capabilities of most cable operators today. The largely manual processes on which they rely are woefully inadequate for the scale of deployments needed.

Passive optical networks: another solution for 5G scaling

Fiber access technologies have been widely deployed by wireline CSPs for FTTx (fiber to the home, building, curb, neighborhood, etc.) service to consumers and businesses. Chief among these technologies is the Passive Optical Network (PON) architecture where the only active electronics are at the endpoints of the fiber run (the optical line terminal at the central office and the optical network units or optical network terminals at the customer end of the fiber run). In the fiber run, CSPs deploy passive optical splitters to distribute the bandwidth to multiple locations. Many different bandwidth management

[2] https://www.multichannel.com/blog/msos-well-positioned-to-play-major-role-in-5g-deployments

schemes are available from the various suppliers. Lambdas and bandwidths must be provisioned by a configuration management system to meet the service needs of the customers, matched to the various management schemes.

Recently, several alternatives for disaggregated PON architectures have been proposed. In these, the OLT is broken up into several modules with a standardized hardware chassis in which boards from other vendors can be inserted. The embedded control software is virtualized, runs on a white-box computing platform, is separated from the hardware, and can be from a different vendor. The result is a more complex equipment arrangement that is planned to be less expensive in hardware and software but that has increased complexity in configuring the multiple boxes to make the system work as a whole.

Other access arrangements

Other technologies are also available to provide 4G and 5G access, among these, ethernet and fixed wireless access. Each has its own requirements for configuration, and these are changing with time, becoming more complex.

SCALING THE CABLE DISTRIBUTED ACCESS ARCHITECTURE

The cable access architecture needs to evolve to support the growing demand for bandwidth, and to meet the growing need for upstream bandwidth, particularly given the sudden massive need for video conferencing. In recent months, the COVID-19 crisis led to an unprecedented Internet use: about 20% in downstream and 35% increase in upstream utilization.

The distributed access architecture (DAA) disaggregates the cable CMTS and is the best path forward to enable cost-effective backhaul scaling for the cable operators. To meet the increased bandwidth demands, the service size groups are decreasing from typically 500 homes passed to about 64.

It is not surprising that the limited deployments of DAA to date have been bookended (from the same vendor) as interoperability is still lacking; furthermore, despite its promise, DAA deployments have significantly lagged expectations because in no small part to the complexity and lack of an adequate operating framework. Automation can help expand the DAA base and provide additional mobile business opportunities for the cable operators.

AUTOMATION IS CRITICAL

The operational complexity of the 5G access network will greatly increase, driving the need for more automation. This automation must be done at multiple levels of the operations, requiring multiple software technologies and techniques.

Operations Complexity Is Increasing

With increased bandwidth needs, 10 times the number of antennas and commensurate increase in backhaul needs (densification), we can expect an increase in the complexity of the operations of three to five times (Figure 1).

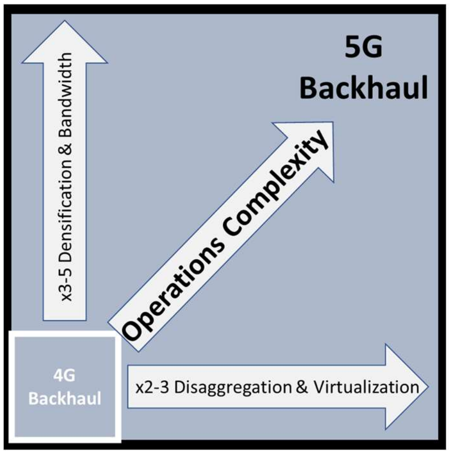

Figure 1. Relative Operational Complexity of 4G and 5G Backhaul (Source: ACG Research, 2020)

The complexity grows because of disaggregation of the network elements into two to three times the number of sub-elements, which increases the complexity of provisioning and managing each of the backhaul paths as well as the virtualization of some of the components, requiring operations management of the virtualized infrastructure, the virtualized multiple applications, and the addition of multiple vendors to what tended to be a single-vendor environment before. The net effect is an increase of three to four times from these aspects of the changing architecture. The overall complexity of the 5G operations would be 10 to 20 times that of 4G operations. Obviously, CSPs cannot spend 10 times as much on these operations. Automation **must** decrease that number.

10xNetwork Goals

Although the complexity of operations is increasing, CSPs believe that their survival is dependent upon being able to radically change the way they do their network operations through automation at multiple levels. ACG Research calls these 10xNetwork Goals.[3]

These involve four aspects (Figure 2):

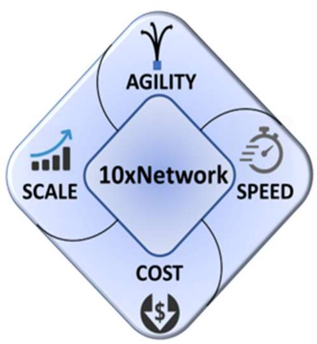

Figure 2. 10xNetwork Goals (Source: ACG Research, 2020)

- Agility: 10xNetworks can be augmented and configured to introduce new services at 10x the rate of networks today.
- Speed: 10xNetworks operations respond to real-time network conditions, faults, and changing customer requirements 10x faster than legacy networks.
- Total Costs: Costs of a 10xNetwork are one-tenth of the current capital expenses and operational expenses.
- Scale: Networks can deliver 10x more service to 10x more people (without 10x the cost).

The only way to achieve these is by embedding automation at every level of the equipment and operations.

[3] See https://www.acgcc.com/blogs/2020/05/18/acg-10xnetwork-project/ and https://inform.tmforum.org/insights/2020/07/vodafone-targets-10x-improvement-in-operational-efficiency/

Automation Map

In a recent comprehensive study of the state of network automation[4], ACG Research mapped out how the 10xNetwork goals could be achieved by automating at various levels (Figure 3).

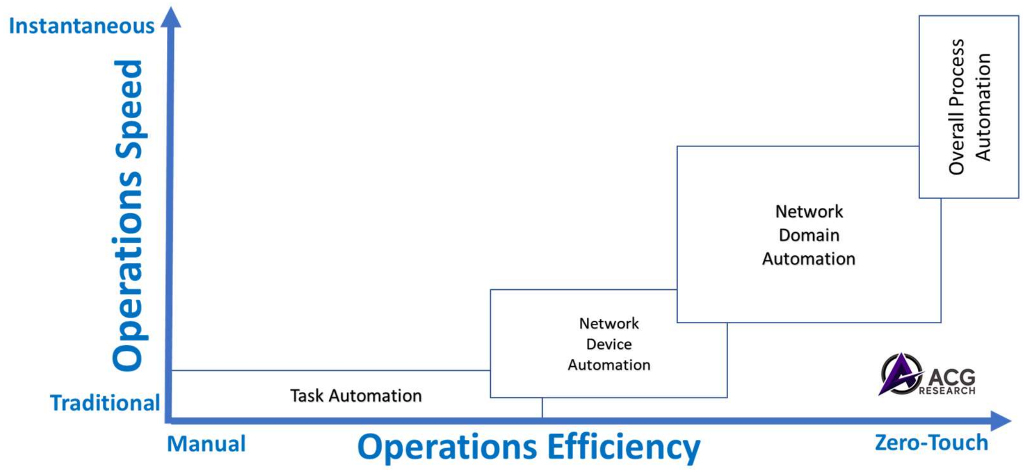

Figure 3. 10xNetwork Goals

Task Automation

The automation of individual tasks that otherwise would be performed by people using command line interfaces represents a major opportunity for automation today. Standardized scripts (sometimes also called playbooks) or processes using Robotic Process Automation (RPA) software packages are usually employed[5]. These scripts are specifically designed for many different kinds of processes for the myriad of individual device types (whether virtual or physical) and often further customized by manufacturer and version. Task automation processes are usually relatively simple with few decision points and very limited error condition handling.

Device Automation

A set of scripts can be pulled together to automate a multiple-step process, thereby automating a process for an entire device. The automation software here can, again, be RPA or more sophisticated process flow software with branches, loops, and error conditions.

Domain Automation

A set of devices that are considered a part of a larger whole are all within one domain. The definition of a domain is dependent upon the policies of the CSP. They can be technological (for example, core routing, mobile core or SD-WAN), geographic (regional work groups) or by manufacturer. The domains follow the

[4] See https://www.cisco.com/c/dam/en/us/products/collateral/cloud-systems-management/network-services-orchestrator/acg-economic-benefits-of-network-automation.pdf

[5] Ansible is one open-source example of RPA technology being widely deployed today for task automation, replacing manually entered commands or technician-created ad hoc scripts.

organizational boundaries of the CSP’s network organization structure. Increasingly, a domain controller is deployed to automate all the work in a domain[6].

Cross-Domain Automation (Orchestration)

Work across multiple domains has usually been done manually, when necessary, via interrelated work orders and then tracked by project management software. New orchestration techniques are allowing these to be standardized and automated much more than in the past.

Overall Process Automation

With cross-domain automation in place, overall process automation can be applied to complete the picture. This involves the configuration of not only the network, but also the operations support systems (OSS) and business support systems (BSS).

Different Technologies for Different Levels

The levels of automation to the left (task, device, and some domain level) are the most amenable to relatively simple automated workflows based on manual playbooks. This level can get most CSPs about halfway to the 10xNetwork goals in efficiency and one-third in operational speed. Domain, cross-domain, and overall process automation build on the task and device automation but require more sophisticated analysis (including cognitive AI, big data analytics, and machine learning) and sophisticated process control, along with a governance structure to oversee the automated operations

FRINX AUTOMATION SOLUTION

The FRINX solution can be used to automate operations at each of these levels. It has proven itself well in the task, device, and domain levels and is being extended into cross-domain orchestration and overall process automation. It is composed of standard, open-source software components that provide future-proofing and ensure that a large ecosystem of users and practitioners are available for configuration and support.

FRINX provides end-to-end automation software for workflow inventory and network control for CSPs’ heterogeneous physical/virtual networks. Capabilities include configuration management and auditing for service provisioning, security, and ongoing management of any network element or system that has an accessible API, achieving end-to-end service enablement and setting the stage for autonomous networks.

FRINX Machine is a software platform for network element configuration; it has three components:

[6] The domain controllers can be considered the next generation of element management systems (EMSs) and network management systems (NMS). These have traditionally been provided by the manufacturers of the equipment with some abilities to manage other manufacturers’ equipment also. The modern domain controllers have more multivendor capabilities, greater automation, and often incorporate both service provisioning and service assurance functions much more powerful than the EMS and NMS systems of the past. ACG Research has initiated a research program titled *Domain Control and Orchestration (DCO)* to track the evolution of this increasingly important area. See https://www.acgcc.com/domain-control-and-orchestration-for-the-future-automated-network .

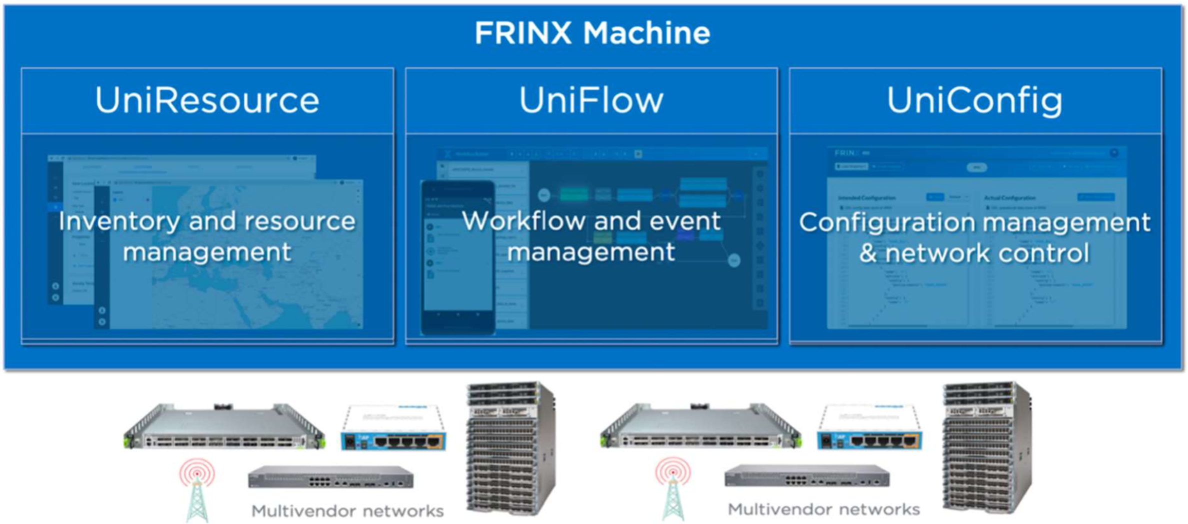

Figure 4. FRINX Components (Source: FRINX)

UniResource: Enables network operators to manage their physical and logical assets and resources, including physical and resource inventory; it stores and correlates service and device attributes in an open-source database. UniResource has a GUI and a GraphQL based API.

UniFlow: A workflow builder based on Conductor Netflix open-source software; it is used to create workflows of microservices for validation and configuration of network devices and services; it uses RESTful APIs and works with NETCONF/YANG and CLI interfaces of multiple vendors.

UniConfig: Used for intent-based configuration management of physical and virtual networking devices through a unified API.

FRINX Machine automates CPE mass configuration as well as self-service and health checks; it provides automation of access and core network equipment deployment for switches, routers, and wireless equipment; it includes CSP apps for dispatchers and installers for work orders, providing automated workflows to aid the technicians.

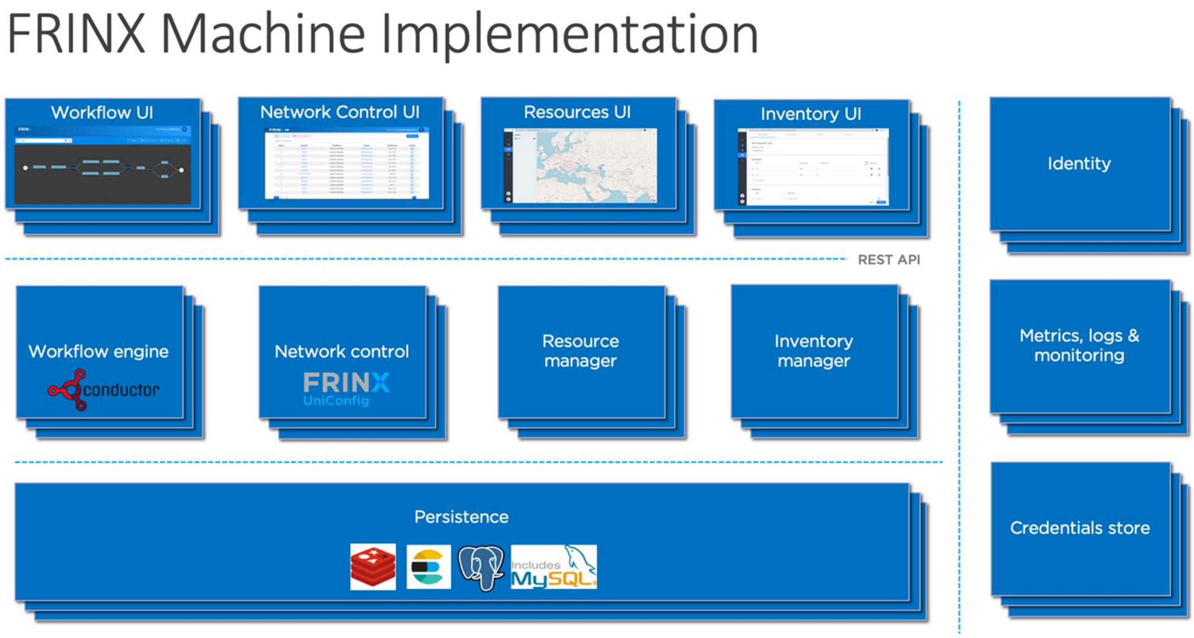

Figure 5. FRINX Machine Architecture (Source: FRINX, 2020)

FRINX Machine has a proven track record in CSPs with IP/MPLS/Segment Routing infrastructures, Metro Ethernet and advanced Layer 2 and 3 VPN services, where it provides key domain management functions, including configuration management and auditing for service provisioning, security, and ongoing management of any network element or system with an accessible interface. Its capabilities are being extended to other domains that include 4G backhaul and the rapidly expanding 5G backhaul using Ethernet, wireless backhaul, DOCSIS, and PON transport technologies. At the same time, FRINX Machine is evolving to support business process automation for configuring not only network elements, but also OSS and BSS systems (anything with an API) to provide full end-to-end business process automation for zero-touch provisioning.

FRINX Machine integrates easily southbound with both new and legacy physical, virtual, and containerized network elements via standard APIs and CLIs; it also integrates with northbound cross-domain orchestrators.

A major value proposition is the use of open source and its integrated open-source inventory and workflow management by FRINX to provide a full solution without vendor lock-in. It addresses the CSP's needs across multiple organizations:

- Marketing: Allows fast creation of new services.
- Product Management: Provides zero-touch provisioning to speed implementation.
- Operations: Automates the resource and service provisioning, security auditing, and ongoing management of the network, enabling operations to handle X5 to X10 amount of 5G backhaul expected in the next several years.
- IT: Provides a fully cloud-native, containerized, microservices-based architecture for deployment on-prem or in private, hybrid or public clouds.

LOOKING BEYOND 5G

Automation is necessary for 5G operations, but, beyond that, there will be additional innovations that will require additional automation:

- Slicing of the network will multiply the operational complexity once again.
- New 5G services will have increased QoS guarantees that will require greater automation to detect, report, and mitigate against QoS violations.
- The increasing automated interconnection of CSP ecosystem partners at the business level will require greater interconnection at the network operations level.
- Increased security concerns will require greater automation built into the equipment, systems, and operations instead of layered-on as it is done today.

All of these will demand greater automation, building on the automation that is being implemented now. The goal? The autonomous network with near-zero-touch provisioning, near-instantaneous services, automatic scaling, and secure, transparent operations. The FRINX solution is well suited to providing a technological base for the automation of networks today as well as 5G and beyond as they further densify, disaggregate, and virtualize.

About the Authors

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ACG Research delivers information and communication technology market share/forecast reports, consulting services, and business case analysis services.