cellwize

ON THE ROAD TO 5G: THE EMERGENCE OF HYPER-AUTOMATION & AUTONOMOUS NETWORKS

THE ADVENT OF 5G REPRESENTS A TIPPING POINT IN MANAGING COMPLEXITY. THE ERA OF HYPER-AUTOMATION AND AUTONOMOUS NETWORKS IS HERE.

Only with a new generation of SON (Self-Organizing Network) will mobile network carriers and operators be able to effectively tackle the increasing complexity of wireless networks. *Autonomous Networks* will be able to efficiently utilize new technologies and functions and will help the MNOs to deliver a superior experience to their customers. The new paradigm of *Hyper-Automation* moves far beyond rule-based automation. It will enable MNOs to enhance performance across all levels of wireless technology as well as assure excellence in the new services that will slice across them. It will deeply transform operations at technical as well as organizational levels!

This report examines the role of *hyper-automation* in the evolution of wireless networks towards 5G, virtualized and disaggregated RAN, network densification and slicing, unleashing the potential of massive IoT and meeting the growing demand for permanent access and super-speed data services.

5G: A TECHNLOGY REVOLUTION

5G carries a great promise. As it evolves and expands it has the potential to drive economic growth, create millions of new jobs, foster the industry 4.0 revolution and enable a whole host of new and exciting services and technologies. It is expected to further expedite the digitization of the global economy with cloud-based services, next-generation transactions such as blockchain, virtual and augmented reality (VR/AR) applications, autonomous driving, artificial intelligence (AI), and the Internet of Things (IoT).

In recent analysis it was highlighted that 5G will enable significant economic benefits. As an example, IHS Markit[1] modelling has predicted that 5G will enable $US12.3 trillion of global economic activity in 2035, shared across all industries and that the global 5G value chain will generate $US3.5 trillion in output and support 22 million jobs. Another example, from a report by the Canadian Wireless Telecommunications Association[2], suggest that new 5G wireless networks will contribute as much as $40 billion annually to Canada's economy by 2026 and the deployment of 5G networks across Canada will lead to the creation of over 250,000 jobs.

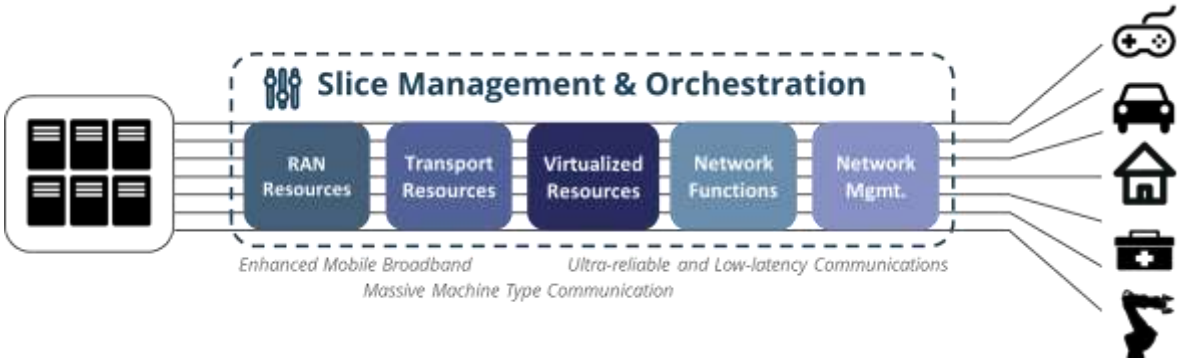
5G promises a versatile and profoundly connected world with X1000 greater capacity, X100 higher data rates, X10 lower latency, X100 massive connectivity and X1000 better energy consumption. As the iPod brought the revolution of carrying music in your pocket, 5G will enable people to carry their personal and professional cloud in their pocket.

5G is expected to embrace and integrate new innovative technologies, driven by the need to evolve and enhance wireless connectivity for future generations of mobile networks. Compared with previous generations of wireless technology, the key motivation for 5G development is to significantly improve spectrum utilization efficiency to enhance customer experience, and to expand the capabilities of mobile networks to exploit new business models. For example, with augmented reality or self-driving cars, latency is critical as it needs to be near real-time for any applications running in the cloud or driving on the road for that matter. Another revolutionary 5G capability is network slicing which refers to the partition of wireless networks to provide dedicated capacity for a specific use case. Network slicing of 5G could provide dedicated resources to special use cases such as self-driving cars or IoT devices to ensure that they work effectively in particular areas or industries. In addition, it may allow

1 IHS Economics & IHS Technology (2017) "The 5G Economy: How 5G Technology Will Contribute to the Global Economy", January 2017, p.4

2 https://www.5gcc.ca/wp-content/uploads/2018/06/CWTA-Accenture-Whitepaper-5G-Economic-Impact_Updates_WEB_06-19-2018.pdf

enterprises to manage their networks in a self-service manner and to dynamically orchestrate and allocate the needed network resources. These developments enabled by 5G will pave the way for the provision of new applications and services that previously failed to find a positive business case.



KEY TECHNOLOGIES EMERGING IN 5G

There are already some key technological frontrunners that are very likely to underpin and enable the significant network enhancements that 5G will bring. These include *Millimeter Waves, Small Cells, Massive MIMO, Beamforming* and *Full Duplex*.

Millimeter Waves - Today's radio-frequency spectrum is struggling more than ever before to support the ever-growing number of devices and the exponential growth in data consumption. The net result is that customer experience is suffering increasingly from slower data speeds and dropped connections. A brand-new spectrum band broadcasting on millimeter waves will add significantly more airwave capacity, broadcasting at a frequency of between 30 and 300 GHz, far higher than the 6 GHz used by current mobile devices. The one disadvantage of using millimeter waves is that they do not propagate well through buildings or obstructions and so to compensate for this the deployment of a small cell layer will be an essential element of 5G.

Small Cells - Many Mobile Network Operators (MNOs) already have the densification of their networks as part of their long-term wireless strategy, providing essential capacity uplifts to their mobile traffic hotspots. The deployment of many thousands of small, low powered cells is central to this strategy, especially in relation to 5G. One benefit for planning 5G small cells deployment is that the antennas for millimeter waves are considerably smaller than today's base station antennas. This can make the deployment of 5G small cells and the siting of its antennas an easier affair compared to the small cells of today. The downside is that it may not be financially viable to deploy many thousands of small cells in rural areas simply to

provide 5G coverage. Here, at least for 5G, MNOs will face real challenges in expanding 5G coverage.

Massive MIMO – MIMO (multiple input, multiple output) technology will deliver a significant enhancement to an antenna's capacity to handle cellular traffic, potentially enhancing existing mobile network capacity to handle simultaneous customer connections by a factor of 22 or more. The "massive" MIMO part reflects the ability to deploy multiple antennas on a single array, outstripping the capacity of existing 4G antenna configurations. MIMO also promises to deliver a far higher level of spectrum efficiency compared to existing antenna technology. But as the number of antennas that are deployed in 5G arrays increases significantly with MIMO, so does the risk of interference. Beamforming offers a solution.

Beamforming – is an advanced technology that enables base stations to be able to identify the most effective directional route for delivering data to and from connected mobile devices, and in doing so, reducing levels of interference for other mobiles close by. Beamforming will be critical for 5G massive MIMO antenna arrays to be able to support vast numbers of simultaneous connections carrying ultra-highspeed data traffic in a way that actively mitigates levels of interference and is spectrally efficient. Furthermore, beamforming will compensate for the propagation limitations of millimeter waves by concentrating and directing mobile signals towards connected devices rather than shooting it out in all directions.

Full Duplex – is a technology that is promising to contribute to very high data throughput and very low latency. It addresses a long-term characteristic of mobile networks of "turn-taking" when transmitting and receiving information. Today's mobile networks cannot support simultaneous information flows in both directions using a single frequency. To do this, multiple frequency bands would be required. With full duplex this is no longer a constraint. A 5G transmitter will be able to transmit and receive information in the same frequency band at the same time. The implication is that full duplex has the capability to double the capacity of the cellular network. A downside that will need to be considered when optimizing 5G networks is that Full Duplex, whilst being more spectrally efficient, will generate its own unique kind of signal interference and this will need to be actively mitigated.

5G provides a unique opportunity for MNOs to enable a strategic shift from predominantly being providers of voice and data connectivity, to becoming true enablers of next-gen ecosystems. A few MNOs have already taken a strategic lead in 5G deployment and announced big rollout plans. Others are still evaluating their next steps and we assume, during the next 18 months, that many of them will formalize their decisions.

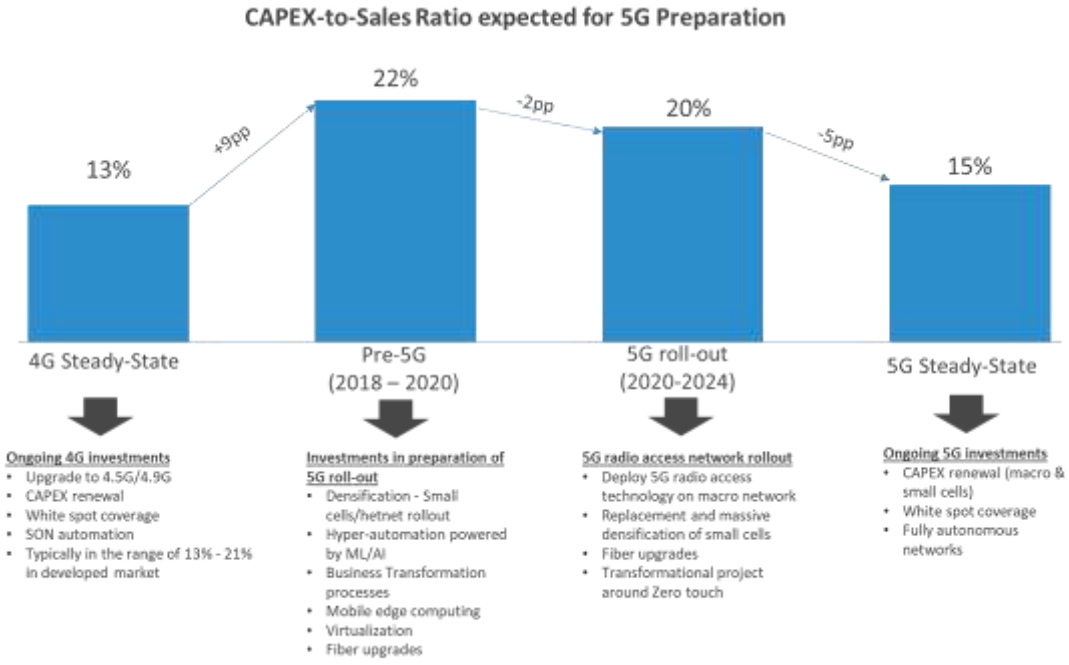
HOW CAN MNOs PREPARE FOR 5G?

Many MNOs struggle to meet the constantly increasing demand for more data volume and higher data rates. Simply adding new cells or more servers to the network is no longer a sustainable model and a qualitative evolution in how networks are planned, deployed, optimized and operated is essential.

The capabilities of modern automation solutions and platforms are evolving by necessity. From reactive network optimization and simple process automation solutions, to smart, autonomous machine learning and pattern recognition. They will incorporate the ability to predict network behavior in advance and proactively allocate appropriate network resources.

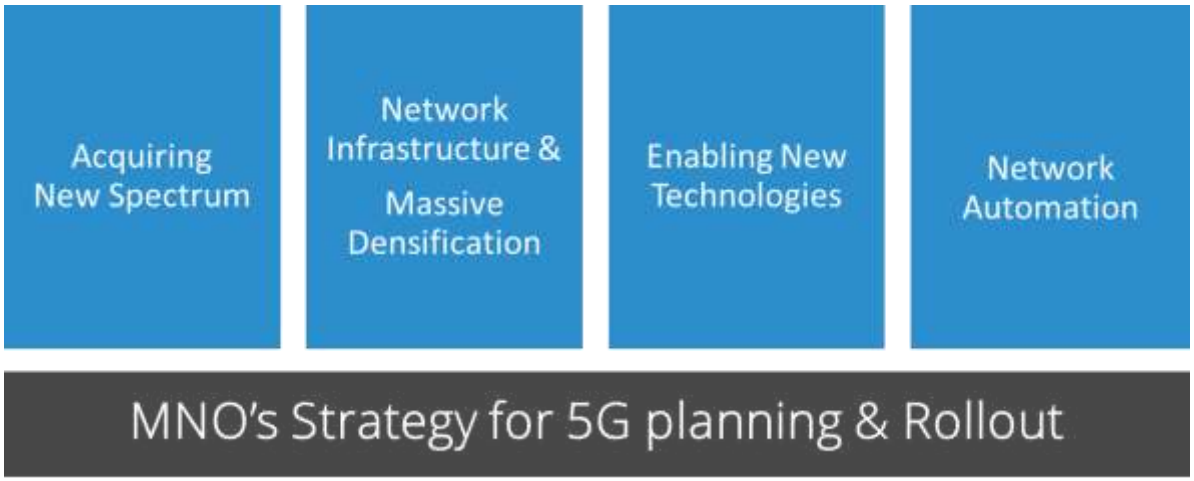
5G, with its fantastic benefits, also brings a significant increase in network complexity. MNOs are starting to realize that automation must play a fundamental role in managing this complexity and in enabling the full benefits of 5G. For example, in June 2018 Deutsche Telekom Group announced a major multi-billion Euro network investment program funded in part by savings from a significant increase in automation. Similar statements have been provided recently by leading Tier-1 carriers such as AT&T, Telefonica, Telecom Italia and Telenor.

The road to 5G is paved with challenges including the need for new higher bandwidth frequency bands, massive network densification and the integration of the new technologies highlighted earlier in this report. Given the challenging economics the introduction and expansion of 5G will not happen overnight. To reduce cost, MNOs must prepare both their networks and organisations for fundamental change. In doing so, MNOs will be in a strong position to streamline their processes and reduce their operational costs in a way that can significantly offset the huge cost of the 5G rollout.



Source: BCG analysis, Mckinsey & Co, Cellwize analysis

According to BCG[3], in the next few years, CAPEX-to-Sales ratio is expected to increase to over 20% in order to prepare the networks for 5G. Mckinsey & Co.[4] are presenting a similar view stating that the Total Cost of Ownership (TCO) for RAN would increase in the period from 2018 through 2023, by about 60%. With this in mind, MNOs will strive to manage their investment and better utilize their existing assets to delay or mitigate the massive investment needed for 5G. In terms of optimizing this huge investment MNOs will need to seriously consider how to leverage advanced technologies such as hyper-automation and network virtualization.



MNOs strategy in terms of planning and rolling out 5G networks must incorporate 4 pillars:

- Acquiring **New Spectrum**
- Evolving **Network Infrastructure** with **Massive Network Densification**
- Enabling **New Technologies**
- Exploiting **Cutting Edge Hyper-Automation**

New Frequency Spectrum

MNOs will need to develop a comprehensive radio spectrum strategy as new spectrum will be purely the oxygen of 5G. It must consider both licensed and unlicensed spectrum which will carry implications for the ecosystem including automation and network policy solutions.

Although spectrum is still released for auction in low bands in many countries, most MNOs will primarily use them for increasing 4G traffic over the short term. For the immense amount of traffic that is expected in 5G it is expected that regulators will put up for auction additional spectrum in high-bands (>3.5GHz) and mmWave (>30 GHz).

[3] "5G - The Emperor's New Clothes?" ; BCG, H. Bernhold, 2017

[4] "The inevitable growth of infrastructure cost", Mckinsey & co., Feb 2018

Network Infrastructure & Massive Densification

Whilst waiting for 5G standards to be finalized and the new technology to be available for roll out, most MNOs will follow a natural path and will continue to evolve and densify their existing 4G/LTE networks.

Massive network densification projects are already in progress in many Tier-1 MNO networks and according to a recent report by Analysis Mason[5] 79% of MNOs are planning to deploy dense networks by 2020. While macro sites are still being rolled out in rural and suburban areas, as well as along railway lines and highways to improve service coverage, the focus has now shifted to the roll out of small-cell solutions. Today, small-cells are the first choice for dense urban populated regions and in areas with high traffic concentrations. From a 5G perspective, they will enable the implementation of higher spectrum frequency bands and mmWave with very small cell radius (<200m).

When planning for network densification MNOs must also carefully consider how they will carry the immense amount of traffic volume to and from their core networks. In the world of 5G, fiberization seems to be the only possible solution. Fibre to the antenna (FTT-A) and fiberized backhaul will be essential to support massive network densification programs with small-cells, embracing the flexibility and capacity-enhancing benefits of centralized and virtualized Cloud-RAN solutions.

MNOs should plan the rollout of small-cells including the provision and expansion of backhaul capacity to address specific local demands, and for 5G and mainly high-band 5G this will be different because of its economic model. Consequently, rollout decisions are likely to be made at the level of micro-markets each with its own unique business case. Solutions such advanced analytics could source data coming from a variety of sources including SON/OSS, social networks and crowdsourcing that could help MNOs in justifying, planning and prioritizing these micro-markets for densification.

New Features and Network Functions

As discussed earlier in this paper, *beamforming* and *massive MIMO* are the technologies that will enable the use of higher frequency spectrum and will become increasingly important for the next generation of mobile networks. With the ability to direct traffic precisely to where it is needed, these technologies will need a robust management and control solution.

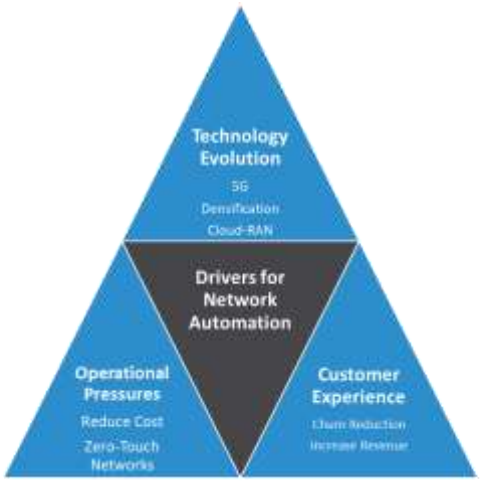
Furthermore, enhanced network management and control functions will be required to manage resource aggregation, not only for carriers of the same radio technology, but beyond network and technology borders. There will be a need for smart automation solutions that provide orchestration capabilities in HetNet environments across 4G and 5G networks. These will meet the service requirement demands of the new 5G era and ensure MNOs remain competitive in markets with shrinking ARPU and increasing TCO.

[5] http://www.analysysmason.com/Research/Content/Reports/5G-SON-brains-Jan2017-RMA18/#04%20January%202017

Network Automation

MNOs are working hard to reduce their infrastructure costs by incorporating and leveraging the benefits of virtualisation, standardized hardware solutions, edge computing and by taking radical steps forward in networks sharing. To remain competitive, they must continue to reduce their network operating costs and look for new and innovative approaches such as dynamic allocation of resources, virtualisation and micro-service architecture, very similar to the approach developed by the leading OTT players. Network sharing is already proving popular in terms of cost cutting, with many leading MNOs signing such agreements globally, mainly for 3G & 4G. These network sharing schemes, depending on their set-up (e.g. MOCN vs. MORAN), have introduced some major operational challenges, mainly in terms of network management, policy control and optimization.

In summary, 5G presents several fundamental challenges to MNOs: How to effectively deal with the massive increase in complexity that 5G will bring, how to leverage its considerable benefits for the customer (and for the MNO) and how to do this in a way that efficiently utilizes available human resources and keeps operational costs contained. For Analysys Mason[6], this challenge can only be met by fully embracing automation: *"…5G will introduce significant complexity in terms of ongoing configuration and optimization. CSPs will require advanced SON solutions to operationalize these technologies, while keeping the everyday costs down by using high levels of automation".*



THE ERA OF HYPER-AUTOMATION IS HERE

Until now, for MNOs, automation has been a matter of choice. Most MNOs already have some kind of automated operation of their networks, but the degree of automation and the type of tasks that are automated depend on a number of factors, including regional context, size of the network, the business culture and the maturity of operation.

But times are changing and as networks become more complex horizontally, with a new virtualized 5G technology layer coming, and vertically, as new network services slice across

6 The revival of the SON: 5G, cloud-RAN and densification will drive market expansion, Analysys Mason, Anil Rao, May 2018

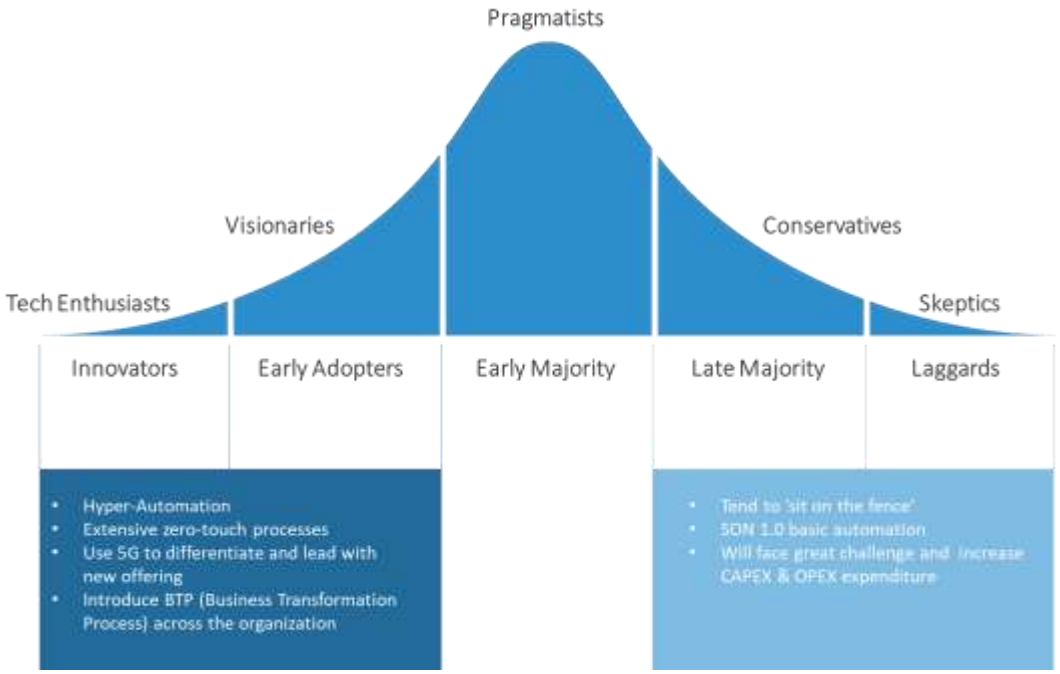
multiple radio technologies, it is clear that automation is no longer a luxury option but more an essential and mandatory aspect of managing and leveraging increasingly complex networks.

Hyper-automation is fast becoming the new paradigm in the effective management of complex Heterogeneous Networks and holds the answer to the challenges that lie ahead. It incorporates smart and rapid automation driven by *advanced analytics* and *machine learning* as discussed in Cellwize's whitepaper "On the Road to 5G: Open SON powered by machine learning"

SON is at the core of the shift to *hyper-automation* and is fast becoming a vital component of the wireless ecosystem. Knowing the wave of network complexity that is approaching, MNOs will have no choice but to rethink their traditional approach to network planning, deployment and operations. They must comprehensively explore all opportunities in terms of process automation and embrace the operational and cost benefits that will inevitably come from more autonomous network management driven by smart policies and ML/AI capabilities.

Hyper-Automation Holds the Key to Success

The mobile communications industry must now take automation to the next level – the level of *Hyper-Automation*, and the more forward-thinking MNOs are already developing aggressive transformation programs, driving an automation revolution in every aspect of their business, including networks, call centres and other customer touch points.



The concept of *hyper-automation* incorporates at its heart the notion of a Zero-Touch operation with an autonomous network, operating with little or no human intervention. It is able to configure, monitor, and maintain itself independently, with an inbuilt capacity to learn. The concept of automation itself, the idea that technologies could be self-provisioning, self-diagnosing, and self-healing, has been around for some time. But with advances in computing

power, cloud technologies, Artificial Intelligence (AI) and Machine Learning (ML), the autonomous techniques that will underpin *hyper-automation* are fast becoming a reality.

Of course, the extent to which MNOs will embrace the *automation revolution* in their business strategy will depend upon their corporate persona. MNOs that are ***Tech Enthusiasts & Visionaries*** will pursue a more aggressive route to *hyper-automation*. They will commit to a major program of automation across a broad range of network-related activities and will be passionate in their efforts to introduce many *zero-touch* processes. Due to the scale of change it is likely that they will heavily utilise a BTP (Business Transformation Process) approach. MNOs that are ***Conservatives*** & Sceptics are engaging with little automation and sometime tend to "sit on the fence". It is highly likely that these MNOs will face greater challenges and increasing CAPEX and OPEX costs as they struggle to keep pace with the complexity that 5G will bring.

The new generation automation solutions and platforms are no longer restricted to tackling simple processes. They enable MNOs and carriers to effectively manage the increased complexity of multi-layered wireless networks, deepen their understanding of how their networks function, and better serve their customers to take full advantage of the new wireless technologies being incorporated into their networks.

The call for Autonomous Networks

This new type of automation offers so much more than simple housekeeping of radio networks and dealing with mundane and repetitive activities. It is a key enabler of a radical change in the way wireless networks are operated, fostering a new agility and creating unique opportunities for innovative service creation and smart monetization with new revenue streams.

As the technology within telecommunication industry continues to evolve and as new OTT players continue to emerge, the broader technological ecosystem has completely changed in recent years. More and more these organizations are integrating and leveraging the substantial benefits of smart automation systems such as SON. The increasing complexity and pervasiveness of networks boost the demand for automation in mobile networks.

Rolling out new networks and effectively optimizing them in an autonomous way requires access to a large number of network elements and the many interactions between them. In this environment, there is a growing operational necessity to move from more traditional ways of running the network to more of an OTT approach, with the dynamic allocation of resources based on OTT need.

For instance, in a modern *HetNet* network, the combination of macro and small cells requires tools such as advanced SON, to coordinate and manage traffic in a given area in a fully automated and autonomous manner. Recently, Cellwize was working closely with Bell Mobility, a leading mobile carrier in Canada, in deploying a smart SON solution to manage the complexity of their multi-layered wireless network.

The scope for automation in 2G-3G is relatively narrow. It is targeted at processes that are well defined and so can be easily understood and easily automated. This is mainly done by

having clear algorithms and set scripts of network actions. These algorithms and scripts need to be adapted in conjunction with upgrades of the radio network and, assuming the radio vendor has an open platform, the adaptation should be relatively quick. As wireless technology moves on, so must the approach to automation. Considering the complexity that will come with new and advanced networks such as LTE-A and 5G, there is a pressing need to have a far more smart and autonomous automation solution, that can learn from its modifications on the network and improve its actions moving forward. This continuous *cycle of learning* will be inherent in new smart automated solutions and marks a major change from today's automation approach. In smart solutions, learning is not a one-off task to be completed as part of a clear set of actions but rather a continuing effort both to refine, adapt and improve what has been learnt, keeping pace with the dynamic nature of complex networks.

The next evolutionary step for 5G will be moving to a smarter, more cognitive SON where the incorporation of AI and deep-learning algorithms will improve the efficiency of SON activities in complex wireless networks. The real value of a more cognitive SON will be its ability to *predict* based on a learnt understanding of the way the radio network behaves. Let's take congestion as an example. If a cell site is congested, remedial actions will of course be taken but *only* after customers have been impacted. Furthermore, the applied remedies may not take effect instantly. If a traffic load pattern or unexpected events in an area are able to predict impending congestion, SON could proactively manage or steer traffic, e.g. by compressing video or changing traffic priorities, reducing the impact of congestion on the customer. SON could then use the same predictive capabilities to revert to the default traffic management mode when the congestion is gone.

Of course, the more sources of data available to a cognitive SON, the more accurate its predictions will become; therefore, it is crucial for the next generation of SON solutions to be *open* to multiple data sources. These sources can be a mixture of real-time and historical data, but together building a working memory of network activity from which a SON solution powered by AI can learn and adapt its actions accordingly. In terms of deciding which sources to expose to SON, an important consideration is that learning is more effective and efficient with smaller volumes of higher quality data regardless of the processing power available. Therefore, it is important that a cognitive SON fetches the data as and when it is needed (this is something that Cellwize micro service architecture is already doing).

Real-time optimization of beam forming, massive MIMO and topics related to mass event handling (like concerts, sports events etc.) will require, in addition to legacy data sources (e.g. counters, traces etc.) a broader spectrum of inputs, e.g. utilizing crowdsourcing data to better understand a customer's user experience of their mobile device.

Existing SON deployments already reveal a picture of complexity: multiple technologies, multiple RAN vendors, shared networks and various network policies for all kinds of wireless scenarios. Multi-layered networks with a diverse infrastructure require programmable SON systems for zero-touch process automation, traffic coordination and mobility management.

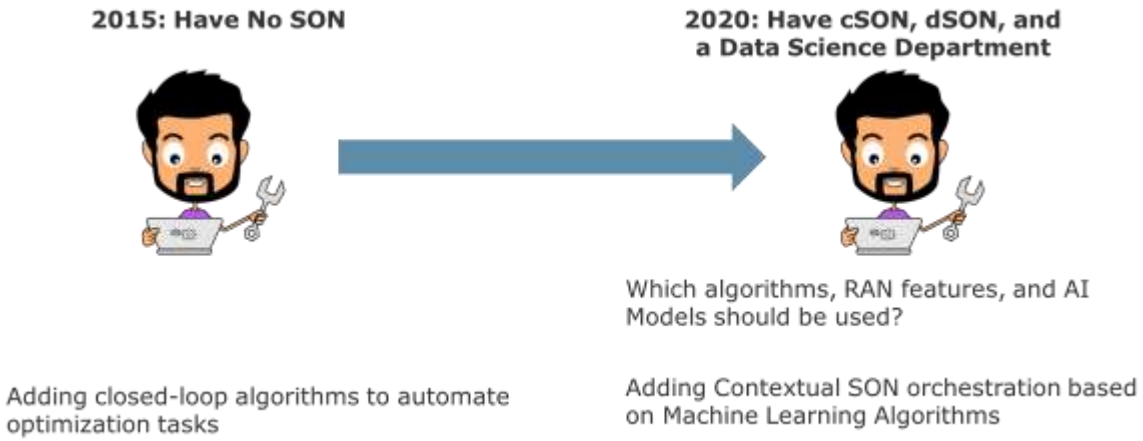
The efficiency and dynamism of a smart, autonomous SON is not something that can be replicated manually. In a wireless network that is growing ever more complex, maintaining a manual optimization approach will not only be costly but it will result in performance

degradation. Resource utilization would become less effective, leading to an undesirable rise in per-bit cost.

MNOs that depend on modern SON solutions not only understand the operational and financial benefits of automation, but also appreciate the absolute necessity for autonomous network governance solutions in the face of relentless technological change.

SON and The RAN DevOps Transformation

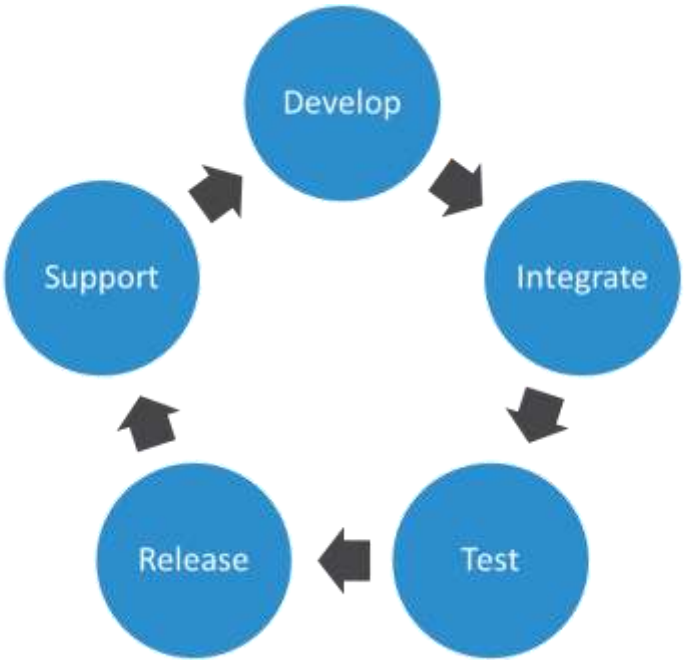
There has been an ongoing evolution of automation technology, moving from a first generation of SON 1.0, deployed in earlier less complex network scenarios with a very limited automation scope (e.g. managing neighbor relations), to a new generation of SON 2.0 that embraces the concept of *RAN DevOps*, where future RAN engineering skills will have incorporated a deep understanding of software and data science. The future RAN engineer will have a variety of solutions available, including cSON, dSON, in-house and externally sourced algorithms, RAN features and AI/ML models that can all be orchestrated in a flexible and open fashion. As the advance of wireless technology creates ever more complex network landscapes to manage and optimize, it is clear that the concept of RAN DevOps must become an inherent characteristic of the next generation of SON.



The concept of RAN DevOps finds its origin in the DevOps movement of the software industry. It is a software engineering culture and practice that aims at unifying software development (Dev) and software operation (Ops). The main driver of the software DevOps movement is to strongly advocate and monitoring at all steps of the software lifecycle.

A DevOps culture targets shorter software development cycles, increased deployment frequency and more dependable releases, in close alignment with business objectives. The

push for a DevOps way of working is a consequence of the increasing success of agile software development and the demand from organizations to deliver new releases more quickly and more frequently. Faced with this pressure, software companies adapted their release management processes, successfully integrating new tools and methodologies such as application release automation, continuous integration tools and continuous delivery.



So if RAN DevOps is to be summarized in one sentence it would be *"an engineering culture and practice that aims at unifying network evolution and design (Dev), optimization, and RAN operation (Ops), strongly advocating* automation *and* monitoring *at all steps of RAN evolution, engineering, rollout, and operations"*.

For the future RAN engineer to be successful in the face of growing network complexity, Cellwize believes that the concept of '*virtual RAN engineer*' should be integrated into its new generation of automation solutions, with smart capabilities that enable the seamless orchestration of related dSON and cSON features, mirroring the processes that a RAN engineer would have to follow to configure and operate the various tools and features needed to effectively optimize the network. To this end, Cellwize is developing a '*SON Recipe Book*' with an extensive inventory of orchestration *recipes* that will enable RAN engineers to define, test, update, and rollout these recipes as and when required.

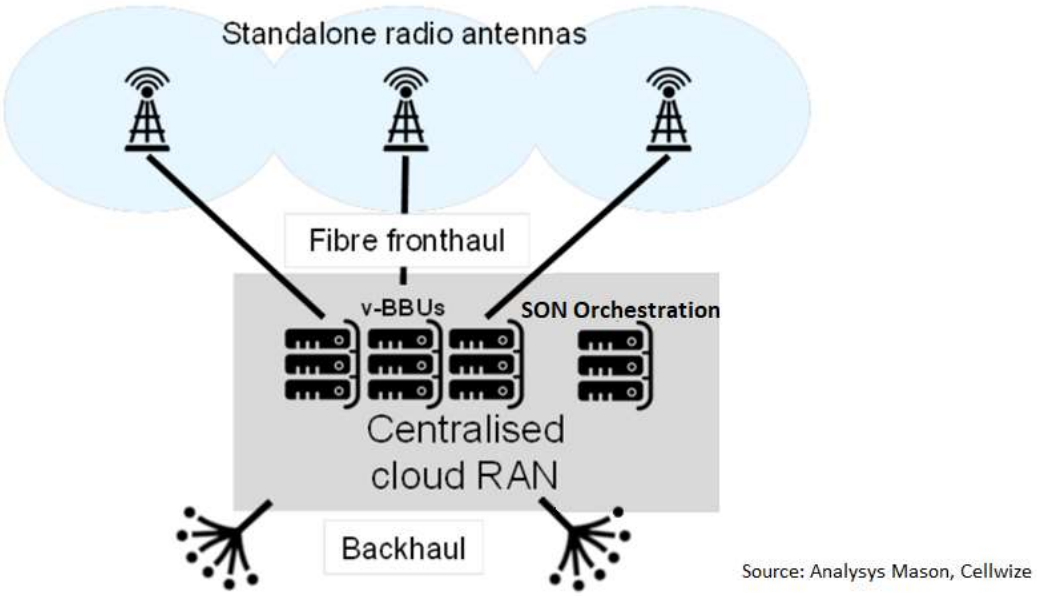
SON FOR 5G

From Managing Access to Managing Services

5G introduces innovation in multiple domains. It will become the *unified connectivity fabric* of the next decade, enabling new services with diverse connectivity requirements to be created and served to customers and business on top of the 5G infrastructure.

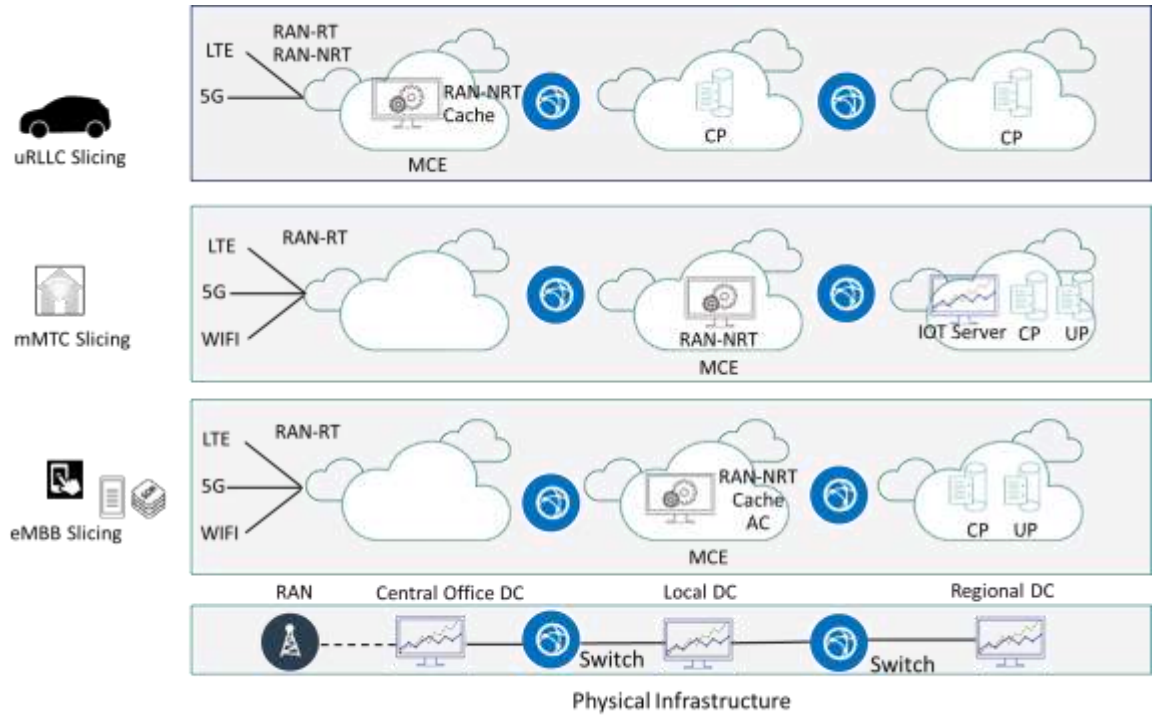
To successfully deliver such a variety of services, network providers will need to transform their current approach for planning and optimization. Instead of managing levels of access technology (2G, 3G, 4G & 5G), they will need to manage the services that are being delivered across their networks, each service with its own unique set of characteristics.

The main enabling technologies for effectively creating and managing dynamic and diverse services are *virtualization* and *network slicing*. Virtualization will allow service providers to allocate network resources in a much more dynamic manner.



Virtualization - Next-generation SON solutions will be empowered by virtualization" (source: Analysis Mason)

Network slicing will enable the creation of end-to-end, logically isolated networks comprising the 5G device and access, transport and core networks. Each network slice can be configured to deliver a distinct set of service characteristics.



Network Slicing - The enabler to efficiently deliver diverse services

Managing Complexities of New Radio (NR) Interface

A key component of 5G is a new air interface called New Radio (NR). The interface is designed primarily to support new frequency bands (such as millimeter waves) but is intended to serve as the foundation for the universal Licensed Spectrum-Shared Spectrum-Unlicensed management. Low frequency bands are intended to provide coverage. In parallel, LTE is continuing to advance with new capabilities such as *Narrow Band-Internet of Things* (NB-IoT).

As with any innovative technology, this new wireless landscape will require management solutions incorporating a new set of planning, configuration, and optimization capabilities. With complexity increasing exponentially, SON will become a crucial component, effectively and practically managing new and legacy networks through optimal and automated configuration and parameter decisions.

Enabling A Smooth and Gradual Introduction Of 5G

The industry, in seeking a smooth and gradual introduction of 5G over a long transition period, will introduce a high level of interworking between LTE evolution and NR. One example is *dual connectivity* that allows overlaying very high data rates from a dense high-frequency layer, and at the same time continuous and ubiquitous connectivity through an LTE layer. Another example is *user plane aggregation*, allowing to combine resources from both LTE and NR.

Enabling this close level of interworking will become possible via the natural evolution of elastic-SON features:

- Carrier Aggregation optimization: will configure NR in addition to LTE layers
- Border Optimization: will stretch NR borders to achieve optimal eMBB experience

Optimizing A Single Slice

Network Slicing is being introduced to enable the creation of isolated logical networks, each optimized to provide distinct service characteristics. SON will become an autonomous 'brain' that will configure and optimize each slice in accordance with required service characteristics and service level agreements (SLA).

For example, the SON optimization algorithms of a *voice slice* will be configured to achieve maximal mobility robustness, while the algorithms used for *eMBB slice* will be setup for maximal data quality and throughput.

To support slice optimization, SON must be able to model both the physical network (antennas, RET, etc.) and the logical slices at the same time. The intention of the ETSI SON POC is to demonstrate that SON is able to effectively manage and optimize a network slice rather than layers of access technology.

Optimized Slicing

While slicing will enable the creation of multiple logical networks, these networks will all share the same physical resources, including spectrum, infrastructure and more. Although the NFV management and organization (MANO) layer will support the initial dynamic allocation of resources to each slice, determining the optimal allocation for each slice during constantly changing traffic conditions will require advanced SON optimization.

SON will analyze the cross-slice SLAs and will identify and provision the right balance of optimal resource allocation, one that will maintain the required SLA for each slice with minimal underutilized resources. The obvious benefit being a higher Return on Investment (ROI) and leaner CAPEX allocation.

SONCloud™ Evolution

5G infrastructure will require the implementation of SDN/NFV architecture, as well as Cloud RAN. Cellwize is continuously evolving its automation platform to support the new 5G landscape: Cloud RAN architectures, interfaces, and implementations.

CELLWIZE: THE RIGHT PARTNER

SON and automation are in the DNA of Cellwize. As a strategic partner, we always strive to be close to our customers and to explore their current and future challenges. We focus on developing innovative solutions that answer the real needs of our customers and are motivated to give engineers a fighting chance to effectively manage the exponentially upward curve of network complexity. In the context of relentless network expansion and transformation, Cellwize can equip their customers with advanced automation capabilities. With the introduction of *Zero Touch* processes, network operators will be more than prepared to meet these challenges in an efficient and cost-effective way.

As an example, utilizing Cellwize SON technologies, a large Tier-1 MNO in West Europe was able to make a 37% time saving in the engineering effort associated with the execution of

routine daily tasks. This enabled the operator to invest more time in the execution of more crucial tasks related to the introduction of new advanced features and launching new services. Another example is in a Tier-1 MNO in the Americas where Cellwize ZeroTouch automation for new site rollout introduced an overall saving of 42.7% in the team efficiency, enabling the organization to reassign resources for new strategic initiatives such as introduction of new network features, rollout of new services and research activities related to 4.5G/4.9G (e.g. carrier aggregation) and 5G technologies.

SON is fast becoming the brains of the network, effectively taking care of process automation, network configuration routines and special events, in a way that delivers and assures an exceptional quality of experience. Fully autonomous SON solutions with programmable business objectives will become the brain of disaggregated and software-defined networks and will seamlessly orchestrate virtualized network functions in the cloud. Cellwize is highly involved in Hyper-Automation for 5G both in defining the strategic direction of the upcoming automation standards as well as in conducting trials, while collaborating with market leaders. As an example, Cellwize recently conducted a POC with ETSI (European Telecommunications Standards Institute), Verizon, Orange, NTT Communications, among others focusing on "5G Network Slices Creation, Autonomic Management & E2E Orchestration, with Closed-Loop (Autonomic) Service Assurance for the Slices: IoT (Smart Insurance) Use Cases"[7].

As a leading SON vendor, Cellwize understands and embraces its role as a leading pioneer in the development of the next generation of automation solutions, SON 2.0. For Cellwize, SON 2.0 embodies hyper-automation, end-to-end autonomous closed-loop service assurance and the collaboration of individual, network specific control loops.

CONCLUSION

5G represents a tsunami of complexity with multiple technological waves: Millimeter Waves, Massive MIMO, Beamforming, Full Duplex and finally a major rollout of small cells. If that's not enough, 5G will be virtualized and cloud-based. Strategically, MNOs will have little choice but to look towards innovative and autonomous automation solutions and their vendors to help them integrate and manage this complexity, and to realize the promise of 5G through the creation and delivery of innovative services that slice seamlessly through multiple layers of wireless technology. It is these services (IoT, AR/VR, enhanced streaming etc.) that promise to return the investment that operators will make in 5G.

Cellwize knows that first generation, rule-based SON solutions are simply not up to the task of managing this kind of complexity. For SON, a major paradigm shift is needed. It must evolve. It must become *smart* with a capacity to continuously learn. To enhance this learning, it must become *open* to more diverse sources of data (e.g. crowdsourcing).

The next generation of Cellwize SON, SON 2.0, will be powered by Artificial Intelligence and Machine Learning and will introduce a new era of *hyper-automation* and *autonomous networks*. SON 2.0 will incorporate the DevOps concept into its operation, utilizing AI/ML to

[7] https://ntechwiki.etsi.org/index.php?title=Accepted_PoC_proposals

orchestrate its own features and algorithms in conjunction with the dSON features inherent in the RAN and with other useful optimization tools and systems within the Operator's ecosystem. *Orchestration recipes* will direct and govern complex orchestration for a vast number of optimization scenarios in full compliance with the operator's own network governance strategy.

Most of all, Cellwize's SON 2.0, enabled by 5G, will play a crucial role in enabling operators to shift their focus from managing their networks horizontally, across multiple layers of wireless technology, to vertically, assuring a superior service experience for customers as the service slices through a complex technological landscape.

In summary, SON 2.0 will ensure that Operators can put customer experience where it belongs – *as **the** top priority*! Cellwize and its automation solution is ready to deliver this goal.

ABOUT CELLWIZE

Cellwize develops innovative Connectivity Management and Optimization solutions that enable mobile network operators and digital enterprises to deliver continuous digital services across wireless technologies. Cellwize offers advanced solutions that transform rigid, pre-set networks into adaptive, user-centric and responsive "organisms" that continuously match capacity, optimize coverage and provide superior personalized user experience. Cellwize solutions are enabling the digital transformation for customers across North America, Latin America, Europe, and APAC.

For more information, visit Cellwize at: www.cellwize.com

Corporate Headquarters

Cellwize Wireless Technologies LTD.
21 Habarzel St.
Tel-Aviv 69710
Israel

Cellwize Wireless Technologies PTE Ltd.
195 Pearl's Hill Terrace, #03-34
Singapore 168976

Email: info@cellwize.com | www.cellwize.com