

Hybrid Approaches to Artificial Intelligence

*For Realizing Intelligent
Networks in the 5G Era*

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You can't blame technology vendors and service providers for pushing the limits of marketing hype with Artificial Intelligence (AI). After all, it is the hottest buzzword since cloud computing. But digital service providers in the emerging era of 5G need practical, real "AI" solutions to cost-efficiently scale their operations and deliver the quality of service that will deliver the promise of 5G to themselves as well as their customers. Hybrid approaches to AI are needed to accelerate return on investment as operators evolve their infrastructure and operations for a 5G future.

5G Means More Opportunity and More Complexity Along a Hybrid Roadmap

While theories abound regarding how 5G will bring about the fourth industrial revolution, enable autonomous driving and create amazing new business opportunities for communication service providers, one thing is absolutely certain - 5G will bring with it great complexity that will impact the bottom line of any opportunity. Much of this complexity will be brought about by the virtualization of the network from the core to the radio as an estimated 1.2 billion 5G connections come online by 2025 according to GSMA Intelligence.¹ Ironically, it is also the virtualization of the network that enables the promise of improved cost-efficiency, flexibility, elasticity and scalability of the 5G network.

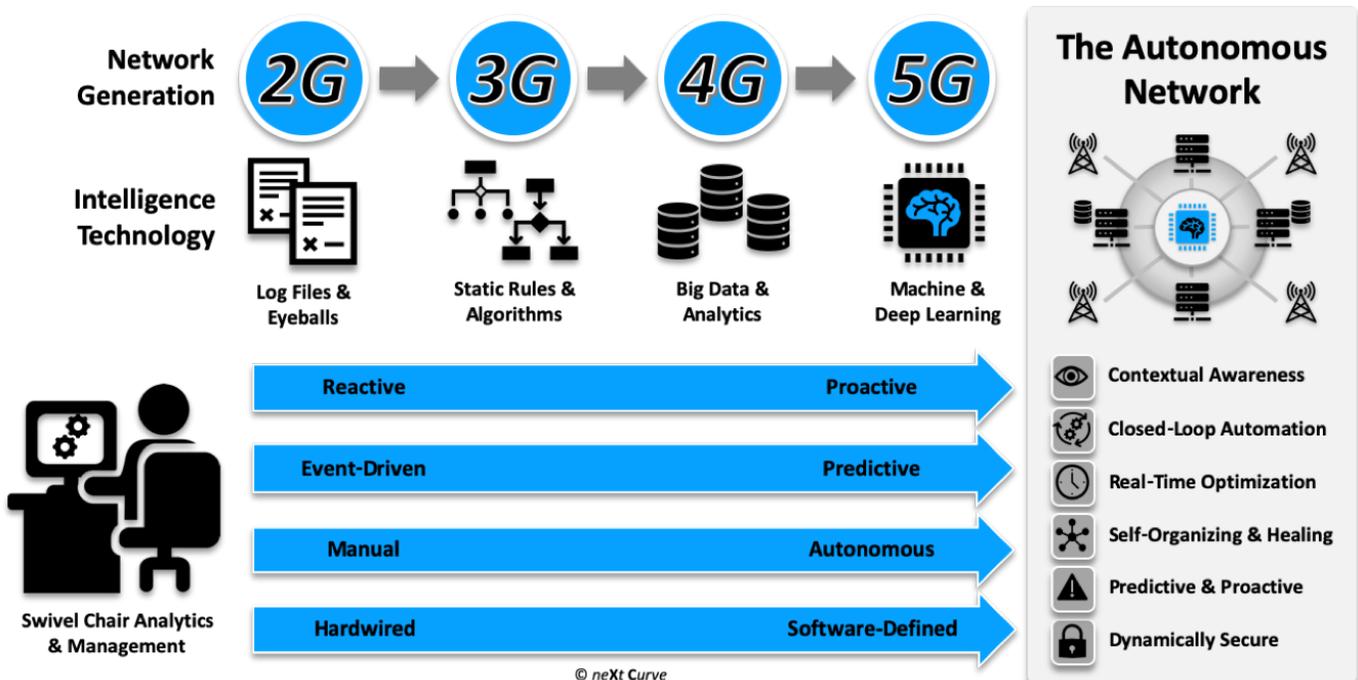


Figure 1. The Autonomous 5G Network

¹ GSMA Intelligence. (2017, October). *GSMA Issues New Report on 5G Slicing*. Retrieved from www.GSMA.com.

Unfortunately for legacy communications service providers (CSP), their 5G reinvention will not happen overnight. 5G, like any major transformation program, will take time, is complex and is a progression as we have seen in the IT world with efforts by enterprises to modernize and virtualize their data centers to be cloud-friendly. We can only expect that CSPs aspiring to become hyperscalers for the next-generation network will have their work cut out for them as they grapple with legacy infrastructure, legacy services, legacy operations, legacy organizations and legacy mindsets.

Consequently, CSPs and their vendor and consulting partners will need to figure out how to accelerate value creation and realization along the transformation timeline as the network, operations and organization evolve toward the state of "5G". While U.S., and Korean operators such as Verizon, AT&T, SK Telecom and KT have led the commercial foray into 5G, there is still a long way to go for these pioneers. For those operators on the sidelines, many continue to be wary of the upside potential of 5G while struggling with how to approach 5G investments and operational transformation despite all the excitement about the next-generation network. The reality is until CSPs realize their aspirational 5G state they will be dealing with a hybrid environment and portfolio for quite some time regardless of deployment strategy. In short, hybrid complexity on top of virtualized complexity.

Another emerging factor of complexity arises from the recognition by CSPs that accelerated 5G benefits and returns will require sharing of cost and resources between operators given the high degree of network densification that will be required to provide reliable coverage and quality of experience both indoors and outdoors. So how do CSPs manage resources and capacity that are shared across operator domains while enforcing privacy and security policies and delivering on service level agreements for every network slice? To make things even more complicated, consider neutral host communications services that are carrier-agnostic, multi-frequency and multi-tenant across the 5G Edge.

Automation & Optimization are Key to Unleashing 5G Value for Operators and for Customers

The keys to addressing the complexity that operators must overcome in order to realize the 5G promise of enhanced revenue and cost-efficiency are automation and optimization. They are not new concepts but automation and optimization in a software-defined world take on a different twist and, as we have experienced in the IT world, can be complex and challenging in very different ways.

Over the last decade or so, we have learned the benefits that automation can bring to the operation of 3G and 4G networks. To date, SONs (Self-Organizing Networks) have helped operators manage 4G and earlier generation networks with dramatically increased efficiency and effectiveness enabling operators to improve capacity, network performance and quality of service (QoS) while improving operational economics.

5G will be a different game all together as an operator's infrastructure portfolio becomes increasingly virtualized and cloud-native. Not only will new virtual services and functions have to be efficiently, securely and reliably managed, orchestrated and placed across the network; bare metal assets and capacity will need to be managed as well. In effect, you will have a lot of the new and a good bit of the old even in the 5G era in what will ultimately be a hybrid environment that will become a persistent reality for operator CTOs and CIOs.

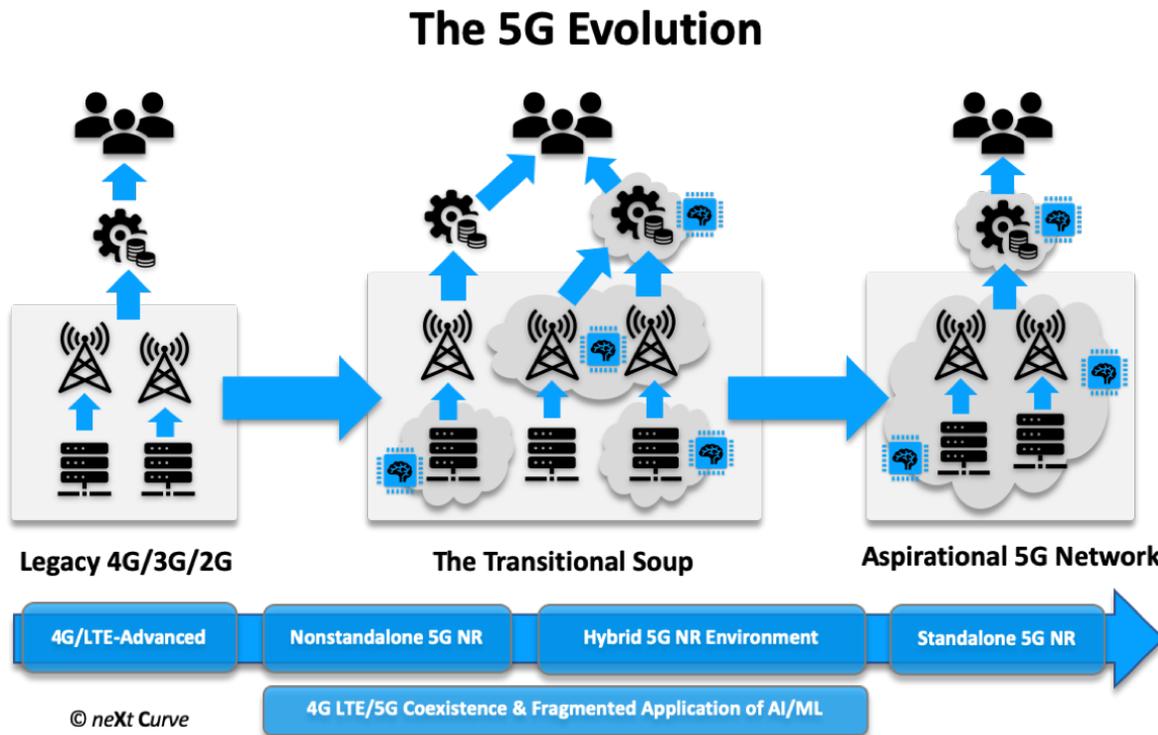


Figure 2. The Hybrid Path of 5G Evolution

Needless to say, the concept of SON will have to continue to evolve to help operators orchestrate and manage a dramatically more complex cyberphysical network infrastructure and to take on cloud-native capabilities of self-provisioning, self-service and zero-touch operation that hyperscalers enjoy. In fact, this is the direction that the operation of intelligent networks is going with the help of the ONAP (Open Networking Automation Platform) project by the Linux Foundation based on AT&T's ECOMP which will bring SON, Closed Loop Automation (CLA) and OSS concepts to virtual networks which will be the basis of 5G evolution for operators.

As network complexity and virtualization increases, security becomes an increasing concern as policies and controls need to be instituted across physical and software-defined operating environments. Operators will need to realize a high level of contextual awareness of their network, users and activities on the network in order to intelligently and proactively detect aberrant behaviors and autonomously isolate any threats that may compromise the secure and privacy-protected delivery of network services to customers. Without automation and intelligent

monitoring of the network, the promises of the 5G network will be challenging for operators to deliver and realize.

A Hybrid Approach to AI is Required for Heterogeneous Environments

Inevitably, artificial intelligence, machine learning in particular, will play an increasingly important role in enabling the next level of automation and optimization of network operations on top of a mixed portfolio of "traditional" and software-defined infrastructure assets and capabilities. There will likely be no boilerplate strategy for infusing AI into your operations.

Each operator, each enterprise is different and will have differing environments, technology portfolios and levels of readiness to automate their network and their operations. Some of the legacy systems that operators and enterprises will continue to sweat will not be able to support aspirational AI solution architectures and standards at the get go.

To make matters even more challenging, our research indicates that CTOs are finding that there is a general lack of interoperability across vendor platforms that make it difficult to gain a holistic basis of data needed to train ML (Machine Learning) models for strategic operational applications that could benefit from AI such as network planning, resource and capacity optimization or network security.

Connectionist Fuzzy Logic Control/Decision System

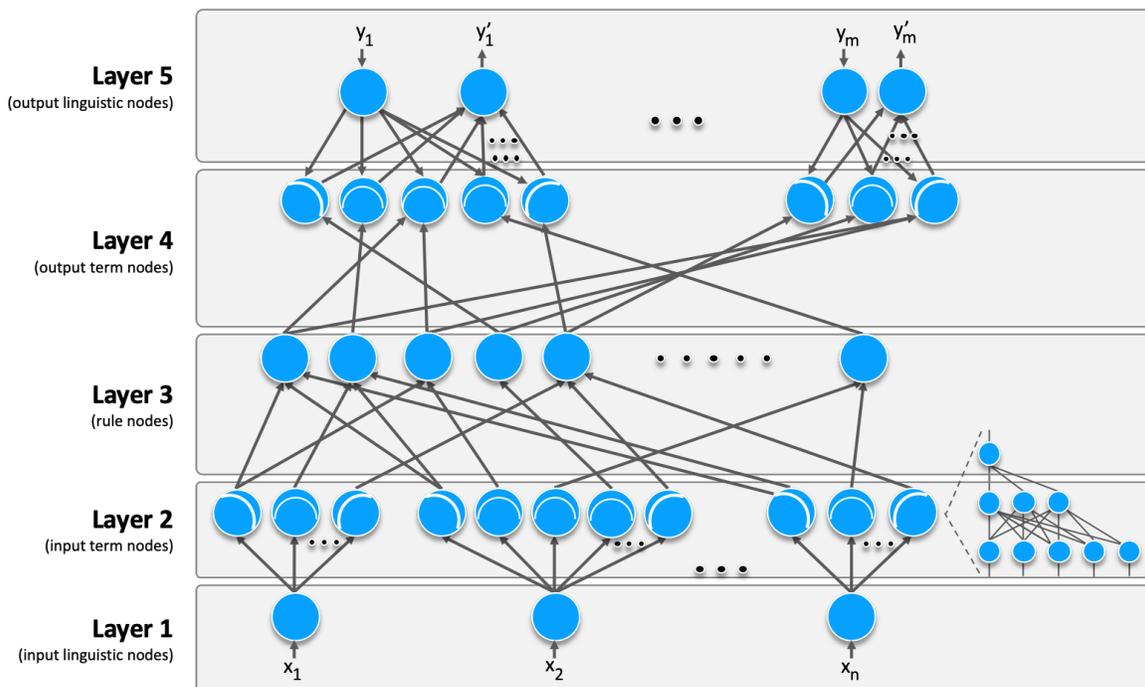


Figure 3. Hybrid AI. Source: "Neural Network-based Fuzzy Logic Control and Decision System", CT Lin & C.S.G. Lee, 1991

Network engineers and architects in charge of designing and managing the evolution of their intelligent network will want to consider a hybrid approach for implementing ML in a trusted, fit-for-purpose way while allowing existing coded-algorithms and expert system decision trees to provide a level of transparency to the intelligence of the network. This idea is not new. In fact, it was proposed to the IEEE by CT Lin and C.S.G Lee in their paper "Neural Network-based Fuzzy Logic Control and Decision System" back in 1991.² In principle, a general neural network (connectionist) model and fuzzy logic control would help the overall system adapt to events and changes in context by selecting and applying the appropriate algorithm, policy or rule among many to drive an optimal outcome or handling of an event.

This hybrid approach will allow network engineers to work around the maturity gaps and variances in their technology portfolio to gain the tactical benefits of contextually-driven optimization through the application of ML while continuing to leverage more transparent fuzzy logic-based algorithms and rule sets for dynamic automation of network operations and security.

But network engineers should be wary about deploying ML algorithms on the production network and should work very closely with data scientists to supervise the training of the ML model. As the ML model continues to learn the ML algorithm can eventually be codified as a rule once proven "correct" and "safe".

² C.T. Lin, and C.S.G. Lee. (1991, December). *Neural Network-based Fuzzy Logic Control and Decision System*. Transactions on Computers, vol. 40, pp. 1320-1336. IEEE.

Implications for Business and Technology Leaders

In these early days of AI, operators and enterprise CIOs and CTOs need to anticipate and plan on dealing with legacy complexity as they inherit a new portfolio of digital complexity with a network that is becoming increasingly software-defined as it moves toward 5G. As a result, any AI-enabled solution architecture should be designed and progressively adapted to deal with a changing network technology portfolio.

Business and technology leaders should adhere to a simple principle when considering the use of AI-enabled applications: if you don't trust it, don't use it. AI should not be trusted by default. The AI-application should prove that it is trustworthy. Use controlled, supervised approaches to train your ML models to associate the correct workflows, policies, procedures and actions based on recognized contextual patterns. Have data scientists determine what the decision tree and rules are within the patterns and codify them to foster transparency and visibility to any biases or undesired results. Limit the application of ML on live networks to just controlled, supervised learning.

Enterprise CIOs and CTOs should consider the use of hybrid AI solution patterns that help to unleash the power of ML-driven analytics and fuzzy logic-based algorithms to augment legacy automations and decision systems of strategic priority, and bring the benefits of AI into data and proprietary technology silos that will likely persist for some time in the technology portfolio of operators.

AI governance and controls are vital as operators evolve their networks for 5G. Network and data architects should collaborate with data scientists in determining architectural principles for applying AI technologies to the network and defining data management strategies for supporting AI-enabled applications. These AI governance policies should be progressively expanded and extended based on the maturity and readiness of the organization and the technology portfolio so as to prevent AI from inadvertently amplifying a problem or introducing broken processes at scale across the network.

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