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# The Evolution of Self-Organizing Networks

## Multidomain, user centric, service aware, ML enabled, open, and cloud native

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# Introduction

When self-organizing networks (SON) were initially defined by 3GPP in 2008, the industry had high hopes for the technology. Arguably, the first generation of SON did not live up to these expectations. The solutions often failed to win over network optimization teams because of steep learning curves and a fear of relinquishing control to automated systems. However, the underlying concept behind SON remains sound.

To cope with the complexity of multiple radio access technologies (RATs), multiple radio access network (RAN) vendors, multiple spectrum bands, and multiple layers of cells (macro, pico, femto) operators need an automated solution. As new frequency bands are introduced (e.g., millimeter wave) or refarmed, and as new technologies are introduced (e.g., 5G, open RAN) or retired (e.g., 3G), the challenge of mobile network optimization is set to increase.

The manual configuration, maintenance, and optimization of an increasing number of dynamic network nodes is no longer feasible. SON is needed to reduce operating and capital costs. As 5G device penetration increases and traffic grows, operators will need SON to be more opex and capex efficient. Among its many use cases, SON can help reduce energy consumption (and hence electricity costs) and defer capex through load balancing. Operators need to invest in the right technologies in the right locations based on subscriber needs. SON can help them do this.

The tangible benefits of SON include faster rollouts, easier network upgrades, fewer dropped calls, higher data rates, less network congestion, and increased customer satisfaction. To deliver these benefits, SON solutions must become more intelligent and autonomous, reducing the burden on operations and engineering teams.

# End-to-end optimization

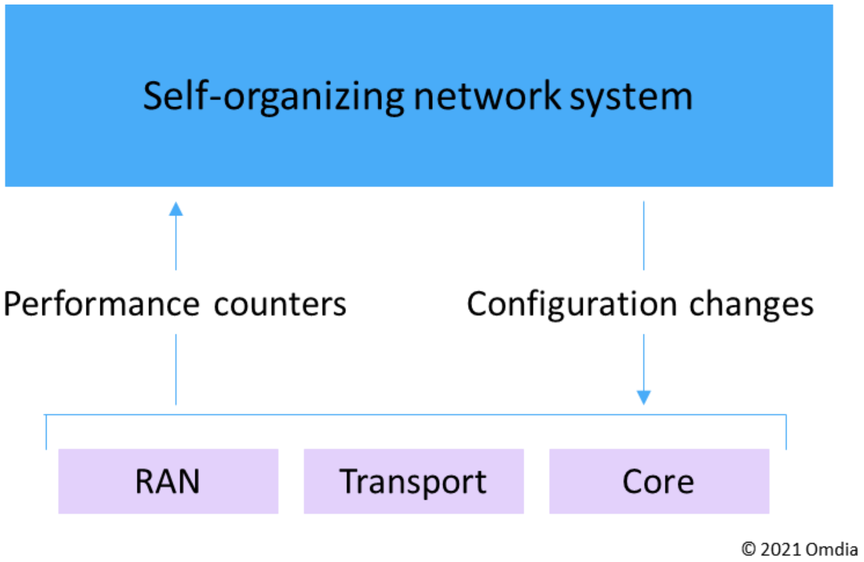
Traditionally, SON was focused exclusively on the RAN domain. To assure the quality of service of a specific service flow (e.g., video streaming), and to support end-to-end network slicing, next-generation SON must also be aware of and interact with other network domains such as the transport and core domains. To optimize across the network, SON will need to integrate the domains and to collect and use new data sources.

For example, performance counters in the RAN will detect cell-level performance degradation, whereas performance metrics in the transport network will identify the status of a specific backhaul link. The SON can decide which actions to take to achieve an optimal outcome across both domains. For example, traffic can be steered to neighboring cells in the RAN that use a different backhaul link. To do this the SON system must learn the topology of the transport network and collect performance metrics on links using protocols such as TWAMP.

If the SON detects user-level degradation, it will run root cause analysis (RCA) to identify the domain that caused the degradation and the number of users affected. In some cases, load balancing in the RAN will resolve the problem. However, in other cases the SON system might need to instruct the mobile core to temporarily reduce the maximum bit rate for an individual user, a group of users (e.g., prepaid customers), or a specific service type (e.g., YouTube streaming).

While the concept of coordinated optimization appears straightforward, in practice the responsibility for RAN, transport, and core lies with separate teams within most operators. Just as RAN teams have been reluctant to embrace SON in the past, it will take time to convince transport and core teams of the merits of taking a more joined-up approach.

**Figure 1: SON across RAN, transport, and core**



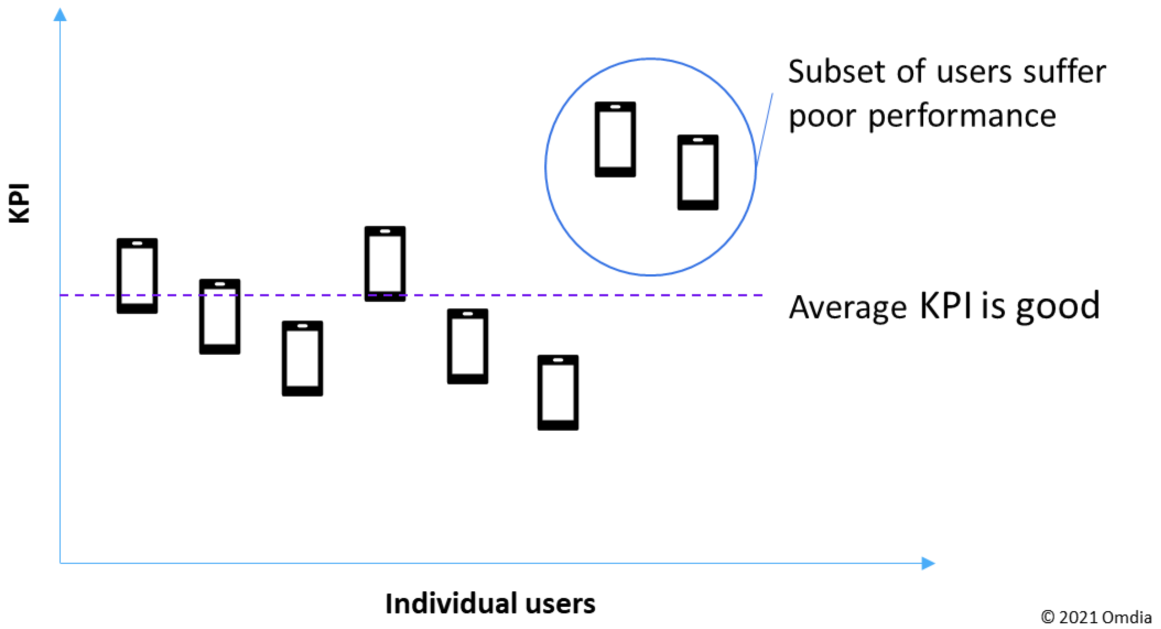

Source: Omdia

# User- and service-centric SON

To support the concept of network slicing and the associated service level agreements (SLAs), SON needs to optimize at the user level. The SLA for a video service will not be the same as for a connected car. SON solutions can provide a vendor-agnostic network-slice management function to automate the radio-slice lifecycle and resource optimization.

SON has traditionally been used to optimize the performance of the RAN at the cell level, improving network key performance indicators (KPIs) such as dropped call rates, handover success, and data rates. As **Figure 2** illustrates, the cell-level performance is an average of multiple users' experience. Cell-level performance may appear acceptable while individual users are suffering a poor quality of experience.

**Figure 2: Cell-level performance measurement misses the outliers**



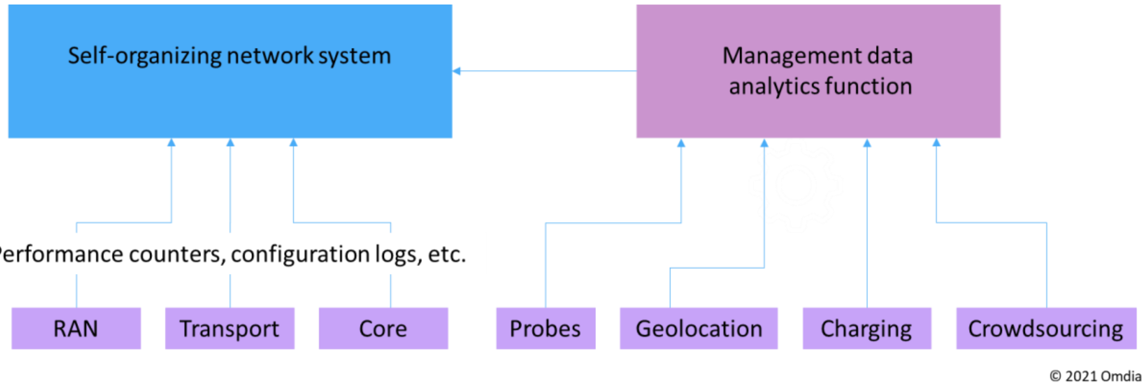

Source: Omdia

Next-generation SON should measure key quality indicators (KQIs) at the individual user level. To do this, SON must have access to the mobile core so that each user's IP address can be mapped to a cell global identifier. The SON should also distinguish between different services' SLAs. Users that are downloading email attachments will be more tolerant of delays than those watching a video stream. To identify what service the user is consuming, the SON requires access to external data sources such as event data records, either via a charging system or directly from the packet gateway of the mobile core, or probes.

Understanding the performance at this more granular level will be key to supporting the concept of network slicing, a key differentiator for 5G. Each slice type will have its own SLA, which the network must try to meet. The SLA for mission-critical services such as public safety will be more stringent than the SLA for smart meters. The network slice might be for a specific group of users (e.g., an enterprise account) or a specific use case (e.g., factory automation).

To deliver user-level performance optimization, operators need to incorporate additional data sources beyond the performance and configuration metrics they have traditionally collected from the RAN. As **Figure 3** shows, examples include network probes, geolocation, charging (event detail records), and crowdsourcing. These data sources could be supplied to the SON system directly or via a separate analytics platform such as the management data analytics function, as defined by 3GPP.

## Figure 3: Cell-level performance measurement misses the outliers




Source: Omdia

Crowdsourced data provides an alternative to drive testing. It is collected directly from the user's handset via an app that has been voluntarily installed. The app collects data from indoor and outdoor locations, 24×7. Examples include speed-test apps or the operator's own customer care app. These can provide granular data on the end-user experience that can help identify coverage gaps in the network through geolocation (triangulating the position of the user based on the signal strength of surrounding transmitters). The SON system can then suggest changes (e.g., antennae tilt or transmitter power levels) to fix the problems that have been identified.

Moving from aggregated cell-level statistics to customer-level KPIs allows SON to identify customers that are receiving a poor service even though the cell-level performance appears to be satisfactory. By correlating the data, the operator might find, for example, that the poor performance is associated with a particular handset model or content provider and engage with the manufacturer or provider to resolve the issue.

# The importance of artificial intelligence

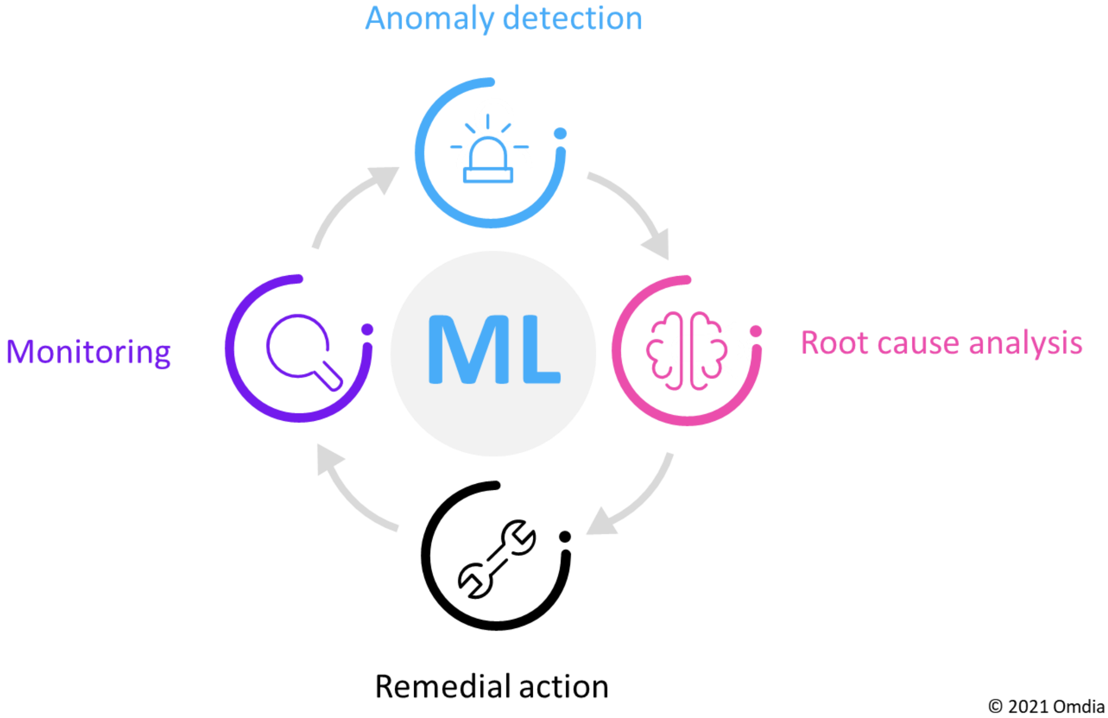
Traditional SON solutions were often based on heuristics (rule of thumb) rather than true mathematical optimization. The outcome of such heuristics is often limited to simple trigger actions; for example, if KPI is greater than A then take action B. As a result, many operations (e.g., network fault resolution) are still highly manual.

Next-generation SON systems employ machine learning (ML) and sophisticated algorithms to optimize across multiple tunable parameters and carry out autonomous (closed-loop) self-healing. Ongoing ML is needed so that systems can improve over time, learning from experience as they are fed with more data. ML can help network management move from being reactive to becoming predictive, resolving network issues before they affect customer experience.

Network operators are already sitting on large datasets. Given the volume and variety of data that will be collected in 5G networks, the task of extracting actionable insights from this data will become a greater challenge. ML can reveal new ways to improve network performance.

As shown in **Figure 3**, the ML analytics cycle starts with the monitoring of a set of target KPIs, for example, throughput or dropped call rate. If an anomaly is detected, then RCA is undertaken to pinpoint the cause. For example, throughput degradation in a video session could be due to congestion in a RAN node, transport switch, or application server. With ML, hundreds of different parameters can be correlated simultaneously. Moreover, the system can consider the correlation of parameters across different domains (e.g., RAN and transport). This compares with traditional correlation analysis, which usually only considers a few parameters from a single domain, because engineers in each domain work independently. Finally, the ML analytics engine will recommend remedial actions that it sees have been successful in the past for similar problems. By quickly executing the steps in this cycle, the ML engine can reduce outages and improve customer satisfaction.

**Figure 4: ML analytics cycle**




Source: Omdia

There is still some skepticism about artificial intelligence (AI) in the network community after years of overpromising by the vendor community. It will take time to build trust in ML applications, particularly before such systems are allowed to implement their own decisions in a closed loop without human oversight.

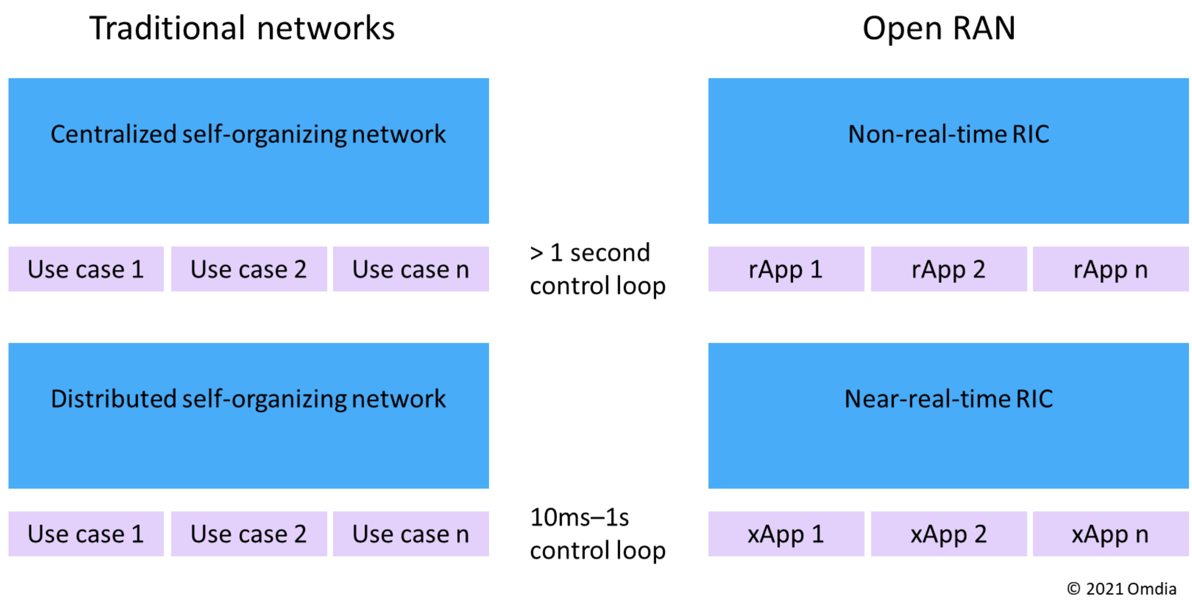
# SON’s role in open RAN

The philosophy of open RAN encourages independent vendors to supply separate components instead of monolithic turnkey solutions. In the open RAN architecture there is a SON-like system called the RAN intelligent controller (RIC). This is divided into a near-real-time and non-real-time RIC, like the distributed (D-SON) and centralized (C-SON) architectural split in 3GPP SON. The non-real-time RIC is part of the service management and orchestration (SMO) layer of the open RAN architecture. Next-generation SON systems should be able to provide this non-real-time RIC functionality along with the associated use cases, known as rApps.

Future networks are likely to be a hybrid of open RAN and traditional, integrated RAN. Operators will benefit from having one management console to control the hybrid network with traditional optimization solutions, such as SON, and SMO/RIC solutions running underneath. Some applications will need to optimize across both traditional and open RAN cells, for example, where these border each other.

The O-RAN Alliance’s E2 interface will allow third parties to get access to the near-real-time data necessary for near-real-time RIC use cases, known as xApps. While the near-real-time RIC is out of scope for C-SON solutions, it will be important for next-generation C-SON to interact with xApps to collect information from the edge of the network to optimize things such as mobility management or load balancing. C-SON oversight will also be key to the orchestration of rApps and xApps and the avoidance of conflict between them.

**Figure 5: Comparison between C-SON, D-SON, and non/near-real-time RIC**




Source: Omdia

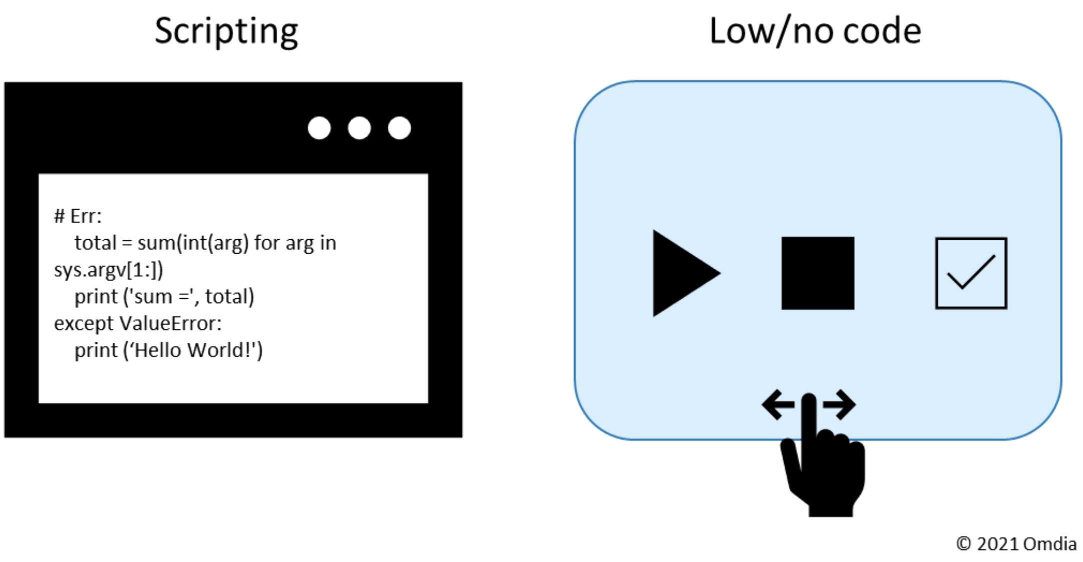
# Low-code development

Next-generation SON should not just support open networks with multiple vendors; it should itself be an open platform for third-party applications. These might be developed by other software vendors (as with the x/rApp concept in open RAN) or by the operator itself.

With traditional SON systems it was very hard for operators to develop their own use cases. Radio engineers might be able to design an optimization algorithm but lack the coding skills to implement it. Therefore, they would be dependent on the SON vendor to develop the use case and make it available, a process that might take 12 months and could require additional payment.

To facilitate app development by operators, next-generation SON solutions have low-code tools with an intuitive graphical user interface. This allows radio engineers to build their own use cases without needing extensive scripting or being reliant on the SON vendor's roadmap. Operators can move from feature design to test and deployment in just a few weeks. As the community of developers grows within an operator, especially a multinational, there is a great opportunity to share experience and features. Even within a single-country operator, engineers responsible for different regions can benefit by sharing apps they have developed.

**Figure 6: Scripting versus low/no-code solutions**




Source: Omdia

# SON in hybrid cloud

Traditional SON solutions ran on dedicated servers in the operator's network or in its data centers (private cloud). Next-generation solutions should be able to run both in the operator's private cloud and in public cloud. For example, the bulk of the data storage and processing could be in the private cloud with the public cloud used for some analytics.

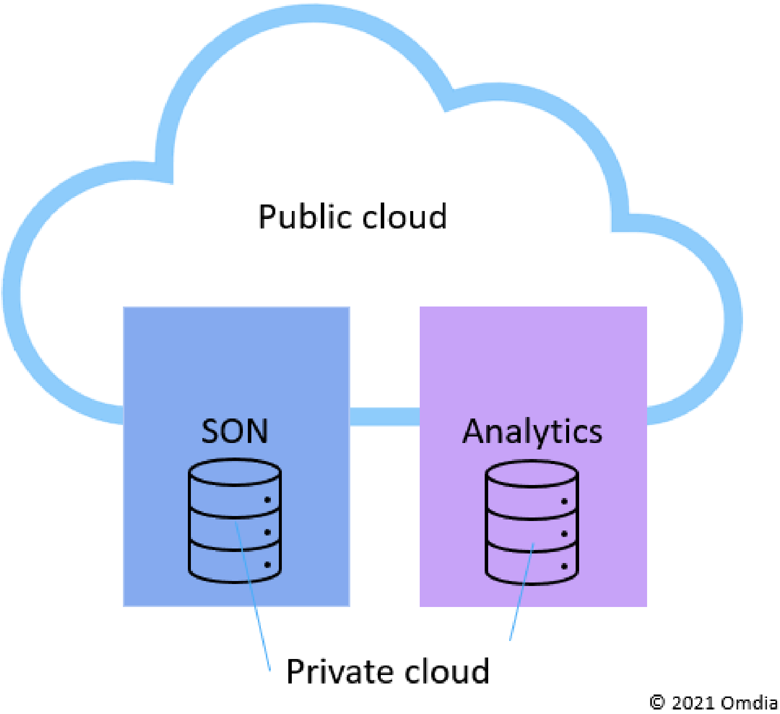
Just porting an existing solution to run on public cloud is not enough. To leverage the full capabilities of public cloud, applications need to be architected according to cloud-native principles:

- **Microservices oriented** – software that is broken into loosely coupled components
- **Container packaged** – to ensure resource isolation and simpler operations
- **Dynamically managed** – using a central orchestrator to improve resource utilization

Running on public cloud reduces the upfront cost for operators adopting SON. It allows them to scale up or down the SON solution according to their requirements without being locked into an agreement or any specific hardware. This flexibility is particularly important for smaller operators or for private mobile deployments.

Operators are already using public cloud to host their big data lakes and analytics platforms. Hosting SON systems in the same public cloud will enable multinational operators to develop use cases and features that can be more easily shared across their operating companies.

## Figure 7: SON solutions will be deployed across public and private cloud




Source: Omdia

# Conclusions

Self-organizing network technology has evolved in recent years to support greater mobile network automation. This is key to coping with the complexity of multi-vendor, multi-RAT (2G, 3G, 4G, 5G), multiband (800MHz to over 3GHz), and multilayered (macro, pico) networks. The key aspects that set next-generation SON solutions apart from traditional SON include the following:

- **Next-generation SON does not end in the RAN.** For end-to-end optimization, the SON concept must be extended beyond the RAN to include core and transport. This will be critical to addressing the requirements of network slicing.

- **Next-generation SON is service and user centric.** Instead of optimizing cell-level KPIs, SON should optimize user-level KQIs. It should also distinguish between services (e.g., file transfer and video streaming).

- **Next-generation SON leverages ML.** Sophisticated algorithms optimize across multiple tunable parameters and carry out autonomous self-healing. ML can reveal fresh insights about how to improve network performance and can help network management move from being reactive to being predictive.

- **Next-generation SON can provide the non-real-time RIC function of open RAN.** SON can also provide the associated use cases (rApps). While the near-real-time RIC is out of scope for centralized SON solutions, C-SON oversight will be key to the orchestration of and avoidance of conflict between rApps and xApps.

- **Next-generation SON is an open platform for optimization applications.** These might be developed by other software vendors (as with the x/rApp concept in open RAN) or by the operator itself. With software development kits and low/no-code tools, radio engineers can build their own use cases without needing extensive scripting or being reliant on the SON vendor's roadmap.

- **Next-generation SON will run in private cloud and public cloud.** Running on public cloud reduces the upfront cost for operators adopting SON. It allows them to scale up or down the SON solution according to their requirements.

# Appendix

## Methodology

This report is based on desk research and Omdia's ongoing briefings with telecoms operator and technology executives.

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The HCL Augmented Network Automation (ANA) Platform takes SON (acquired from Cisco in 2020) to the next generation with a closed-loop network automation environment that supports multi-vendor, multi technology deployments. HCL ANA automates wireless network configuration with hands free corrections of network anomalies to optimize network performance, thereby driving faster time to market of new wireless services in 5G cell networks and ensuring subscriber quality of experience.

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