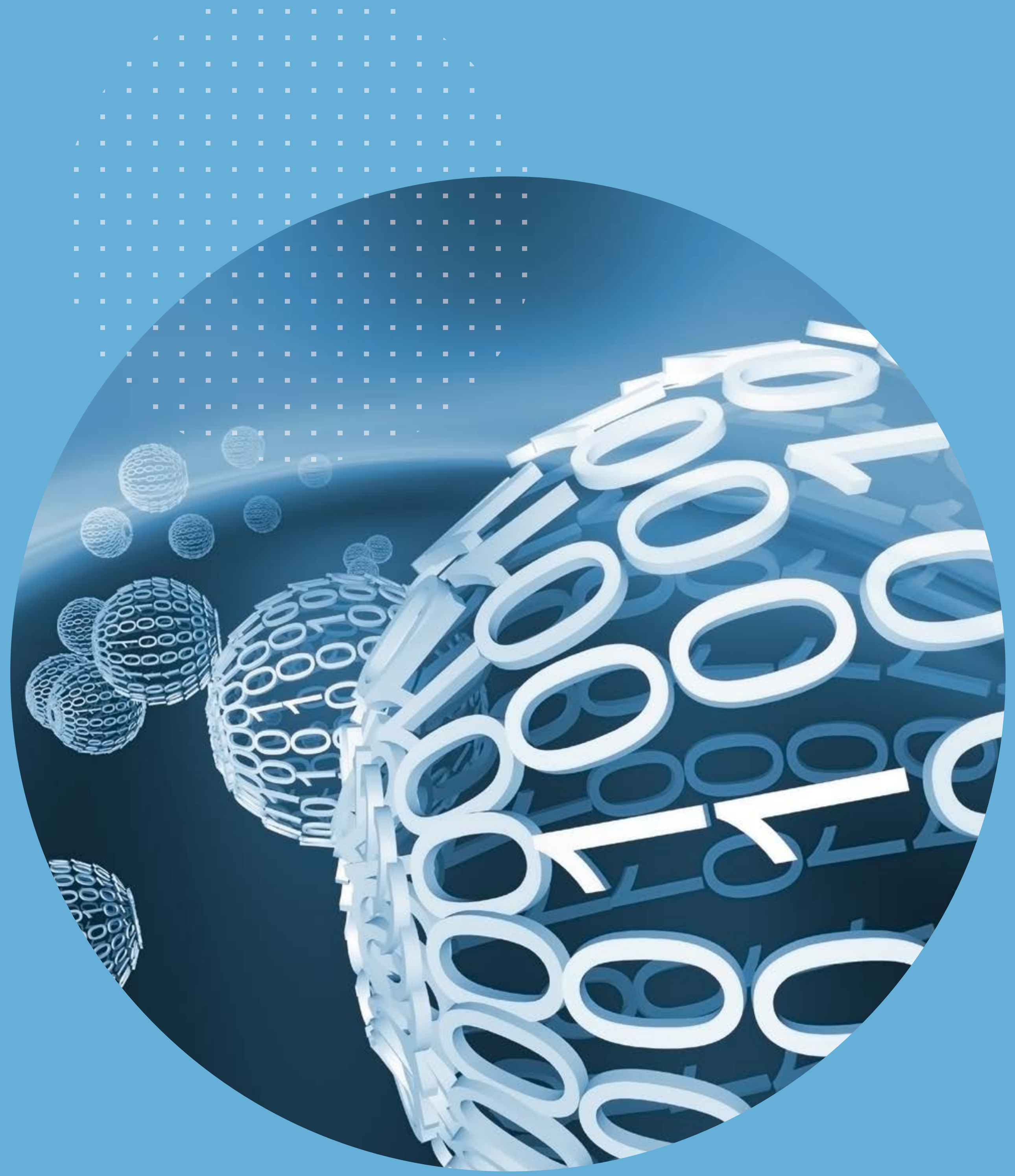
HUAWEI

Next Generation SON for 5G

White Paper by TELUS and Huawei

HUAWEI TECHNOLOGIES CO., LTD.
Bantian, Longgang District
Shenzhen518129, P. R. China
Tel:+86-755-28780808

www.huawei.com



Contents

Executive Summary

It has been almost a decade since the concept of Self-Organizing Networks (SON) was introduced by the Next Generation Mobile Networks (NGMN), and was subsequently standardized by 3GPP along with the Long Term Evolution (LTE) network. However, despite having gained much attention initially, SON has not yet fully delivered on the expectation the operators were having since its inception.
Originally, the main expectation was that SON would automate the Operation and Maintenance (O&M) of cellular networks to help operators improve network efficiency and performance. In practice, SON implementation has been primarily focused on several use cases affecting the Radio Access Network (RAN), and has not been a part of an end-to-end solution. Some SON functions, such as Automatic Neighbour Relation (ANR) and Plug and Play (PnP), have been deployed by the operators and brought gains. However, the standardization effort on SON so far has been mainly focused on a limited set of use cases and on defining the interfaces.

Furthermore, the adoption of SON has been slowed down because it was always seen as an optional/complementary solution to the existing RAN rather than its integral part.
Our vision is that the Next Generation (NG) SON should be considered as an integral part of future wireless networks including 5G, not just an add-on feature, and as such, needs to be carefully designed together with the other network features. The NG SON needs to be developed to maximize automation of all the aspects of the O&M tasks, with clearly defined inputs and outputs. Moreover, the NG SON should also enable Cloud RAN and 5G to ensure sustainable network development. Thanks to the ever increasing measurement and processing capabilities, the NG SON should allow not only high level (cell or cluster scale) scenario-based optimization, but also accurate optimization on a finer scale, such as grid level (smaller than a cell scale) and user group level (service of capability level).

Objectives of the NG SON

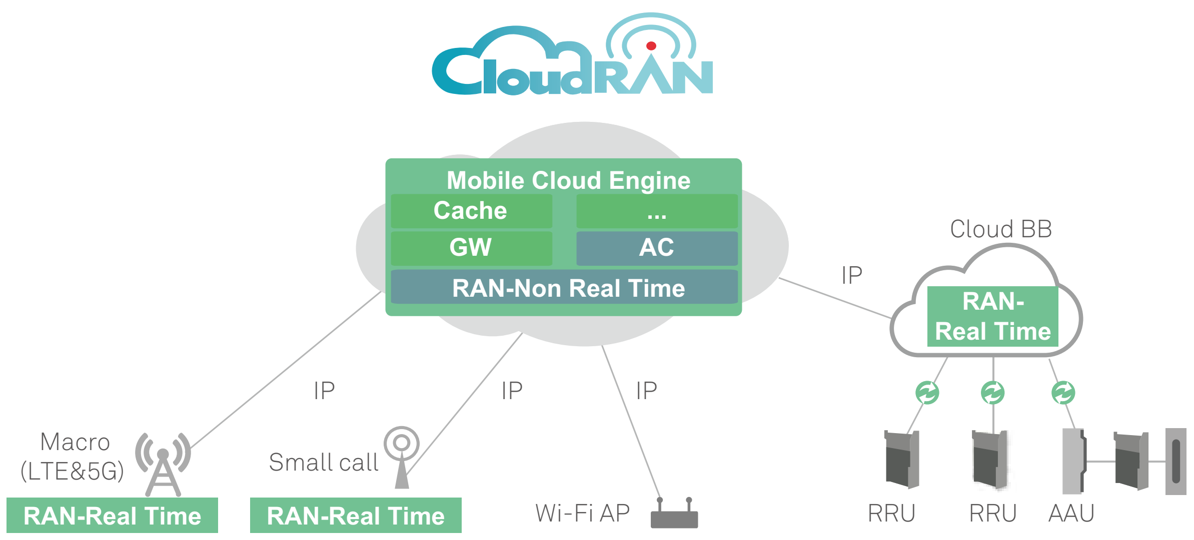
The main purpose of the NG SON should be to greatly improve the O&M efficiency and help operators keep pace with the complexity of fast evolving wireless networks. Additionally, the NG SON should significantly enhance network performance through self-organizing intelligence.

2.1 Bridging the Gap between the 3GPP and Daily Operation

The NGMN identified SON as a key design principle for LTE network back in 2007, and published a technical specification paper in 2008. Following that, SON was introduced in 3GPP Release 8 and has been further extended in subsequent releases to enable NGMN identified use cases. Some SON functions, such as ANR, have already demonstrated their usefulness by eliminating the need for manual list generation.
With that said, the 3GPP defined SON still falls short of its full potential. Namely, SON currently only addresses several use cases and is viewed as an optional element in the solution. To fulfill the promise of self-organized and self-optimized networks, we need a complete solution that can make use of all the available information to automate the planning, optimization and maintenance. Therefore, it is essential that the NG SON be developed as an integral part of the next generation wireless network.

2.2 Enabling Cloud RAN

Currently, the RAN is undergoing a transformation from distributed to cloud based architecture, in which most of the RAN functions are being centralized, while still leaving some of the functions retained at a remote base station. Namely, the functional modules with low real-time requirements (e.g., in the order of seconds or higher) will be integrated into the Mobile Cloud Engine (MCE), while those with high real-time requirements (millisecond order) will still be located at a base station, as shown below.

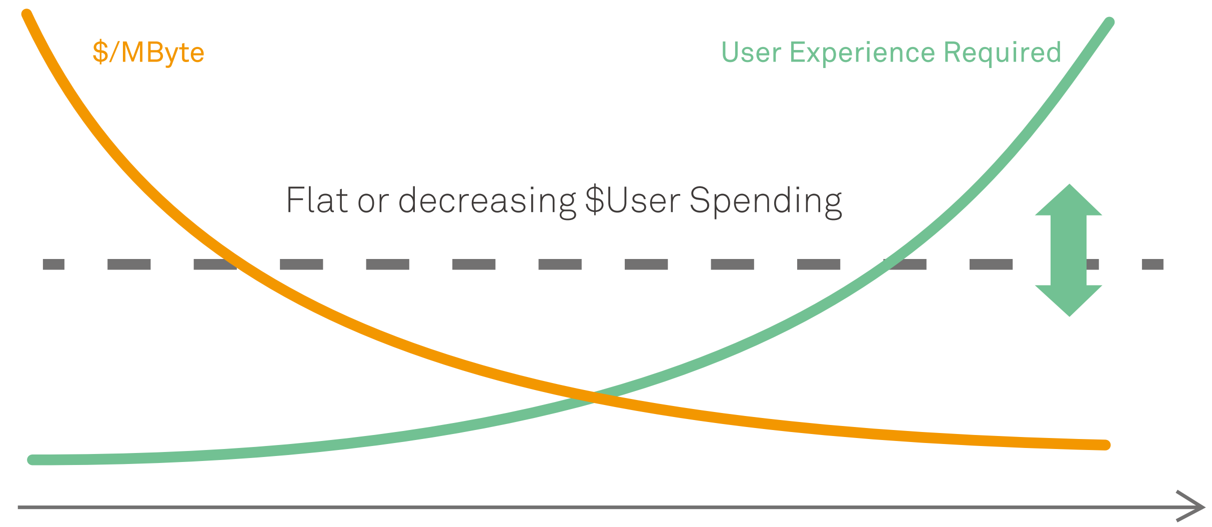


The cloud-computing based MCE will provide automatic scaling capabilities, making it possible to quickly respond to service and network changes. The guiding principle in designing of the MCE is that it must be able to predict the service growth accurately or trigger a resource allocation at the right time.

The rationale for this new architecture comes from the lessons learned with the legacy networks. For instance, when smartphones began to increase in popularity, UMTS networks were overwhelmed by huge signaling storms from various Instant Messaging (IM) applications and keep-alive detection related signaling that produce frequent small packets. In response, operators had to manually expand the signalling processing capacity. Our vision is that the NG SON, combined with the new, cloud-based architecture, will be able to address such challenge by automatically monitoring network load, and even predicting network load based on historical service statistics. With the help of NG SON, the MCE will be able to automatically increase the signaling processing capacity based on the signaling load, which ensures optimal network performance when traffic volume increases.

2.3 Improving O&M Efficiency

Based on the current trends, it is to be expected that the mobile subscribers will continue to demand higher data rates, reduced latencies and more applications and services. At the same time, they will not expect their phone bills to grow.



Note: this figure is only for illustration purpose

This improved user experience will be enabled by the introduction of new radio transmission technologies that will increase the spectrum efficiency and offer higher data rates. However, this will come at the cost of increased network complexity due to the following:

Increased number of carriers

More radio carriers are required to increase the datarate. The industry and 3GPP are already targeting higher frequency bands, such as those above 6 GHz, which provide larger bandwidths. Increased number of carriers with different channel bandwidths, and different propagation losses (and consequently different coverages) will increase network management complexity.

Increased number of antennas

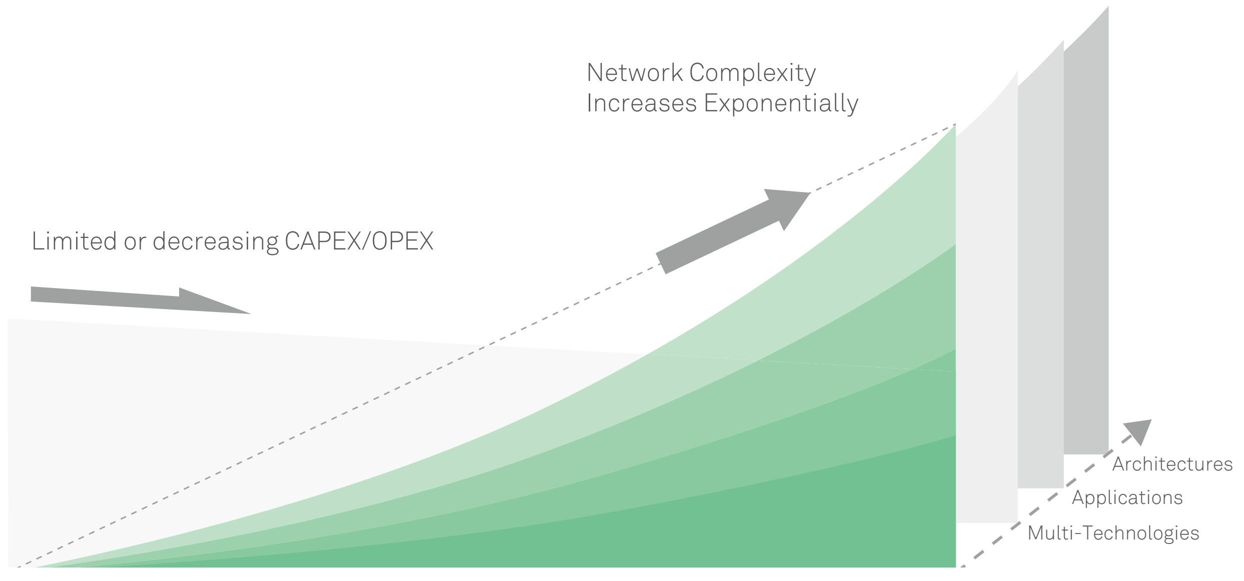
Multiple Input Multiple Output (MIMO) antenna is a key technology to boost spectrum efficiency. A low order, 2T2R MIMO is the basic configuration of today's LTE network. Some operators have already deployed 4T4R and even 8T8R in some special scenarios (i.e., TDD-LTE) to improve spectrum efficiency. In the future, it is expected that large scale antenna systems, a.k.a. massive MIMO will require many more antenna element. The increased number of antennas for different bands and higher MIMO order will further increases the network complexity.

Increased number of sites

When high frequency bands are used, cell coverage decreases due to larger propagation loss, and more sites are required to cover the same area compared to low frequency bands. In addition, operators may want to take advantage of smaller cell coverage to expand network capacity through spectrum reuse. In either scenario, the network complexity grows due to the need to coordinate transmission and avoid interference among the cells.

Increased number of RAN features and parameters

New technologies, services, and RAN features and parameters are introduced at an ever increasing pace Furthermore, the traffic patterns are no longer static, and change frequently both in time and over different geographic locations. . This imposes more pressure on O&M as it makes it more difficult to monitor and optimize a larger number of parameters at an increased frequency. Additionally, the coexistence of multiple technologies, different applications and heterogeneous network architectures will further increase the network complexity.
On the other hand, the revenue growth for an operator does not match the network complexity growth, thus limiting the amount of budget allocated for network CAPEX and OPEX. Therefore, a much higher O&M efficiency is critical to maintain a sustainable business.



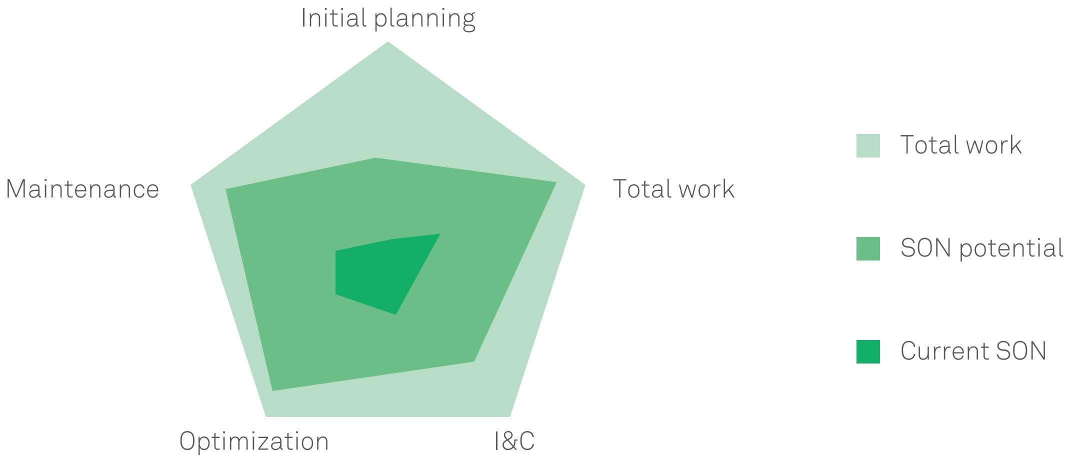
2.4 Further Automating the O&M Tasks

Wireless network O&M tasks can be divided into five stages:

· Initial planning: deciding the high level network design, including site selection and base station type selection.
· Detail design: defining the detailed site configurations and RF features.
· Installation &Commissioning (I&C): implementation and verification of the designs.
· Optimization: optimization of legacy or new networks periodically.
· Maintenance: maintenance of network and equipment

By taking a closer look at the specific activities required at each stage, we can get a better idea on how much work can be automated.

In the initial planning stage, only some work, such as coverage prediction and capacity prediction, can be automated through SON. All other tasks, such as site selection, rent, transport, facility check, and base station type (macro or micro) selection, still require manual operation.
In the detailed design stage, most designs, particularly RF parameter design (e.g., Cell ID, power levels, channel configurations), can be accomplished through SON's plug and play feature. Transport and core network design could prove more challenging due to limitations from transport network capabilities, such as lack of plug and play support. In addition, facility and building design still require manual operations.
In I&C stage, some tasks such as hardware shipment and installation cannot be automated through SON, whereas other tasks, including software commissioning, configuration scripting, and function verification, can be automated.
The optimization stage has the highest potential to be completed through SON, while at the same time it presents the biggest challenge to running a successful network. Majority of the optimization work is based on measurements and network parameter changes, and can be automated, but requires specialized expertise and internal RAN designs.
In the maintenance stage, SON monitors the network and equipment to detect failures, and efficiently rectifies each detected failure either by indicating a need for a software change or for a hardware replacement.



2.5 Buildiging a SON Friendly 5G Solution

Some early SON functions emerged from 3G networks such as UMTS and more SON functions have been included in 4G. While, SON is still far from being able to take control of the wireless network management, it's philosophy of self-organizing does show a big potential for future even more complicated networks, such as 5G.
It is anticipated that 5G will have much higher aggregated bandwidth, larger frequency range and thus larger variety of cell coverages, many more Transmission Points and much higher MIMO order. This will require increased coordination between the sites and increased number of technologies. Therefore, the 5G network will pose big operational challenges. In our view, the NG SON will be a key technology for operators to address such challenges. It will not only be an integral and mandatory part of 5G, but also it will also be a key enabler for 5G success.

What is NG SON

The Next Generation SON should have the capability of full awareness of current status and the ongoing changes, the ability to do necessary analysis to determine optimal network parameter values, and the ability to implement the network adjustment, and thus minimize the human intervention as much as possible, and also to provide network maintenance in an optimal and timely fashion.

TWhat is NG SON

3.1 Built-In Capability from Day One

Most traditional RAN features require manual operations to optimize parameters that become non-optimal as the network conditions change over time.
Future network should work in a self-organized manner. This requires a fundamental change of the way we design and develop the network products. The ability of self-planning, self-configuration and self-optimization will need to be considered from day one of any RAN feature design. Thus, the SON functionality should be one of the key requirements for system design.

- **Design for SON**

All future RAN features are expected to have the following capabilities:

- Self-planning

Each RAN feature can evaluate whether it applies to the current scenario, namely, whether it is advantageous to enable the feature. Each RAN feature can also decide when and where it needs to be enabled and disabled.

- Self-configuration

After enabling itself, each RAN feature can complete necessary configurations without any manual operations. For example, the feature does not need to associate with specific neighboring cells, set up an IP connection with a site for information exchange, or work with a site for joint transmission or reception.

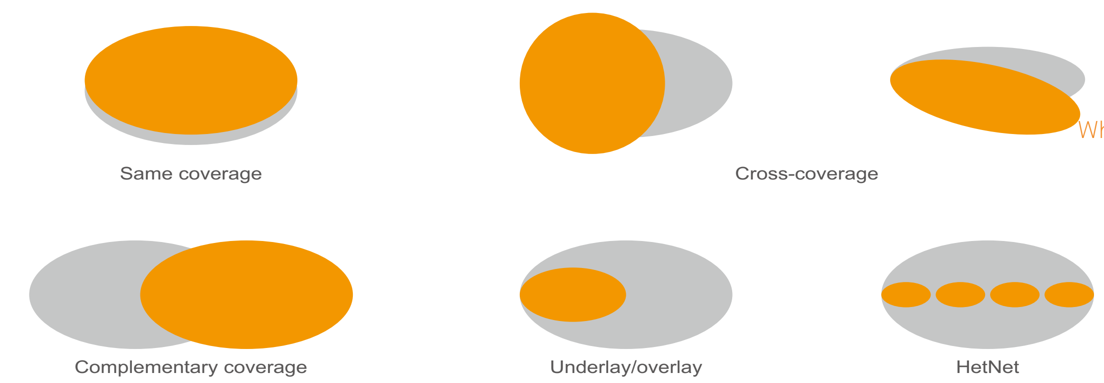
- Self-optimization

Each RAN feature is able to monitor its own performance, as well as to evaluate whether it is working properly and whether any adjustment is needed.

- **Self-Awareness of Cell Topology**

A number of RAN features depend on cell topologies. Take the UMTS blind handover function as an example. This function applies only to co-coverage cell topology. The evolution to 4.5G and 5G has made coordination between cells increasingly important. Different coordination policies may be adopted to adapt to different topologies. It would be time-consuming for engineers to manually configure these topologies. Powerful UE capabilities and high speed connections in LTE enable operators to collect a large amount of network measurement data, which helps identify cell topologies.
In addition, the centralized management function of SON enables operators to use detailed configurations of cellular networks to identify cell topologies.

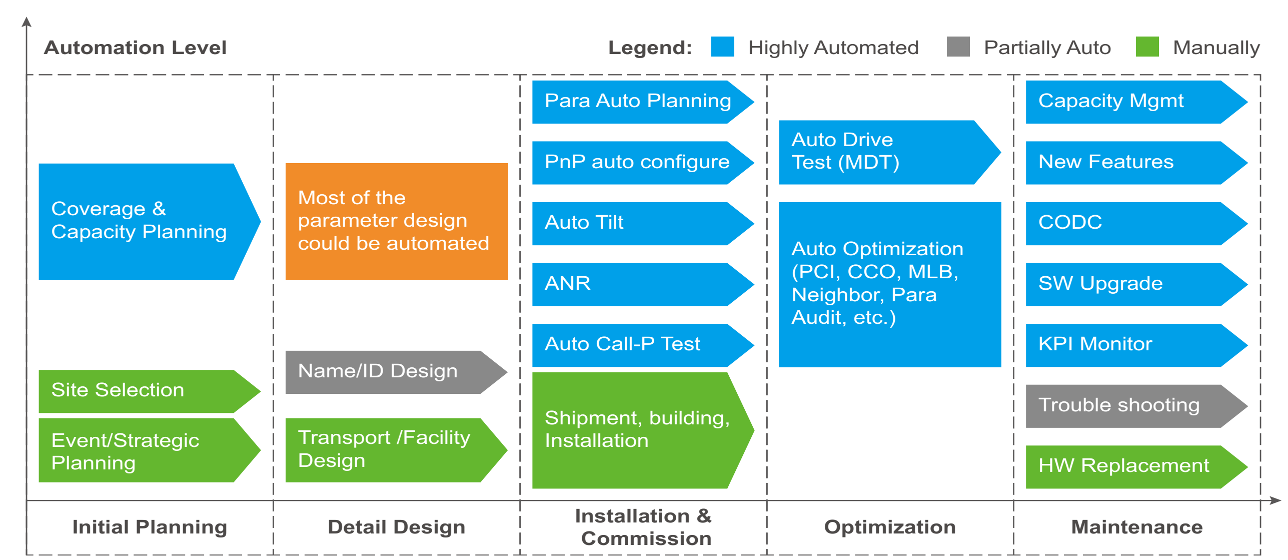
Future 3GPP releases may define even more efficient measurement procedures for UEs to monitor all neighboring frequencies and access points (APs) and to report the monitoring information for optimal decision making.



What is NG SON

3.2 Full Automation of Network Deployment and Operation

In 5G Vision publication by 5G-PPP, it was stated that the target 5G advance is to have "1/5 X in network management operational expenditure" relative to 2010 levels. To achieve 1/5 OPEX, all the tasks with clear inputs and outputs needs to be automated through SON, complemented by efficiency improvements brought by NFV and SDN.
Each of the five stages of network O&M tasks can be subjected to various degrees of automation, as illustrated in Figure 3-1 below.



IFigure 3-1 Wireless network tasks and SON potentials

Some of the key SON functions include PnP, auto call-P test, Minimization of Drive Testing (MDT):.

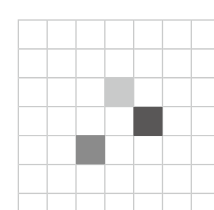
- **Plug and Play Deployment**
PnP deployment takes advantage of DHCP procedures, allowing eNodeBs to connect to the OSS and to update software and configurations automatically. This function has already been used by operators, and is continuously being improved.
- **Auto Call-P Test**
The auto call-P test function helps operators complete various call procedure tests for each new site or cell, which ensures that sites and cells run normally.
- **Minimization of Drive Testing**
The MDT enables UEs to automatically collect network measurement data. The MDT records not only the RF quality of UEs in connected mode but also identifies problems for UEs in idle mode. With MDT, UEs can collect measurement data from locations that cannot be visited in traditional drive tests (e.g., indoor locations), and the collected measurement data can better reflect real user experience.
Given a wider UE support of MDT feature, and provided that appropriate post-processing tools are available on the wireless network side, it is expected that the the MDT can further improve wireless network performance.

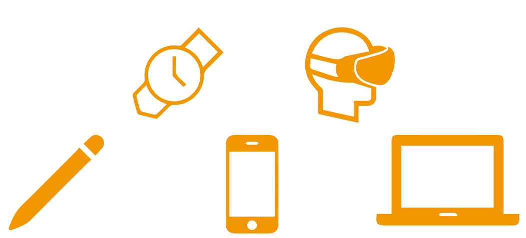
3.3 Multidimensional Accurate Self-Optimization

SFrom the geographic area size point of view, wireless networks can be divided into following categories:
- Cluster of cells, intended to serve a specific coverage scenario, such as indoor coverage, stadium, highway, etc.
- Individual cells are the smallest units with unique RF parameters, usually visually represented with hexagons
- Sub-cell size units organized, usually referred to as grids. The level of grid granularity is not necessarily well defined; sometimes it refers to a relative location within a cell (e.g., cell center, middle, cell edge), and in other instances it relates to the signal strength

Additionally, a network can be divided from the user perspective into various groups, such as groups by device (e.g., iPhone, Android, etc.) or service (e.g., VoLTE, IoT, etc).


Scenario


Grid


Device Group


User Group

Next Generation SON for 5G
What is NG SON

To better address these classifications, the NG SON should be able to manage networks on different levels of scale and provide a better quality of service than a traditionally maintained network.

- **Scenario-based SON**
SON should be able to identify types of scenarios automatically, and provide different configuration strategies according to pre-defined rules.
- **Grid-Level SON**
With UEs' measurement capabilities, different strategies for individual grid level segments can be applied.
- **Device Group and User Group**
If we can identify the groups that users belong to, resources can be allocated to users more efficiently.
- **Traffic and Capacity Driven SON**
Network infrastructure evolves steadily yet slowly, while the applications above that could get popular in one night, and brings the challenges shortly.
Next Generation SON is supposed to be able to detect the emerging traffic models, summarize the key characteristics and make or suggest the accordingly network adjustment needed.

3.4 Advanced Architecture

The network architecture must be carefully designed to support NG SON.

Hybrid architecture: This is a mixture of D-SON and C-SON, each of which has their own advantages. D-SON shortens the response cycle. C-SON can manage long-term data and large-sized networks. The hybrid architecture has all the advantages of D-SON and C-SON.

Data platform: A platform sourced from the Big Data concept is required by operators to take full advantage of all measurement data, trace data, logs, and configurations from the entire network. The platform must be able to collect as much measurement data as possible from the RAN and UEs, providing a basis for automatic decision making.

Process visualization: SON adjusts network configurations, directly affecting user experience. Operators require visualization of the SON's adjustment process and need to monitor the adjustment impact.

Programmable: Various issues may arise during network O&M. SON must provide programming capabilities for RF engineers to develop optimization measures in the event of new issues.

Next Generation SON for 5G
Conclusion

Conclusion

In this white paper we present our joint view on the evolution of the next generation SON and propose the following guiding principles:

- **Built-in capability of 5G**
  NG SON should be designed together with the 5G network to provide sustainable network growth and to enable 5G success.
- **Highly automated network**
  NG SON should be able to automate majority of O&M tasks with clear input and output through key capabilities including enhanced measurement data collection and programming.

TELUS and Huawei will work together to realize NG SON, driving the development of the mobile industry.