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# Legacy Network Management Process and Transition to Self-Organizing Network (SON) and SELFNET

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## ABSTRACT

***Telecommunication sector over the years has undergone rapid transformation catering to high consumer demands and evolving to innovative technologies advancing towards digital convergence. Telecom network system has become more complex and in order to achieve seamless inter-operability among network systems and new technological services along with consistent service delivery in terms of technological and operational change, operators seek more efficient network maintenance practices while reducing capital and operational expenditures. Telecoms will not be able to achieve this without updating to better and automated network management practices thus reducing frequent manual intervention. The transition from manual driven legacy network management process to automated Self-Organizing Networks (SON) for LTE network and to SELFNET for 5G (or beyond 4G network) will enhance existing operations resulting in cost effective, more automated and flexible & cognitive network system integration.***

**Keywords:** *Network Management Process, Self-Organizing Networks, SELFNET.*

## 1. INTRODUCTION

The telecommunications industry is developing rapidly and coming up with new technologies and innovations to meet the ever growing consumer demand. The wireless network has swiftly evolved from 1G to 4G/LTE, with each generation being better than the previous in terms of features it provides and with respect to the advancement of the technology used. These multiple wireless network system technologies converge and inter-operate in a coordinated manner for a seamless connectivity among the user base. In order to maintain inter-operability among the Network Elements (NE) of varied types, a management model or a process is necessary to detect and resolve any occurrence of a failure in an NE which poses risks to the stability of the network.

Radio network management is an operation & maintenance process which aims at detecting, rapid troubleshooting, and prevention of unexpected faults or outage in the radio network to maintaining network stability at all times. Operators constantly seek to improve network efficiency and Quality of Service (QOS) through managed services.

 

A general model of the process can be defined among the groups as follows:

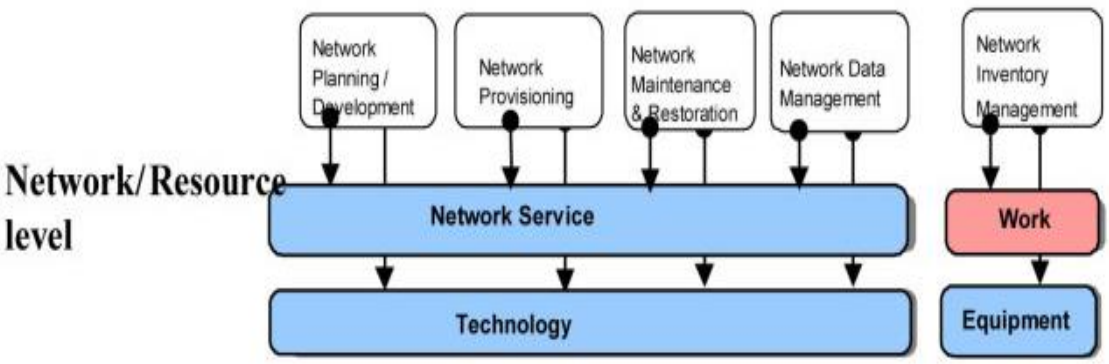


**Fig-1 Telecom Operations Map ©TM Forum**

Planning, commissioning, configuration, integration and management of these parameters are essential for efficient and reliable network operation and associated parameters are manually configured in the legacy wireless mobile networks resulting in significant operation costs.

These processes are categorically defined briefly as follows:

**1) Network Planning/Development**

This process encompasses development and acceptance of strategy, description of standard network configurations for operational use, the definition of rules for network planning, installation, and maintenance.

This process also deals with designing the network capability to meet a specified service need at the desired cost and for ensuring that the network can be properly installed, monitored, controlled, and billed.

(a) Develop and implement procedures
(b) Set-up framework agreements
(c) Develop new network and architectures
(d) Plan required network capacity
(e) Plan the logical network configuration

The network planning team is responsible for both network preplanning and actual network planning, giving site proposals as the output. The network planning team has the assistance of the field measurement team. [Ref 3]

In the legacy UMTS network optimization this turns out to be a tricky and complex task because the target objectives in terms of coverage, capacity, and quality tend to be contradictory (e.g., capacity may be increased at the expense of coverage or quality reduction) [Ref 1] In such case, to maintain QoS requirements efficient network management is required as discussed in SON self-optimization technique.

**2) Network Provisioning**

This process encompasses the configuration of the network, to ensure that network capacity is ready for provisioning of services.

(a) Configuration of the network - installation of initial configuration and reconfiguration due to capacity problems
(b) Administration of the logical network, so that it is ready for service
(c) Connection management
(d) Test the network

It carries out Network Provisioning, as required, to fulfill specific service requests, network and information technology additions, changes, deletions, and configuration changes to address network problems. [Ref 4]

The actions may be requested as part of an implementation program (e.g. additions and deletions), as part of an optimisation program (e.g. modifications), and to maintain the overall Quality of Service (QOS).

The following type of events shall be notified to the Network Manager (NM) if enabled by the NM (these three notification types may be enabled/disabled separately by the NM manually):

*Object creation/deletion*: The created NEs/NRs requires to be:
a) Physically installed/dismantled and tested and initialised with a possible default configuration.

b) Logically installed/removed by means of introduction to the network, possibly involving changes to related existing NE/NR configurations.

(ii) *Attribute value change*: Required modification (physical and/or logical).
(iii) *State change*: The changes of the state and status attributes of a resource shall be notified to the relative manager(s) through system monitoring.

A major aspect of CM is the ability of the operator to monitor the operation of the network. This monitoring capability is necessary for the operator to determine the current operational state of the network as well as to determine the consistency of information among various NEs.

**3) Network Maintenance & Restoration**

This process encompasses maintaining the operational quality of the network, in accordance with required network performance goals. Network maintenance activities can be preventative (such as scheduled routine maintenance) or corrective.

(i) *Preventive Maintenance*

Preventive Maintenance is a maintenance that is regularly performed as per prior agreed time & schedule to keep the network system running and in the desired condition. The regular inspection, health check & servicing is done in order to reduce the probability of it failing unexpectedly. It is carried out by special technical and human system and is applied selectively to critical network elements which have a likelihood of failure and can be prevented by regular maintenance.

(ii) *Corrective Maintenance*

A network needs constant monitoring and early detection of faults in order to provide quick resolution. These faults/errors in the network manifest themselves as alarms to OSS. Alarms are specific types of notifications pertaining to detected faults generated by the network entities using autonomous self-check circuits/procedures, counters, and thresholds.

When a failure occurs in a network, an alarm record is stored in a log and an alarm report is forwarded as soon as possible. A single incident should generate a single alarm even if it results in the degradation of the functioning of more than one physical or logical resource within the network entity. In case the NE fails to recognize that a single incident may render itself in multiple ways then it generates multiple alarms for a single fault.

Alarm reports are generated using a set notification types and parameter definition and supply the following information:

a) *Event Type*: The type of the fault according to ITU-T Recommendation, Communication Alarm Type, Quality of Service Alarms, Processing Error alarms, Equipment alarm type, Environmental alarm type.
b) *Event Information*: Probable Cause congestion corrupt data: I/O device error, fire/heating/ventilation/cooling system problem, loss of signal, processor problem, and threshold crossed: power problem etc.
c) *Perceived Severity of the fault*: Critical, Major, Minor, Warning, Indeterminate, and Cleared.
d) *Event Time*: The time at which the fault was detected.
e) *Additional Text and Additional Information*: It supplies the information that helps understand the root cause and location of the fault detected.

Irrespective of the severity of the alarm, a Trouble Ticket is created and assigned for Problem Resolution to the designated work force following the strict & set SLA promised to the customer/operator.

Reporting Customer Problem processes and providing notifications of any changes/updates is also a part of the overall of the overall Incident/Outage Handling process. These are manual driven processes which will continuously monitor the status of customer problem, make the necessary reports about the problem that occurred, the root cause and the activities carried out for recovery of normal operation.

(iii) *Fault Management*

Fault management functions are used after the fault is detected. This function comprises of fault isolation, network testing and diagnosis and troubleshooting measures to restore the services of the faulty NE. The corrective measures taken depend on the severity of the fault and the configuration of NE. The restoration measures are performed manually either remotely via commands or physically at the fault location if needed.

When a fault has been detected and if the information provided through the alarm report is not sufficient to localise the faulty resource, tests can be executed to better localise the fault. During normal operation of the NE, tests can be executed for the purpose of detecting faults. Once a faulty resource has been repaired or replaced, before it is restored to service, tests can be executed on that resource to be sure that it is fault free.

 

Depending on the type of fault, recovery measures (physically and/or manually) vary:

a) *Software faults*: Such faults can be repaired by means of system initializations, download of a software unit, backup software load, or updated software loads etc.
b) *Hardware faults*: The troubleshoot measures taken in case of hardware faults depend primarily on the availability of redundant/back-up resource of the faulty NE.
c) *Communication faults*: These can be worked upon by replacing faulty transmission equipment and/or by removing the cause of the excessive noise.
d) *Environmental faults*: Necessary measures are taken to check the cause of such problems and solving it to bring the NE back to service. (For e.g., High temperature can be the result of reduced fan speed and hence decreased cooling)
e) *Quality of Service*: The degradation in the QoS can be improved by improving the capability of the system to react against its causes.

The recovery actions taken are system/implementation specific and shall be known to the customer and recovery sequence shall follow a set of rules to avoid degradation of the services. When the faults are completely removed and the alarm is cleared by performing necessary manual operations then a "cleared" alarm is generated. Clearance of alarms by the designated work-force is verified by the same process:

a) By re-using a set of parameters that uniquely identified the active alarm.
b) By including a reference to the active alarm in the clear alarm.

When a clear alarm is generated the corresponding active alarm is removed from the active alarm list and the Trouble Ticket is closed mentioning all the details of the service problem and diagnostic steps followed.

Once the customer problem report has been completed and validated, the service restoration time is updated, and the report is closed. It may still be necessary to contact the customer for feedback by the designated team and at the same time to register the need for improvements in the service.

**4) Problem Management**

The primary objective of the problem management is to prevent incidents from happening again, to eliminate recurring incidents, and to minimize the impact of incidents that cannot be prevented.
Problem management team's role is to identify, troubleshoot, document, categorize, prioritize and resolve the root causes of repeated incidents. It includes the following activities:

(a) Problem detection
(b) Problem logging
(c) Problem categorization
(d) Problem prioritization
(e) Problem investigation and diagnosis
(f) Creating a known error record
(g) Problem resolution and closure
(h) Major problem review

**5) Network Data Management**

This process is responsible for the collection of performance/usage data and events for the purpose of network performance, usage and traffic analysis. It is carried out by a designated team who must ensure that the Network Performance goals are tracked, and that notification is provided when they are not met. This includes information on capacity, utilization, and traffic.

## I. SELF-ORGANIZING Network for LTE (SON)

The Self-Organizing Network (SON) concept was introduced by 3GPP since the initial releases of LTE standardization, in order to help mobile access network operators to cope with the increasing complexity of configuration, optimization and assurance processes. The main drivers are reducing operation cost and capital expenditure due to increased network complexity. Network operators need more automation and reduce human intervention in the network management process.
This is accomplished through Self-Configuration, Self-Optimization, and Self-Healing of the network.

 

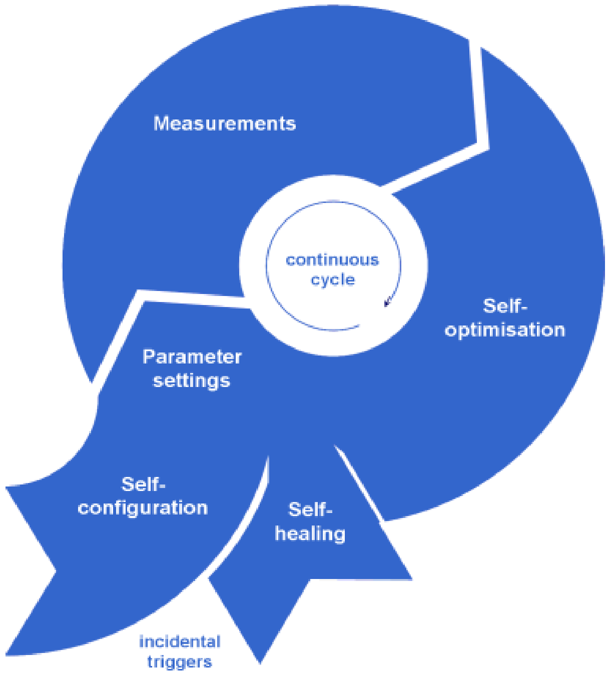


**Fig - 2 Concept of SON**

(i) **Self-configuration**

The Self-configuration SON is a collection of algorithms that aims at reducing the amount of human intervention in the overall installation process by providing "plug and play" functionality in network elements such as the E-UTRAN NodeBs (eNBs). This will result in faster network deployment and reduced costs for the operator.

Major Features – [Ref 11]

- *Automatic configuration of initial radio transmission parameters*: A technique called Dynamic Radio Configuration, DRC is used which allows the base station to become adaptive to the current radio network topology. The DRC configures a variety of items including the cell ID, initial power and antenna tilt settings etc. The various settings required can be determined by the base station, eNB when it is in its installation process.
- *Automatic neighbour relation, ANR, management*: The manual update of neighbours relationships become even more complicated as the network needs to decide if it can handover to a neighbours cell with a similar radio access technology, or whether it has to change, e.g. from LTE to HSPA, etc.. The UE is provided with a neighbours list by the base station or Node B, and this provides the frequencies the UE should monitor for handover.
- *Self-test*: A self-test is normally performed as part of the SON self-configuration to ensure the correct operation of the equipment prior to final active service.
- *Automatic inventory*: This activity includes aspects such as identifying what hardware boards are fitted, software level, antennas, etc. In this way the base station is able to identify its capabilities.

**(ii) Self-optimization**

Self-optimization process is defined as the process where UE & eNB measurements and performance measurements are used to auto tune the network. In the 'self-optimisation' phase intelligent methods apply the processed measurements to derive an updated set of radio (resource management) parameters, power settings, neighbour lists (cell IDs) and a range of radio resource management parameters (admission/congestion/handover control and packet scheduling).

Some of the most important self-optimization SON features are: [Ref - 11]

- *Coverage and Capacity Optimization*: The concept behind this element of the SON self-optimization is to adapt parameters such as antenna tilts, transmitter power levels and the like to maximize coverage while optimizing the capacity by ensuring the inter-cell interference levels are minimized.
- *RACH optimization*: The RACH needs to be accurately configured so that it provides a sufficient number of random access opportunities for any handsets or UEs operating within the cell. The automatic management of RACH requires the network to be continuously optimized to meet the changing conditions.
- *Mobility robustness optimization*: The mobility robustness optimization functionality is included within the self-optimizing network routines to enable robust mobility and handovers within the mobile network.
- *Mobility load balancing optimization*: Some cells are likely to be more heavily loaded than others and methods are used to spread user traffic across the system's radio resources proving the most effective service for users while maintaining overall capacity while keeping investment to reasonable levels.[11]

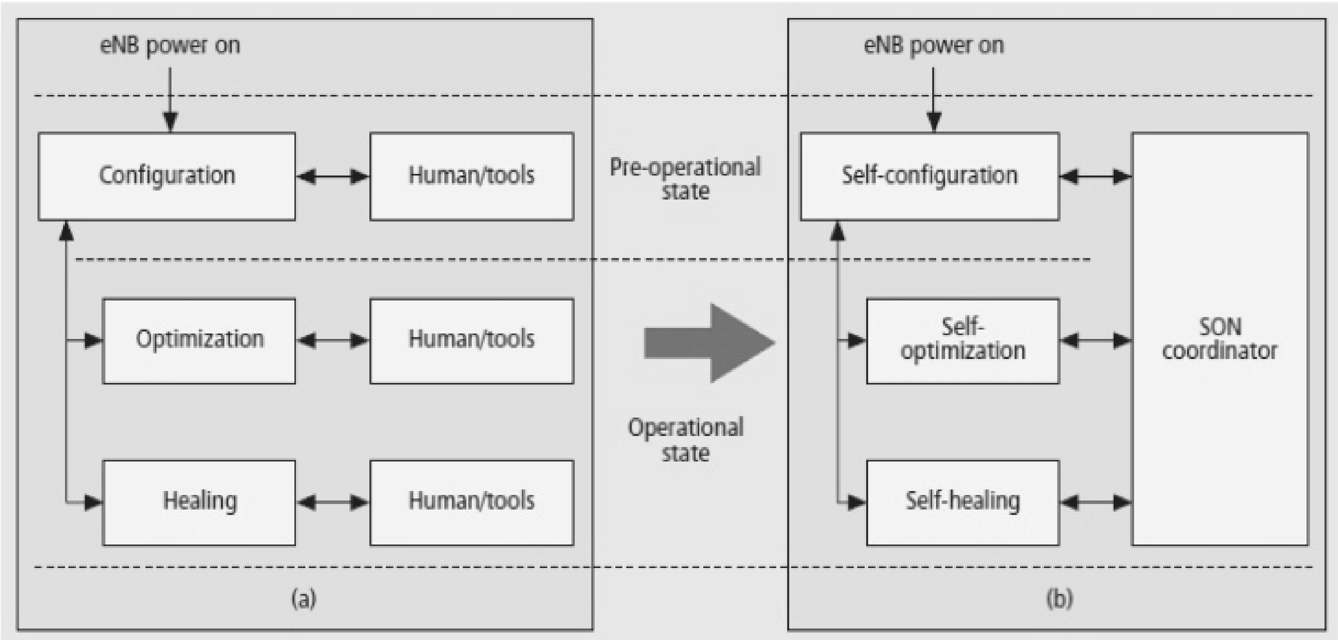


**Fig - 3 SON Automation v/s Manual operation [Ref. 2]**

**(iii) Self-Healing**

The purpose of the Self-healing functionality of SON is to solve or mitigate the faults which could be solved automatically by triggering appropriate recovery actions with a minimum of manual intervention from the operator. Self-healing functionality will monitor and analyses relevant data like fault management data, alarms, notifications, and self-test results, and so forth and will automatically trigger or perform corrective actions on the affected network element(s) when necessary. The two major areas where the self-healing concept could be applied are as follows.

(a) Self-diagnosis: create a model to diagnose, learning from past experiences.
(b) Self-healing: automatically start the corrective actions to solve the problem.

## 2. SELFNET FOR 5G (BEYOND 4G) NETWORK SERVICES

With rapid advancement in technology and growing user demand for high service quality, network operators have begun to progress towards 5G network. These complex set of mobile networks and with emergence of new services, an efficient and smart network management scheme is required. The Self Organizing Network (SON) features introduced as part of the 3GPP Long Term Evolution (LTE) have been enhanced for the upcoming 5G network under the SELFNET project for smart network management. The main objective of SELFNET is developing an efficient self-organizing network management framework by integrating Software-Defined Networks (SDN), Network Function Virtualization (NFV), Self-Organizing Networks (SON), and Cloud Computing & Artificial Intelligence.

SELFNET addresses key network management problems:

(a) Automated network service provisioning
(b) Self-Organized network capabilities
(c) Automated deployment of network management tools
(d) Protection capabilities against distributed cyber-attacks
(e) Automatic network maintenance
(f) Improved Quality of Experience (QoE) of the users of the users.
(g) Reduction in CAPEX/OPEX.

 

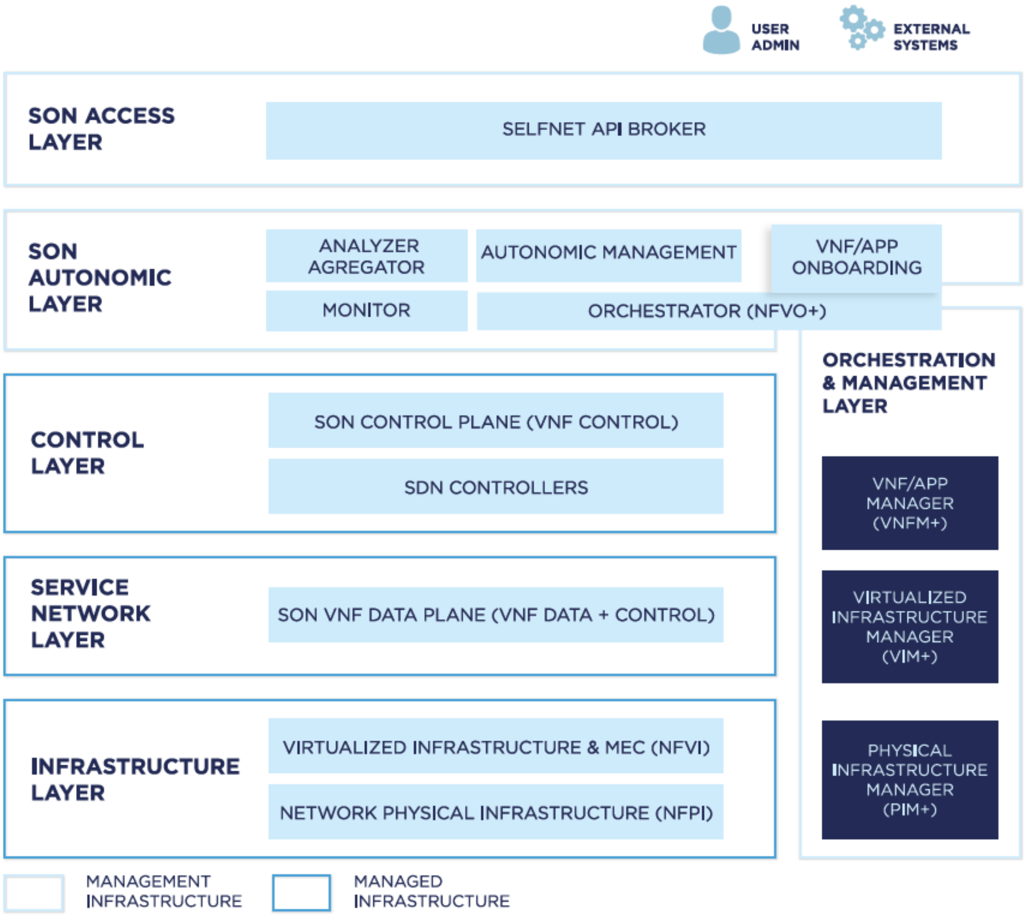


**Fig: 4 SELFNET Architecture Overview**

As per the SELFNET-5G project, the architecture is differentiated into layers as follows: [Ref. 13]

a) **Infrastructure Layer**: This layer provides the resources required for the instantiation of virtual functions (Compute, Network and Storage) and supports the mechanisms for that instantiation. Its sublayer components, Physical sublayer provides physical connectivity, networking, and computation and storage capabilities over bare metal and the Virtualization sublayer provides virtualization capabilities to instantiate virtual infrastructures.

b) **Virtualized Network Layer**: This layer represents the instantiation of the Virtual Networking Infrastructures created by the users of the infrastructure as part of their normal operational plan and those created by the SELFNET framework as part of the SON capabilities. In the context of SELFNET, all Network Functions will be virtual functions and they will be chained across the virtual network topology.

c) **SON Control Layer**: This layer contains the applications that will enable the collection of data from sensors deployed through the entire system (SON Sensors) and the applications that will be responsible for enforcing actions into the Network (SON Actuators) as part of the enabling mechanisms to provide network intelligence in 5G networks.

d) **SON Autonomic Layer**: This layer provides the mechanisms to provide network intelligence. The layer collects from the network pertinent information about the network behaviour, uses that information to diagnose the network condition, and decides what must be done to accomplish the system goals. It then guarantees the organized enforcement of the actions that are determined.

e) **NFV Orchestration & Management Layer**: It is worth emphasizing that the control of the chaining of the NF applications is envisioned as a management functionality to be able to control the topology of the Virtual Network layer depicted in the figure as Network Controller (SDN App) and included logically in the VIM functionalities.

f) **SON Access Layer**: This layer encompasses the interface functions that are exposed by the framework. Despite the fact that internal components may have specific interfaces for the particular scope of their functions, these components contribute to a general SON API that exposes all aspects of the autonomic framework, which are "used" by external actors, like Business Support Systems or Operational Support Systems.

A GUI is also provided on top of the SON API where a network administrator can interact and configure SELFNET and also obtain the complete status of the network, acting as a command and control centre. This GUI will also enable the network administrator to stop, verify or manually enforce any of the actions that SELFNET is governing, allowing always network administrators to have control over their infrastructure. [Ref. 13]

**Key benefits of SELFNET**

(a) Self-Organised network
(b) Resilient Network
(c) Expected OPEX & CAPEX savings
(d) Improved QOE/QOS
(e) Enhanced scalability and response to faults.
(f) Secure and Reliable network
(g) Reduced Service creation time

## 3. CONCLUSION

This review paper presented the legacy network management process and highlighted the advancement in network management features introduced to tackle increasingly complex network systems and services that witnessed evolution to 4G/LTE/LTE-A and now to upcoming 5G network services. The transition from manual based network management process to automate processes viz. Self-Organizing Network (SON) and an enhanced, SELFNET were discussed. SON has already been deployed by several mobile operators around the world and we can foresee the implementation of SELFNET in the upcoming 5G communication system.

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