RAN Evolution and Automation

Project report submitted in partial fulfillment of the requirement for the degree of
Bachelor of Technology

In

Computer Science and Engineering

By

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Under the supervision of

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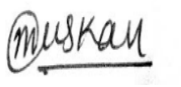
Himachal Pradesh, India

DECLARATION

I hereby declare that the work presented in this report entitled "RAN Evolution and Automation" in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Computer Science and Engineering submitted in the department of Computer Science & Engineering and Information Technology**,** Jaypee University of Information Technology Waknaghat is an authentic record of my own work carried out over a period from 3rd February 2020 to 20 March 2020 under the supervision of **(Jitendra Singh – CA 2nd Level Manager)at Ericsson Global pvt ltd, Noida.**
The matter embodied in the report has not been submitted for the award of any other degree or diploma.



Muskan kaushal
161390

This is to certify that above made statement is true to my knowledge.

Mr. Surjeet Singh
Assistant Professor
Computer Science and Engineering

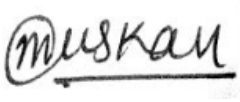
PROJET REPORT UNDERTAKING

I Mr. /Ms. _____MUSKAN KAUSHAL_____-Roll No._____161390_____
Branch_____CSE_____ is doing my internship with _____ERICSSON GLOBAL PRIVATE LIMITED_____ from ___03/02/2020_____ to _____20/04/2020_____

As per procedure I have to submit my project report to the university related to my work that I have done during this internship.

I have compiled my project report. But due to COVID-19 situation my project mentor in the company is not able to sign my project report.

So I hereby declare that the project report is fully designed/developed by me and no part of the work is borrowed or purchased from any agency. And I'll produce a certificate/document of my internship completion with the company to TnP Cell whenever COVID-19 situation gets normal.

Signature____  _____

Name_____muskan kaushal_____

Date _____01/06/2020_____

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for the successful completion of this internship.

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List of Abbreviations

1. SDU - Service Delivery Unit
2. VAS - Value Added Services
3. UTRAN - UMTS Terrestrial Radio Access Network
4. UMTS - Universal Mobile Telecommunications System
5. BTS - Base Transceiver Station
6. BSC - Base Station Controller
7. RNC - Radio Network Controller
8. ENodeB - Evolved Node B
9. MSDP - Managed Services Delivery Platform
10. CPP - Cello packet platform
11. KPI - Key Performance Indicator
12. MOM - Managed Object Model
13. CV - Configuration Versions
14. OSS -Operation Support System
15. BBU- Baseband unit
16. RU - Radio Unit
17. DU - Digital Unit
18. RRU - Remote Radio Unit
19. RAN - Radio Access Network
20. CS - Circuit Switch
21. PS - Packet Switch
22. RAT -Radio Access Technology
23. CSSR - Call Setup Success Rate
24. RET - Remote Electrical Tilt
25. MSDP - Managed Service Delivery Platform
26. QOS - Quality of Service
27. MOM -Managed Object Model
28. ME -Managed Element

Abstract

RAN (Radio Access Network) is a part of the telecommunications system that connects two user equipment's such as mobile phones and computers to the network through radio connections. Traditionally the architecture used to build the network was Distributed RAN (DRAN) and with the advancement in technology it evolved as Centralized RAN (CRAN) and Elastic RAN (ERAN) and Virtualized RAN (VRAN). Also, the hardware and software for managing various RAN nodes in the network have evolved over years. Ericsson is striving towards managing the network in a smooth way using the latest technologies. The aim of this project is to automate the process of health check of RAN nodes to enhance network performance and efficiency. Health check of a node is done to detect any critical alarms or check the status of the network post an upgrade. An alarm is a problematic event that can occur due to multiple reasons such as - power outageat the site, hardware/software failures, time sync failure etc.

CHAPTER 1

INTRODUCTION

1.1 Introduction to Telecommunication:

Transmission of information that allows communication between two people or more, that are separated by a distance. The details can be in voice phone calls, records, emails, photographs or video formats. Telecommunication today are used to link more or less isolated computing systems into telephone networks. The purpose and function of telecommunication is to provide an interchange of contact or information between people, satellites or computers at a distance.

Networks are either wired or wireless:

Wired Network: One common form of wired networks is a cable network. The majority of cable or wired networks use Ethernet cables for data sharing between attached computers. A single router can be used in a small wired network to link all computers to each other.

A wired network is:

- Faster compared to wireless system.
- More reliable and easier to set up connection.
- Provide good coverage
- Has less interference than radio waves.
- More secure due to physical connection
- Easier operation and maintenance.

Wireless Network: wireless networks are computing networks and are not linked by any form of cables. The use of wireless networks help business to escape the expensive process of installing cables into buildings or as a link between various locations of equipment.

A wireless network is:

- Increases efficiency

- Improvised installation speed and simplicity.
- Increased scalability
- Wider reach of the network

1.2 History of telecommunication:

Lars Magnus Ericsson invented the first telephone to combine the receiver and the mouthpiece into a single hand set. The idea was adopted in 1884, and the invention spread quickly around the world. American inventor, Martin Cooper gave us the freedom to do it wherever we wanted.

Before cell phones, landline system used to look like-

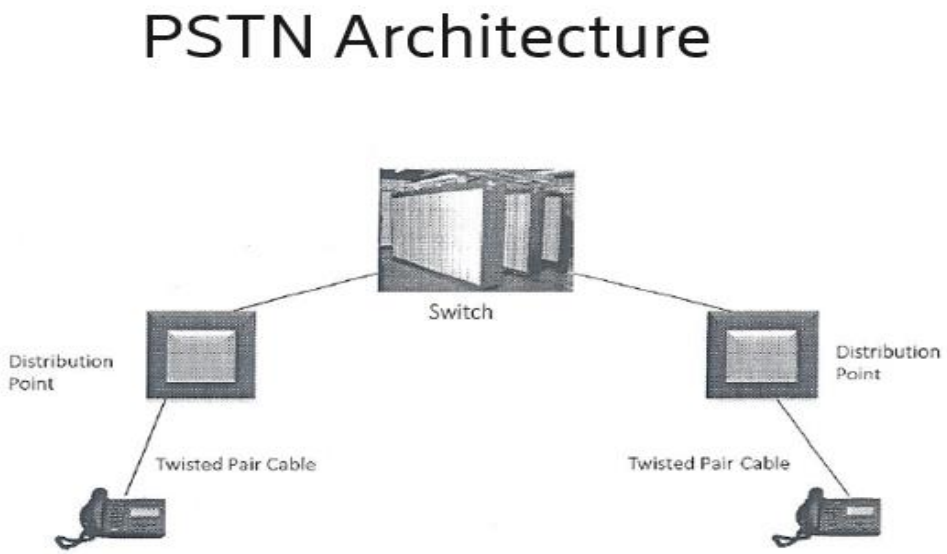


Fig (1) PSTN architecture.

1.3 Evolution of telecommunication:

From sending messages via mail to now texting within minutes' telecom industry has taken a boom, evolving from 1G to 4G. From wired to wireless communication now we have digital communication.

- 1G- only voice.
- Technique used: FDMA (Frequency division multiple access)
- 2G- voice and text.
- Technique used: FDMA + TDMA (Time division multiple access)
- 3G-(WCDMA) more speed, more spreading factor
- Throughput=384 kbps.
- 4G = (Long term evolution)
- VOLTE=LTE+IMS

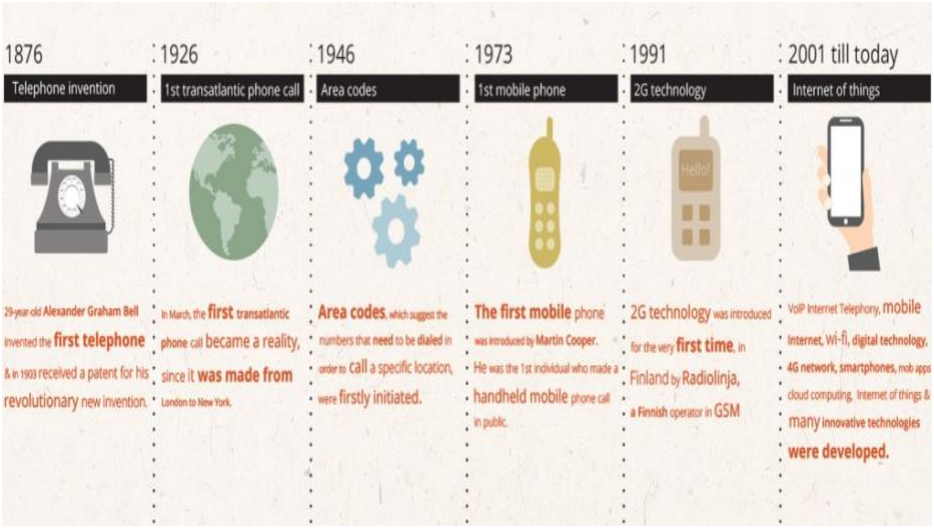


Fig (2) Telecom generations

Digital Communication: In wireless communication the data or voice that we transmit is in the form of binary bits. The user may want to send pictures, emails or video but the transmitter needs to convert this into binary format before sending it to the carrier.

1.4 Communication system: Different communication equipment's assembled together into one forma a communication system.

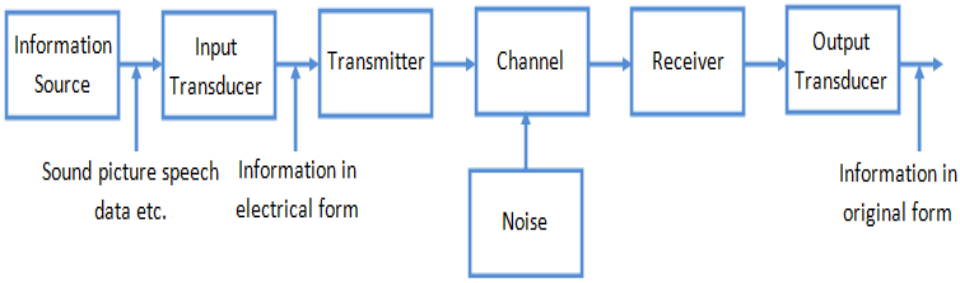


Fig (3) block diagram of communication system

Information source: The communication device is used to transmit a message or information. This information can be a text, a picture message and thus originates from the information source. Function is to provide required message that needs to be transmitted.

Input Transducer: A transducer is a device that converts one form of energy into another.

The information source message may or may not be electrical in nature. In cases where the message produced by information source is not of electrical kind, an input transducer is used to transform into an electrical signal with varying duration.

Transmitter: Function is to transmit these signals. Modulation is transmitters principle function. In modulation the message signal is superimposed on high frequency carrier signal, all these processing of the message are done for the sole purpose to ease the

transmission through the channel.

The channel and the noise: Channel means the medium via which the information is travelling from transmitter to receiver. It behaves as a physical connection between both.

The signal gets skewed during the transmission and receiving process due to noise added into the device.

At any point in communication system noise can interfere in the system. Noise thus has its greatest impact on channel signal.

Receiver: Its main function is to reproduce the message signal from the distorted message signal that is received in an electrical form. Demodulation accomplishes this reproduction of original signal. It is reverse modulation process performed at transmitter.

Destination: Final step where a signal is transformed in its original form.

1.5 Industry structure:

The telecommunication sectors are made up of both cellular telephone networks and internet service providers, and play a key role in electronic technology development

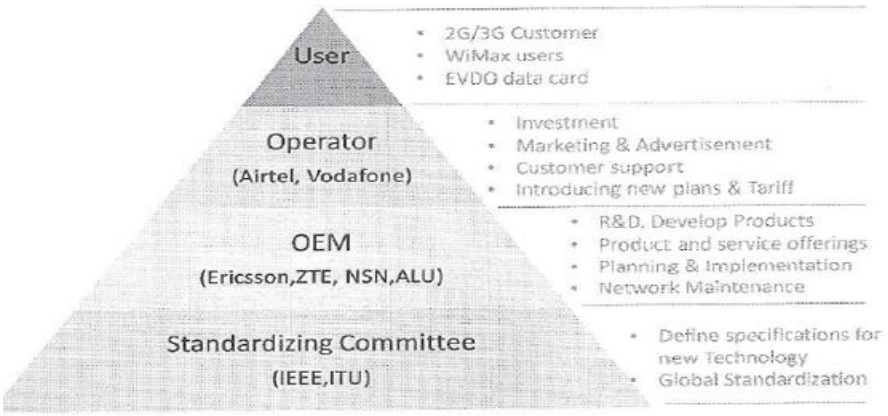


Fig (4) Telecom industry system

Telecom industry ecosystem:

- Telecom operators or service providers (Vodafone, AT&T, Arizone)
- Telecom network OEM or vendors (Ericsson, cisco)
- Telecom regulatory bodies (TRAI, FCC)
- Telecom standardization organizations (ITU, IEEE)
- Subscribers and customers
- Handset vendors (Apple, Nokia)
- Mobile OS (Android, iOS)
- Internet and OTT players (WhatsApp, skype)
- OSS and BSS solution providers (Amdocs, HP)

1.6 Organization Overview:

Ericsson is a leading information and communication technology supplier of telecommunication providers. By creating game changing technology and services that are easy to use, adopt or scale, they enable the full value of connectivity and make their customers successful in fully connected world. The corporation offers information and communications technology facilities, applications and networks for telephone providers, conventional telephone and internet protocol (IP) networking devices, mobile and fixed broadband, logistics and business support devices, cable television, IPTV, multimedia systems and comprehensive application of services.

Lars Magnus Ericsson founded the company in 1876 as of 2016, it has its headquarters in Stockholm, Sweden. Ericsson has continued to offer ground breaking innovations and to reinvent technologies for good ever since.

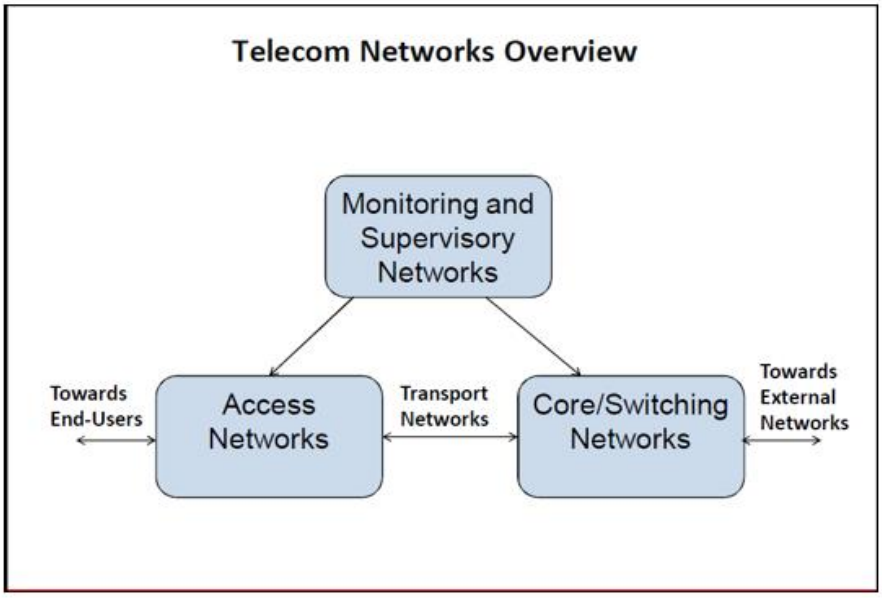


Fig (5) Telecoms network overview

1.7 Ericsson Domains:

- RAN and OSS
- CORE and VAS
- IP and TRANSMISSION

RAN includes the access part of a telecommunication network that connects a user equipment to the core network (CN). With the advancement in technology the architecture has evolved into simpler nodes, from BTS and BSC in 2G to Node B and RNC in 3G to eNodeB in 4G.

These nodes manage radio resource allocation, handovers (intra, inter), channel allocation and transmission and reception of signals.

Here at Ericsson the RAN engineers take care of fault and maintenance activities related to sites/BSCs/RNCs and ensure proper coverage and services to the end user.

Operations Support system (OSS) supports centralized operation and maintenance of the network. This includes:

- 24/7 operations
- Monitoring and troubleshooting
- Software management
- KPI Maintenance
- Productivity tools
- Upgradation of licenses

OSS-RC (Radio and core network) main applications are-

- Fault management
- Performance management
- Configuration management
- Security management
- Ticket management

RANs have evolved tremendously over the past decade as

- DRAN (Distributed RAN),
- CRAN (Centralized RAN),
- ERAN (Elastic RAN)
- and now RAN is evolved on cloud as VRAN (Virtualized RAN).

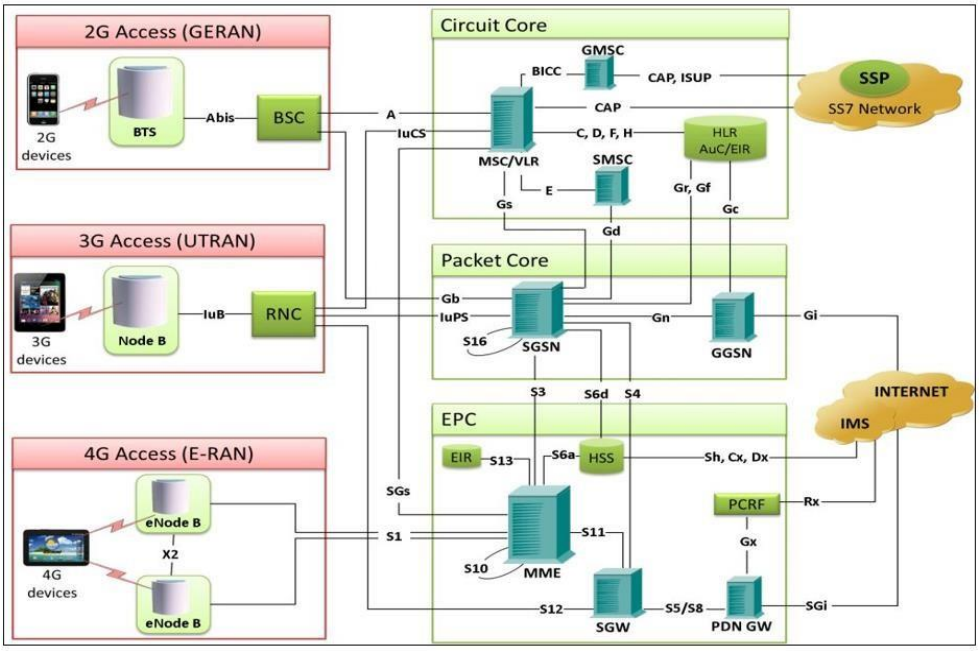


Fig (6) RAN Evolution Architecture

1.8 Interconnectivity of domains:

The three domains have been interconnected as:

RAN part as access network connected to core network via transport or transmission. They are connected via OSS/ENM hich is the ericsson network manager that tends to perform operation and maintenance check.

OSS: (Operation Support System) – computer system used by telecom providers to manage their networks. Management functions are being supported , network configuration and fault management.

Different subdivisions of OSS have been proposed by the forum and accordingly the telecom operators work.

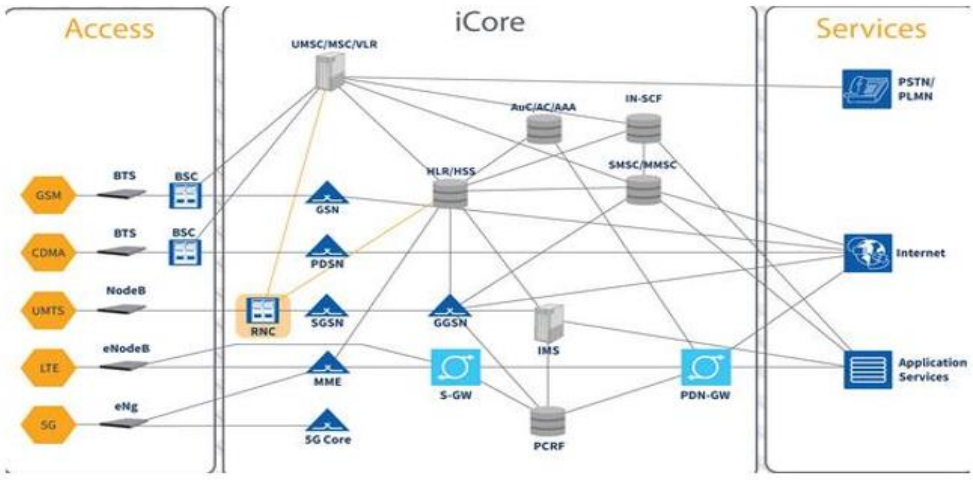


Fig (7) Interconnectivity of domains

1.9 Ericsson Hardware:

1.9.1 RNC Hardware:

RNC is the governing element in UTRAN. It is responsible for controlling the Node B's that are connected to it. EVO Controller 8200 is the latest RNC hardware platform. It supports CPP platform (for RNC) as well as AXE platform (for BSC) which means it can run BSC and RNC applications using the same hardware. This provides flexibility to the operators for easy reconfiguration

- EVO Controller 8200 / RNC
- EVO Controller 8200 / BSC
- EVO Controller 8200 / MULTI

EVO Controller 8200 / MULTI can harbor both BSC and RNC in a single cabinet. Within the cabinet, each Sub rack has 28 slots as shown in the figure.

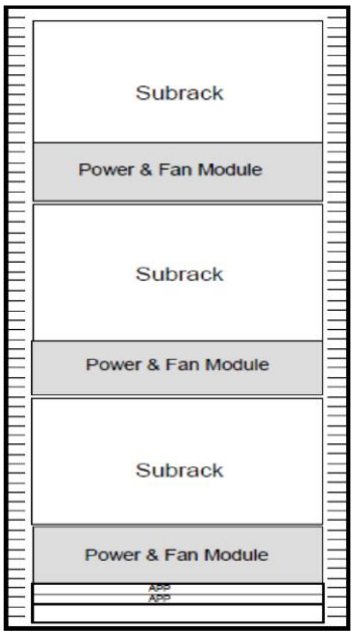


Fig (8) EVO Controller 8200 cabinet

1.9.2 Plugin Units:

Plugin Units are the boards that are responsible for the functions like central processing, power distribution, data backup etc. The boards are as follows

- System Control Switch Board (SCXB3)
- Evo Exchange Terminal (EVOET)
- Evo Processor Board (EPB1)
- Common Main Switch Board (CMXB3)

- Central Processing Unit Board (CPUB2)
- Maintenance Unit Board (MAUB)
- Adjunct Processing Unit Board (APUB2)
- Generic Ericsson Device board – Serial Attached SCSI (GED-SASF/2)
- Generic Ericsson Device board – Digital Versatile Disc (GED-DVD/2)
- Alarm handling board (GEA)
- Network Interface Ethernet (NWI-E)
- Dummy Board – (DB)

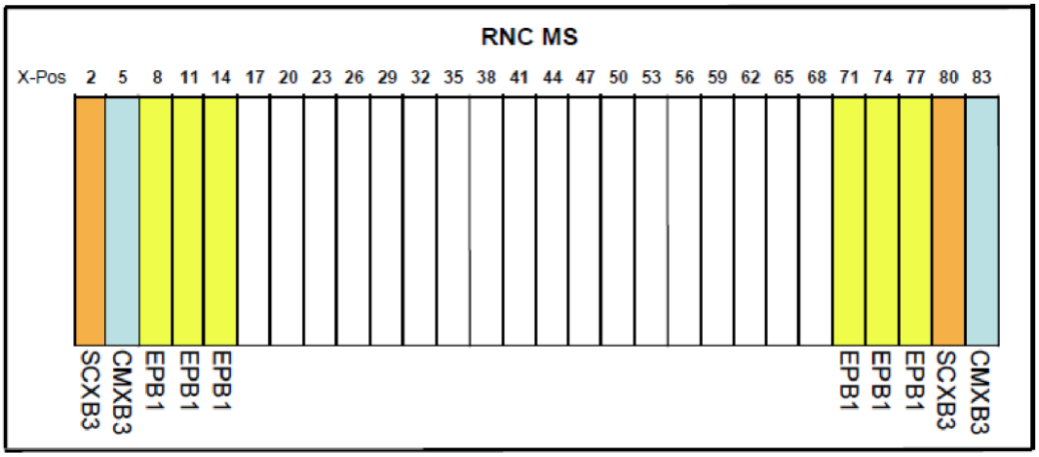


Fig (9) RNC Main Sub rack the boards are in fixed position

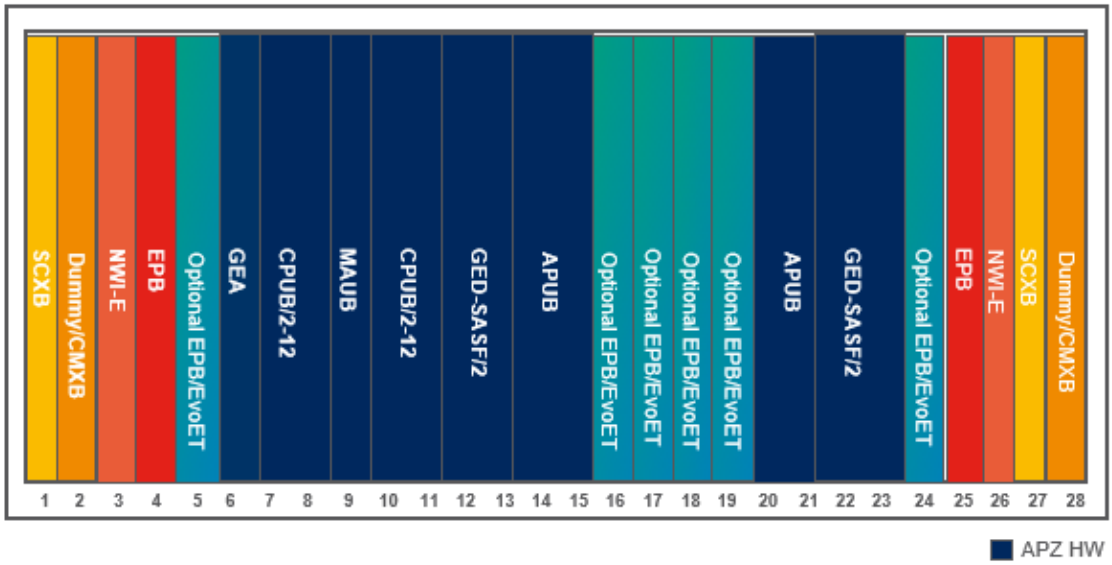


Fig (10) Evo controller main sub rack

1.9.3 LTE Hardware:

LTE (Long Term Evolution) has a very evolved architecture and hardware structure. It consists of the following -

1. DU/ BBU - Digital Unit / Baseband Unit

The DU is Gen1 hardware whereas the BBU is a Gen2 hardware. BBU is a more advanced structure that can configure different technologies (like WCDMA, LTE) within a single hardware. Digital Hardware is responsible for O&M, Traffic Control, Baseband, Transport Network, Synchronization. It includes the following -

- TCU: Transport Control Unit

  It looks after transport network and synchronization.

Cards:

1. **EPB cards**
2. **CMXB cards**
3. **SCXB cards**
4. **EVOET**

- XMU: Auxiliary Multiplexing Unit

  It is basically a CPRI splitter. CPRI cable connects the RU/RRU to the DU.

Fig (11) Baseband Portfolio

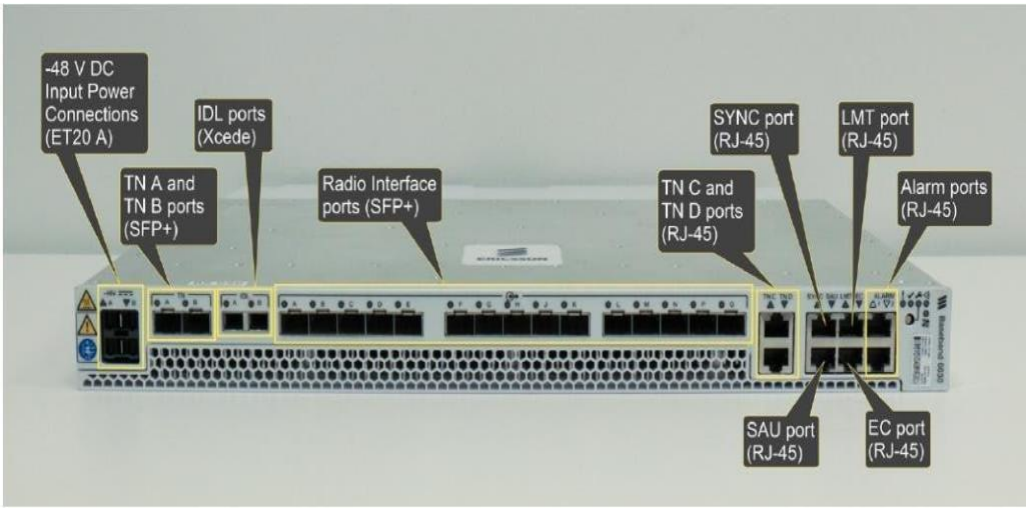


Fig (12) Front Panel Interfaces

2. RU - Radio Unit

The main purpose of the RU is to send and receive signals. It receives digital data and converts it to analog radio signals. It also receives radio signals and converts these to digital signals.

Radio Hardware -

- RU: Radio Unit (in cabinet)
- RRU: Remote Radio Unit (near antenna)
- RC: Radio Core (radio component in micro RBS)
- AIR: Antenna Integrated Radio (RRU+RET inside Antenna)
- IRU + RD: Indoor Radio Unit + Radio Dot (for indoor coverage)
- TMA: Tower Mounted Amplifier (low noise amplifier for Uplink signal, to compensate for feeder loss between antenna and RU)
- RET: Remote Electrical Tilt (to set the vertical tilt of the antenna)

3. SIU - Site Integration Unit

The Site Integration Unit (SIU) is a variant of the Site Transport Node (STN) that provides site routing for site LAN equipment and other collocated equipment (WCDMA/WIMAX RBS). It also provides Abis traffic handling for a multi-TG site.

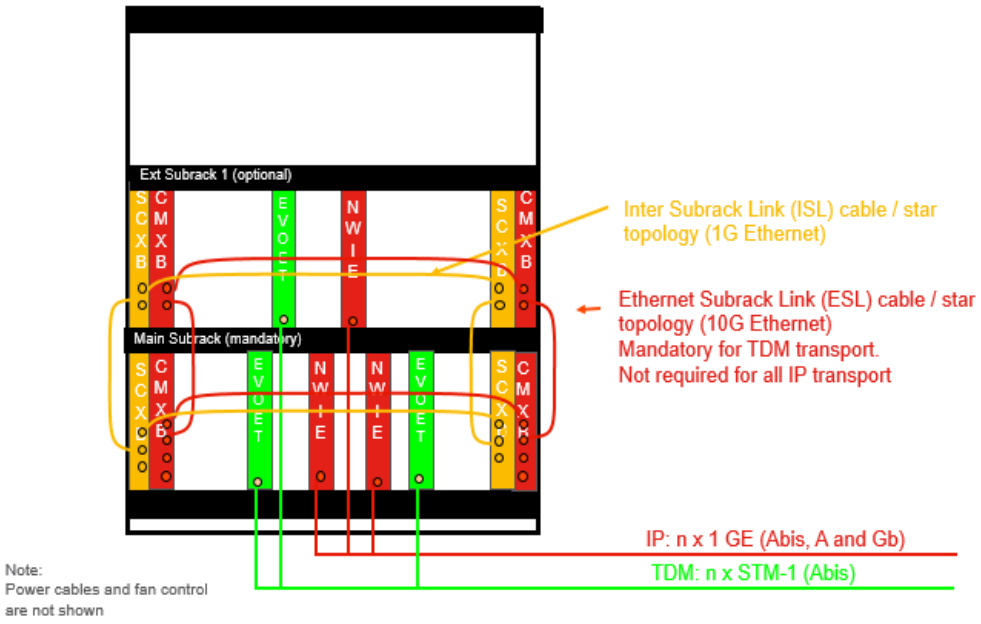


Fig (13) Main and extension sub rack

1.10 Ericsson Tools:

1.10.1 Managed Services Delivery Platform (MSDP):

MSDP, is used when Ericsson has been contracted to manage a customer's network. It contains several solution areas comprising of different tools. MSDP tools serve end-to-end management of networks in multi-customer and multi-country environments, enabling efficient alarm monitoring, trouble shooting, fault restoration, work order distribution and reporting. MSDP tools serve end- to-end management of networks in multi- customer and multi-country environments, enabling efficient alarm monitoring, trouble ticketing, fault restoration, work order distribution and reporting. The two main feature of this MSDP tool is:

- **One FM**: MSDP Fault Manager is a centralized system which supports Fault Management processes or Event Management process (as defined by ITIL/MSTOP). One FM now a ticket is generated which is termed as incident management.

DTAC, Thailand -

Fault management: NOC (Network operation controller) will give us details.

Change management: OPTI team will request us.

MSIP: a platform where we connect with customers, MOAI for asia specific region.

Every 15 days we need to perform a health check.

MSDP TOOLS:

- MSDP tools suite is acting as an umbrella system, to which all Element Managers of multiple types and vendors (or Network Elements directly) send their alarms and events. It provides a common platform to MSDP NOC users to optimize resources and services, and take necessary actions proactively. OneFM tracks alarm/event information in a high- performance, in-memory database, and presents information of interest to specific users through filters and views that can be configured individually.

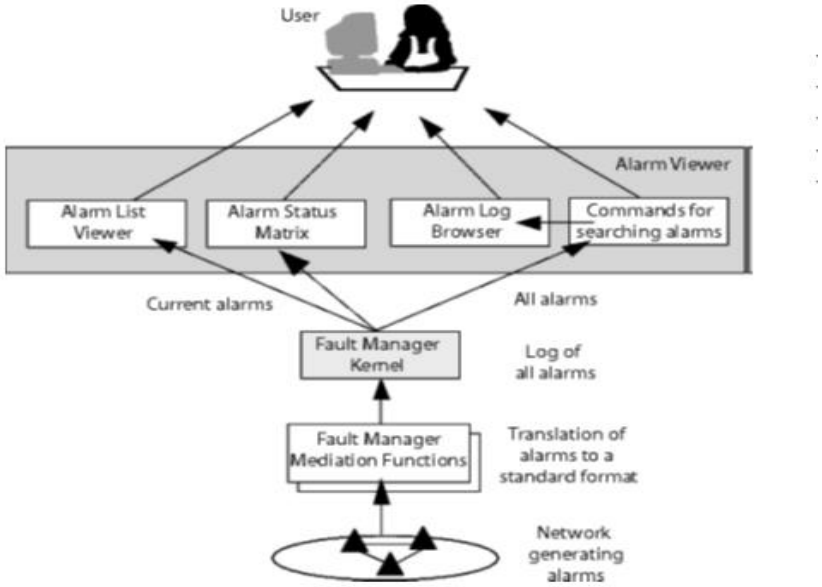


Fig (14) FLOW CHART

- **OneTM:** The Trouble & Change Management Tool used within MSDP is called OneTM. It handles Trouble Tickets, Work Orders and Change Requests in an integrated NMS (Network Management System) solution. Reports on some KPIs are also included. The access is obtained through Citrix clients. OneTM is often used together with a Fault Management system. Tickets can be created based on input from the Fault Management system as well as other sources such as phone calls from end user.

Performance management:

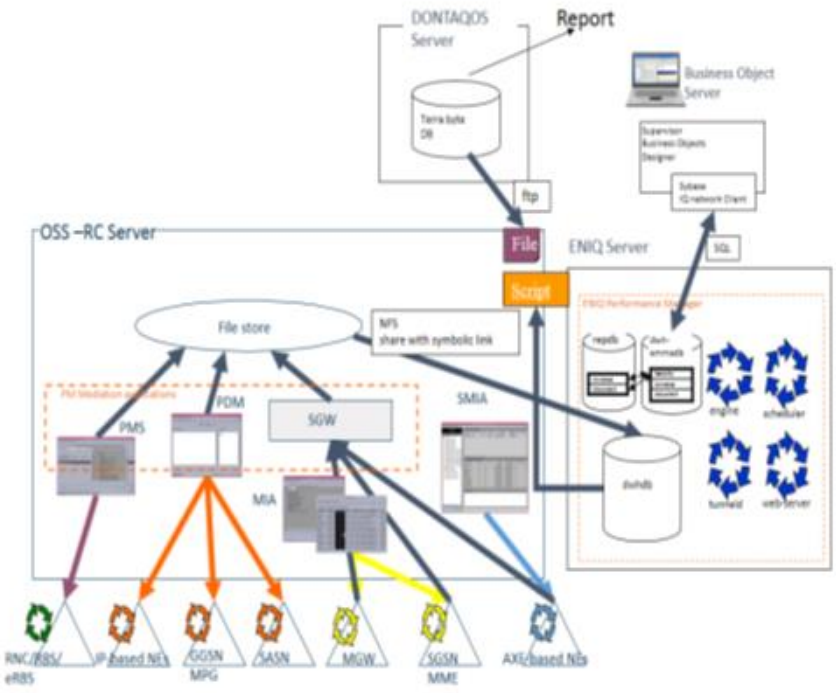


Fig (15) flow chart of performance management

1.10.2 Moshell:

Moshell is a text-based Ericsson-internal Element Management tool for managing Ericsson nodes. Ericsson nodes work on two platforms. They are:

1.10.2.1 CPP nodes: WCDMA RNC/RBS/RXI, MGW/MRS, eNodeB

1.10.2.2 COM nodes: pico RBS, MSRBS V2, TCU, EPG/SSR, APG43L, BSP, PGM, IPWORKS, CSCF, WCG, MTAS, H2S, DUAS etc.

There is also basic support for running MML commands to other node types such as AXE nodes (MSC, BSC), as well as SIU, and TCU

1.10.3 Cygwin:

Cygwin is a POSIX-compatible environment that runs natively on Microsoft Windows. Its goal is to allow programs of Unix-like systems to be recompiled and run natively on Windows with minimal source code modifications by providing them with the same underlying POSIX API they would expect in those systems.

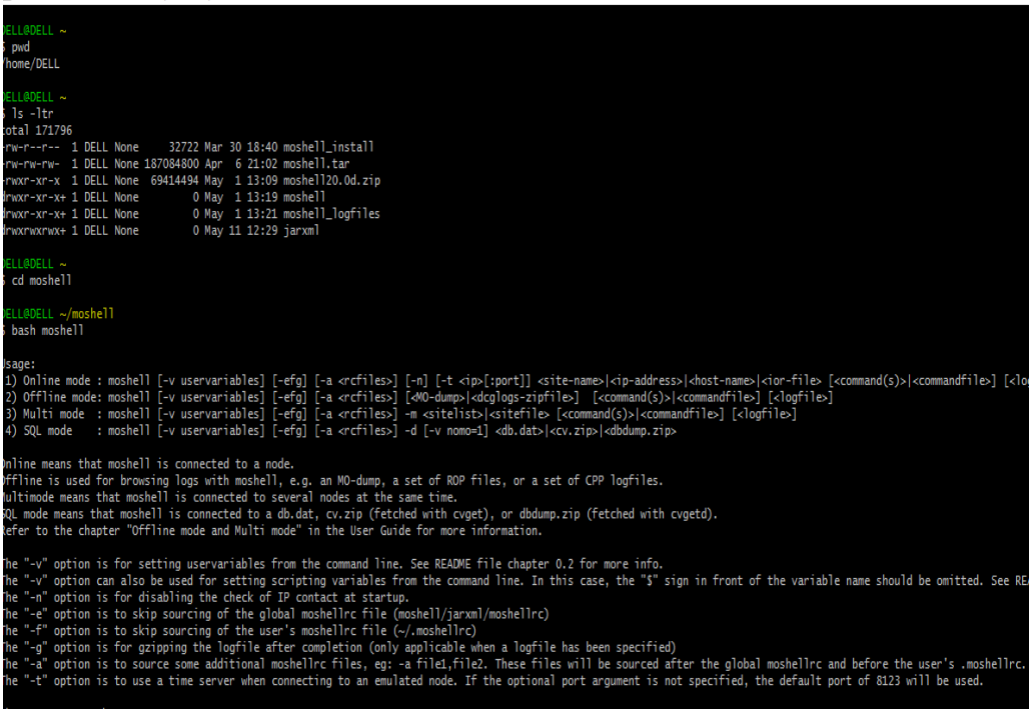


Fig (16) Cygwin

1.10.4 Citrix/ OSS-RC:

OSS is an older version of Ericsson's Network Management tool. Presently OSS-RC has been upgraded to ENM as its functionality and capacity couldn't support the huge network component. Most of Ericsson's customers have switched to ENM, while a few still use OSS-RC. It has the following components to perform various tasks -

- OSS-RC SMO

  SMO stands for Software Management Organizer. Its function is to run upgrades, install licenses, view active jobs and view Active S/W version.
- OSS-RC ALV

  The Alarm List Viewer manages alarms. It has the list of active alarms and is used for alarm supervision. It also maintains the alarm history.
- OSS-RC PMS

  The Performance Management System schedules UE/ cell traffic profiles. It is also responsible for running/ stopping system/ user defined scanners over RBS/RNC.

1.10.5 Ericsson Network Manager (ENM):

ENM is the next generation OSS. As the telecom industry continues to grow in all dimensions, subscriptions the number of devices and volume of data is rising rapidly. Statistics show there would be 28 billion connected devices in 2021 not only for mobile phones, but also for new technology devices such as IOT devices. While this is a huge opportunity for operators, the fact that this can cause challenges in handling the scale of technology shift can't be ignored. So, the real question is how do they manage these huge components in the network?

As the Ericsson OSS system evolved and grew with the addition of new network elements, network types and services, the continued upkeep of these products became more and more expensive due to limitations in their architecture and

original design. Hence the need of an advanced tool became the need of the hour. ENM is designed as a ‘Zero’ Downtime deployment. This means it provides Hardware and Software handling robustness and the upgrades are now designed to happen without the need of a system downtime.

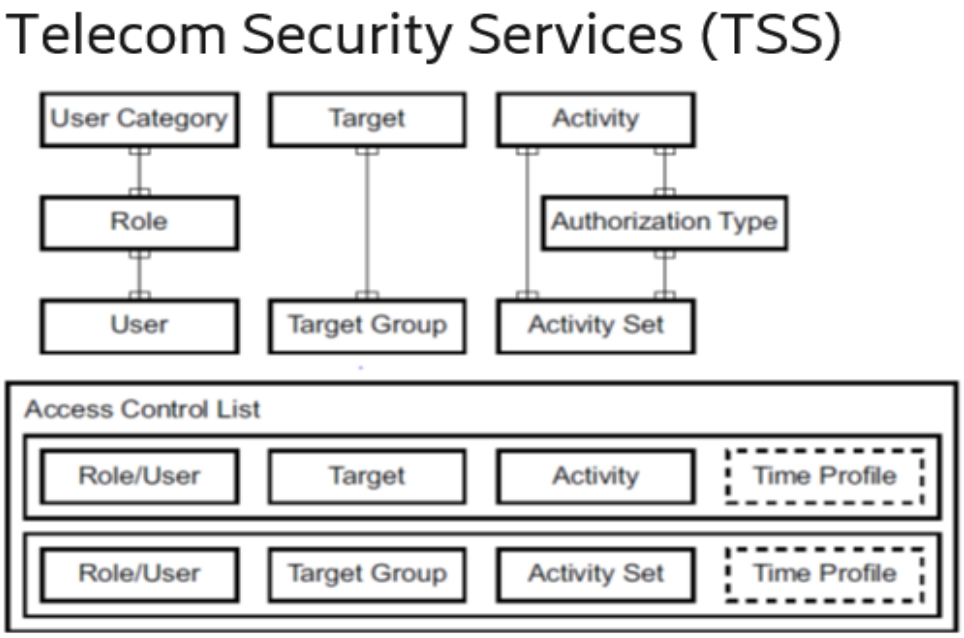


Fig (17) Ericsson Network Manager

Its features referred to as the ‘ilities’ are as follows -

- Upgradability - Software and Hardware Upgrades
- Scalability - Expansion/Contraction Installation
- Usability - User Friendly, Intuitive Interfaces
- Availability - Zero Downtime

ENM has demonstrated very high availability in a live deployment. Availability is important because the functionality provided by an OSS or ENM is of use only if the system is available. When the operational staff use the OSS being 'in the dark' during system unavailability, the systems that rely on data from the OSS/ENM will be missing data for that period too. This could potentially be very detrimental to the whole Operator's business.

The following figures show the function overview of ENM

1. Configurational Management:

This is a part of ENM which is useful in making configurational changes on the network in order keep the network stable. This includes software and hardware manager and Network Connectivity manager.

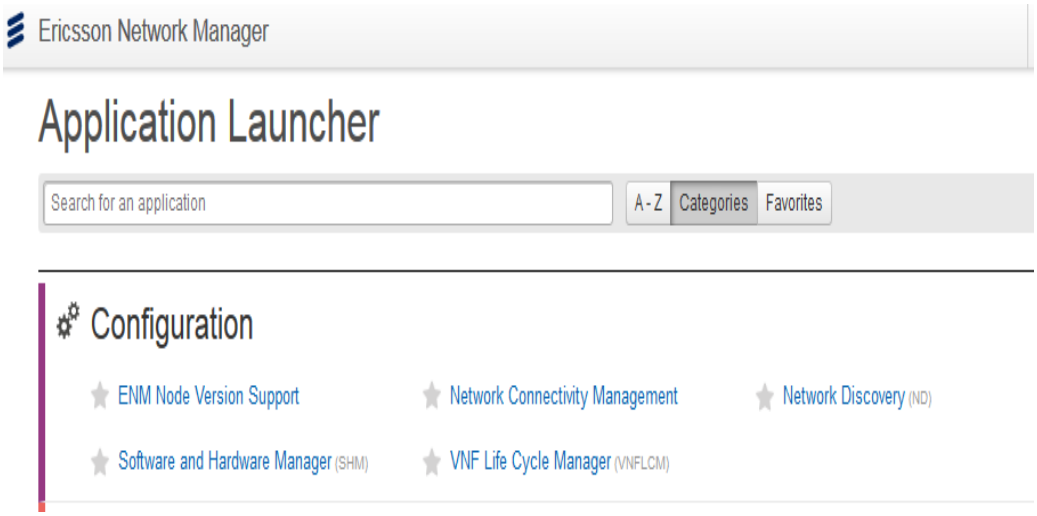


Fig (18) Configurational Management window

2. Software and Hardware Management:

This Software and Hardware manager is useful in:

- License key installation
- Backup administration
- Software upgradation

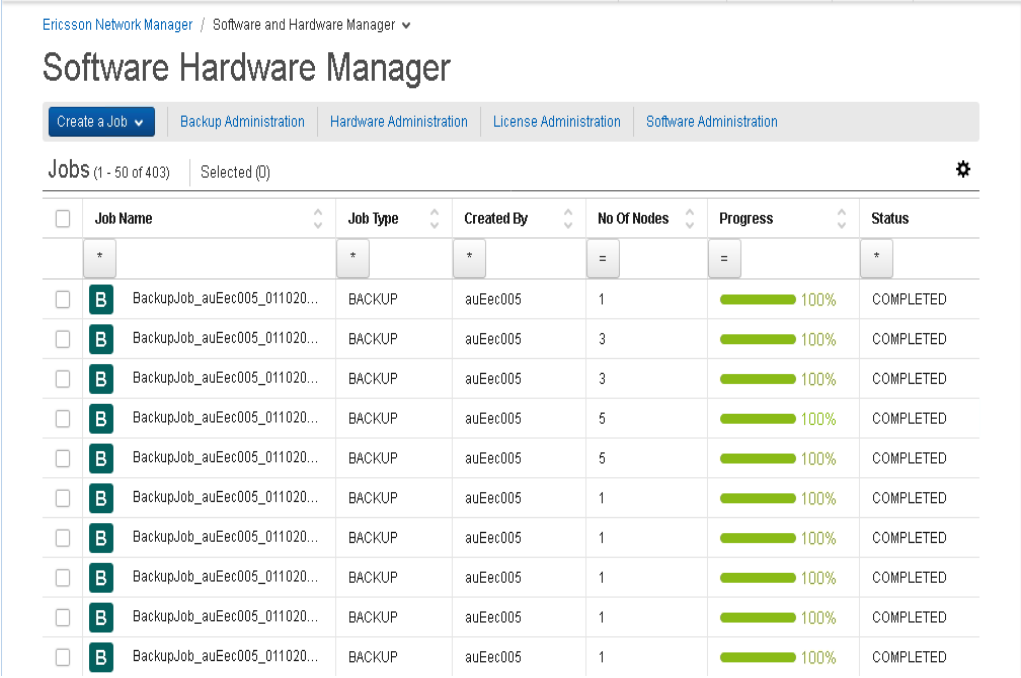
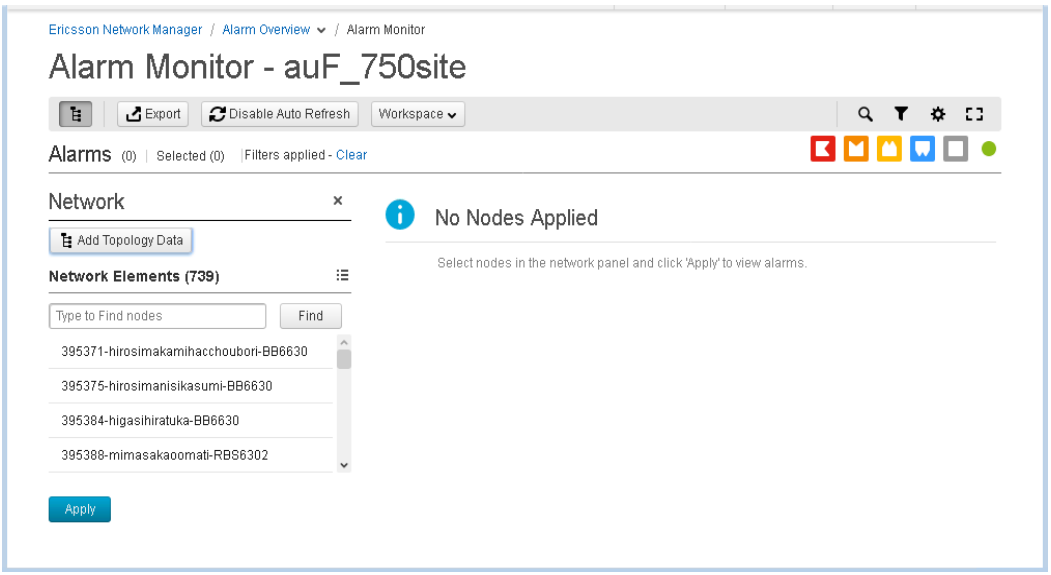


Fig (19) Software and Hardware Management window

3. Alarm Monitoring:

All the FM use cases will be mapped into ENM that includes:

- Alarm routing
- Historical alarm view (Alarm log browser)
- New CLI to view alarms
- Alarm filtering based on severity like critical, major, minor.



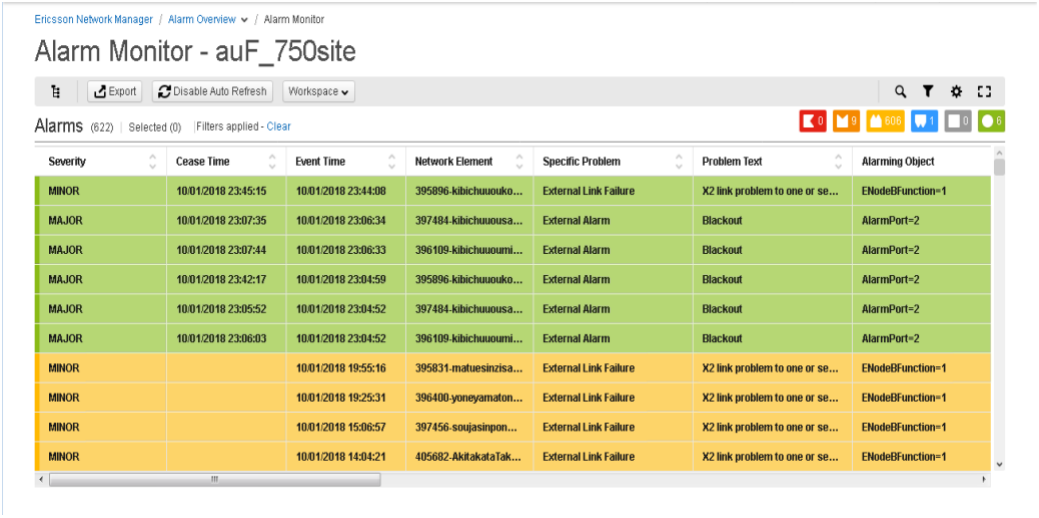


Fig (21) Alarm monitoring window

In fig 1.8, the severity of the alarms is mentioned and these severities have respective color codes like green depicting major alarms, orange depicting minor alarms and red depicting critical alarms. Based on the severity, the RAN engineers should prioritize the troubleshooting of these alarms. In Ericsson, the critical alarms should be resolved within 2-3 days, major alarms should be resolved in 5-6 days and minor alarms should be resolved in 10-15 days.

1.11 Competition in market:

Sharing of telecom infrastructure among telecom service providers is becoming requirement in the telecom industry where competitors are becoming partners in order to lower their increasing investments.

The degree and method of investing can vary in different countries depending on regulatory and competitive climate.

Radio Network Domain	Core Network Domain	Microwave / Optical Transport Network	OSS and BSS	IP Based Transport Network
• Ericsson	• Cisco	• Huawei	• AMDOCS	• Cisco
• Nokia (ALU)	• Juniper	• NEC	• Ericsson	• Huawei
• Huawei	• Ericsson	• Ciena	• Redknee	• Juniper
• ZTE	• Huawei	• Ericsson	• Huawei	• ZTE
• Samsung	• Nokia	• ZTE	• HP	
• Airspan	• ZTE	• ALU (Nokia)	• IBM	

Fig (22) Telecom vendors in market

Product Portfolio

Cellular Network	Fixed Broadband Network	Optical Network Solution	IP Telephony Services
• Ericsson	• Huawei	• Huawei	• Cisco
• Huawei	• ZTE	• ALU (Nokia)	• Avaya
• Nokia (ALU)	• Cisco	• Ciena	
• ZTE		• Ericsson	
• Samsung		• ZTE	
		• Tejas	

Fig (23) Product portfolio

1.12 Motivation:

- To understand the process of managed services
- To handle Ticket acceptance/Update guideline and clarity on ticket flow between different teams like NOC, Planning team, MSIP, another domain, Customer and 3rd Party.
- RAN Basic Parameter Level Understanding
- Project wise understanding and RAN Fundamentals
- RAN Troubleshooting and Configuration
- Basic Cross domain training and overview on Internet Protocol (IP), Circuit switched (CS) and Packet switched (PS) core networks

1.13 Objective:

To automate alarms of RAN nodes to cut down manual work and improve the network performance. The aim is as follows:

I. Deploying two operations, pre health check and post health check over terminals and analyzing node network performance (successfully obtained).
II. Comparing the difference between pre and post health check of alarms (successfully obtained).

1.14 Problem Statement:

The RAN and OSS department observes all the incidents/ alarms to optimize the radio network performance. Apart from this, one of the main responsibilities of this domain includes supervision of KPIs (Key Performance Indicator) to provide better service to the subscriber. KPIs are parameters established by the customer to monitor the performance and even a minor drop in them can lead to loss of business.

The following are the few KPIs -

- Accessibility KPI: - used to measure services requested by users.
- Availability KPI: - used to measure the availability of a network suitable and ready for the user.
- Integrity KPI: - used to measure the character of networks for example the throughput.

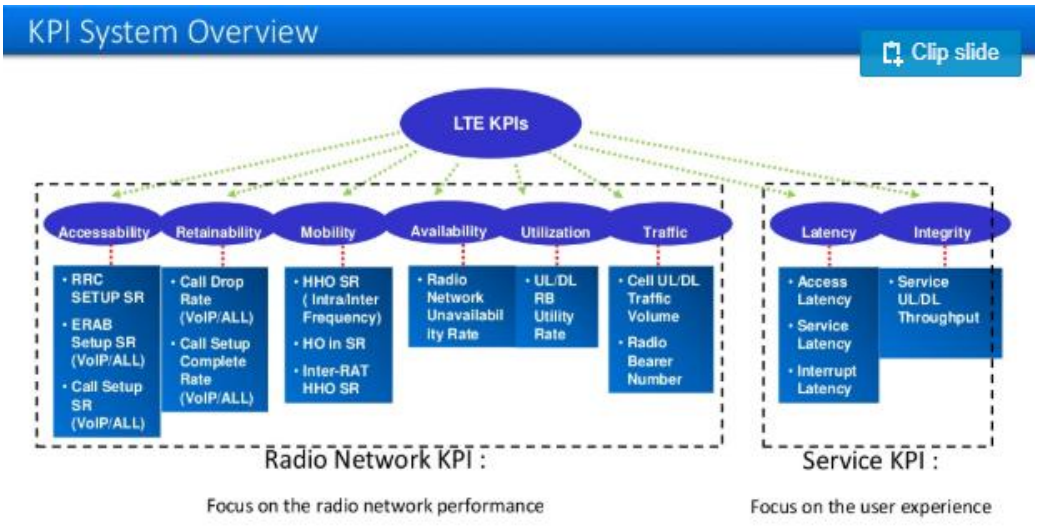


Fig (1.9) KPI Overview

Mobility KPI: - used to measure the performance of a network that can handle movement of the users and still retain the service.

- Retain ability KPI: - used to measure network capability to retain services requested by a user for a desired duration, once the user is connected to the services.

Based on the above criteria, Quality of Service (QoS) can be determined. Alarms are prioritized based on their severity into critical, major and minor alarms. Working at the 2nd level assurance, the responsibilities include assigning tickets for every alarm and troubleshooting them accordingly.

Chapter 2

Literature Review

In a research paper by Racine, Jeffrey., "The Cygwin tools: a GNU toolkit for Windows." the author discuss about how this toolkit can make life easier for applied researchers who find themselves working within the confines of a Windows-based environment [4]. Here in Ericsson we use this Cygwin application to allow programs of Unix-like systems to be recompiled and run natively on Windows with minimal source code modifications by providing them with the same underlying POSIX API they would expect in those systems

On Studying the Research Paper by Valins D, Ruth T, Cochran P, "System and method for generating communication network performance alarms." There is knowledge acquired on Statistical processing of event outcomes, such as call attempts (call setup success rate, PS drop rate) or handoff attempts (CS fallback, Inter RAT) allows reliable generation of performance alarms within a communication network without requiring analysis of historic performance [5]. These performance drop could be due to the interferences or traffic, so these tickets are processed by passing it to optimization team.

In a guide by Finn Magnusson, David Smith, "Moshell 8.0s User Guide", the author discusses the functionality included in MO shell, command line syntax, and MO structure.

The MO structure is divided into two parts

1. Structure: The way that something is built, arrange or organized
2. Managed Object (MO): A managed object is a logical representation of hardware units and software at the base transceiver station [6].

Managed Object Model (MOM) is a structured collection of configuration information that defines the Operations and Maintenance (O&M) capability on an ME. The MOM is defined as a set of classes, containing attributes representing

the configuration, and actions representing the operations that can be invoked by the user.

Here ME is Managed Element on which actions are being performed.

Call flow diagram:

Whenever we make a call, if we have 4G sim, we generally get shifted to 3G/2G calls. Circuit switch fallback(CSFB) – When a call is made we shift from LTE network to legacy network. Soft and hard handovers take place which help us to shift to other without disconnecting the call, hence for smooth call handling we require switching.

- We have channels associated with the operators.
- BCCH
- FCCH
- SDCCH

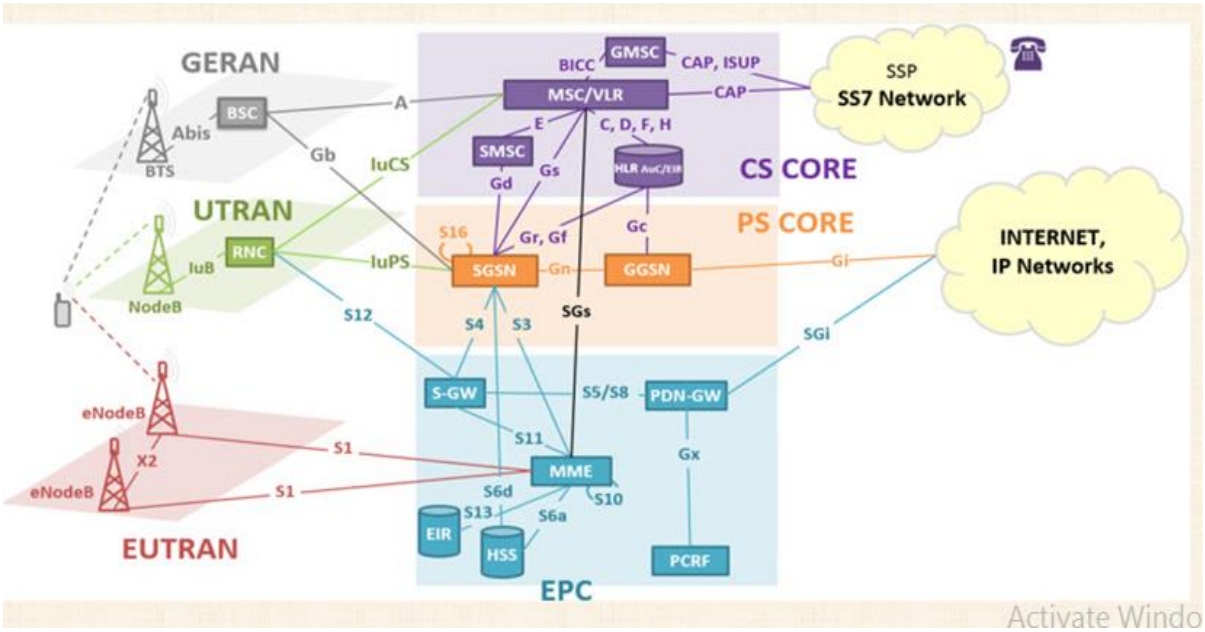
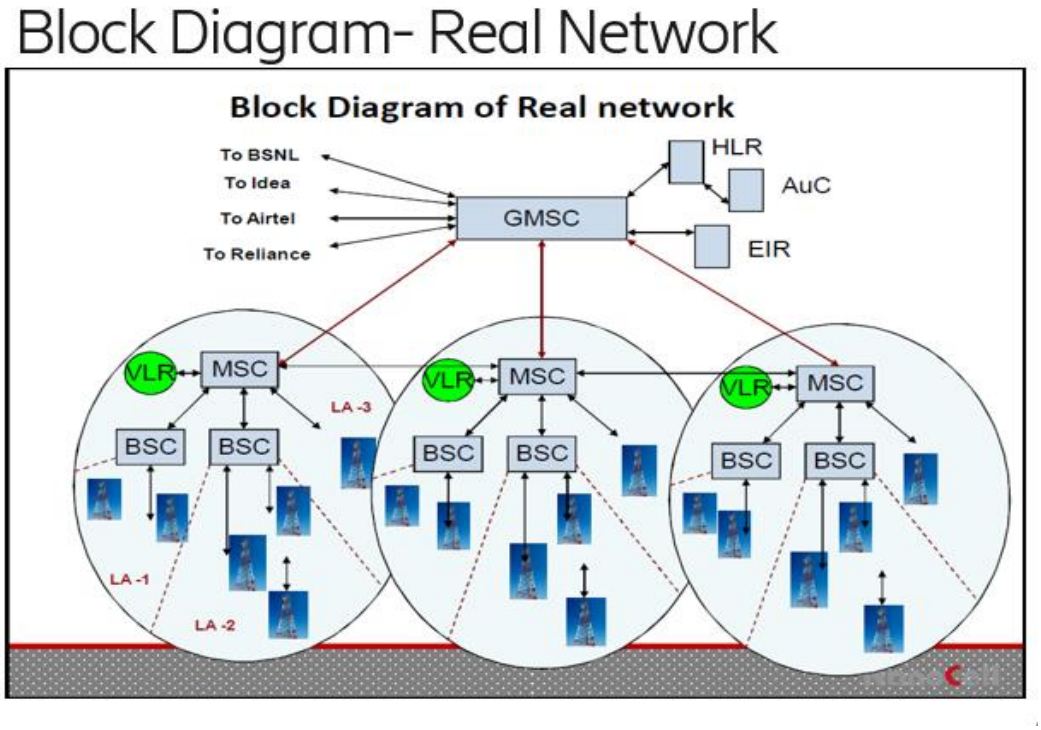


Fig (24) Call flow



Fig(25) Block diagram of a network

One state is considered as one local network. Since a state has number of cities and towns hence we need a fragmented network architecture. Subdivided into regions, each region will have a MSC and many BSC's under that MSC. This is how whole state works. Coverage depends upon the position of antenna, area and cells. The block diagram represents how network is segregated.

Chapter 3

System Development

3.1 Methodology

Day to Day Alarm troubleshooting:

Below are a few of the most common alarms arising at BSC/RNC/node B/enode B and commands for troubleshooting them.

Alarm	Description
PLMN Service Unavailable	The alarm is raised if at least one MO instance of termpoint to mme is in administrative State UNLOCKED, but none of the MO instances of termpoint to mme is in operational State ENABLED
Link Failure	The Link Failure alarm indicates communication link problems for a unit integrated with the Common Public Radio Interface (CPRI) cable.
HW Fault	Hardware Fault in AntennaNearUnit/RRU/Baseband Unit
Service Unavailable	This alarm occurs when a cell is disabled due to faults in underlying resources. The cell is disabled and carries no traffic.
RF Reflected Power High	The measured RF reflected power in the radio unit exceeds a predefined threshold, due to problems in the antenna cable or in the RF connector.

Service Degraded	This alarm occurs when a cell is enabled but degraded due to faults in underlying resources. The cell carries traffic but with reduced capacity.

SFP Not Present	SFP Not Present alarm indicates communication link problems for a unit integrated with the Common Public Radio Interface (CPRI) cable.
Resource Activation Timeout	The Resource Activation Timeout alarm is raised when activation of resources hangs or when the cell is activated and the resource allocation for the cell fails. This is caused by a missing signal from the requested resource.
External Link Failure	The External Link Failure alarm is raised when the X2 link to at least one neighboring eNodeB is down after four reset up attempts. The time between each reset up attempt is controlled by the x2RetryTimer.
VSWR Over Threshold	The alarm is raised when the DC resistance on the branch dramatically increases or decreases resulting from either short circuit problems.
Sync Frequency Reference Not Reliable	The alarm is issued if a "Reference Not Reliabil ity" condition on a supervised packet-based synchronization reference is detected due to high packet drop.

Sync Frequency PDV Problem	The alarm is raised if a high Packet Delay Variation (PDV) condition on an NTP Synchronization server is present for more than two hours.

Table 1: Common alarms in LTE network

Troubleshooting commands:

Commands	Description
Alt	To check alarm
Lga	alarm history for the site
lga 2h	To Check alarm of last 2 hours. Syntax is "**L**o**g** of **A**larms for last **2** **h**ours"
lgay 1d	To check alarms with downtime. 1d is for last one day
Lgg	Board Restart log
Invxg	To get cabinet information with Baseband & RRU's graphical connection.
st fdd|cell|sect|mme|plug|rru	To check operational status of LTE cells
st rilink	To check CPRI connectivity between Baseband & RRU

Get Ntp=1, NtpFrequencySync	To check NTP Sync status
Lgd	UpTime of node/Downtime status
lh ru hwlog read	To check hardware logs of RRU
bl cellfdd	Block sectors
deb cellfdd	De/UnBlock sectors
acc FieldReplaceableUnit=1 restartUnit	To restart Baseband Unit
acc FieldReplaceableUnit =RRU-4 restartunit	To restart particular RRU
ue print -admitted	How many users are online i.e. active users
st termpointtomme	To check S1AP status

st TermPointToENB	To check X2 Link status

Table 2: Common commands for troubleshooting

Health Check:

Health check can help us get the status of Network Elements.
The following information can be shown:

- RF configuration
- Restart information
- Alarm information
- Cell availability
- Hardware status and information

Tools used for Health Check:

We check alarms via alarm check viewer and then categorize them as minor, major or critical.
Days taken to solve alarms-
Critical(1 or 2)
Major(2 or 3)
Minor(2 or 3)

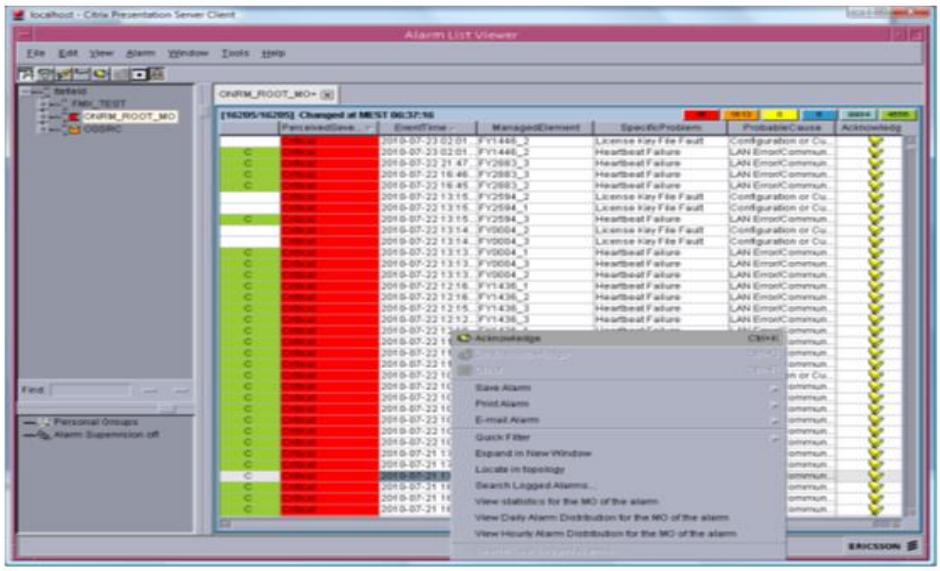


Fig (26) Alarm list viewer

- **Health Check of a node (RNC, node B, e node B):**

  - Current alarm and logs
  - Hardware and Software checks
  - Traffic check
  - Interface status of both IuCS, IuPS
  - ♦ IuCS is the interface in UMTS links the RNC with a 3G MSC (Mobile Switching Centre)
  - ♦ IuPS is the interface which works between the UMTS RNC and the SGSN (Serving GPRS Support Node) supporting services such as multimedia and global roaming to mobile users.
  - KPI Check – cell, traffic (CS and PS), RRC (Radio Resource Control)

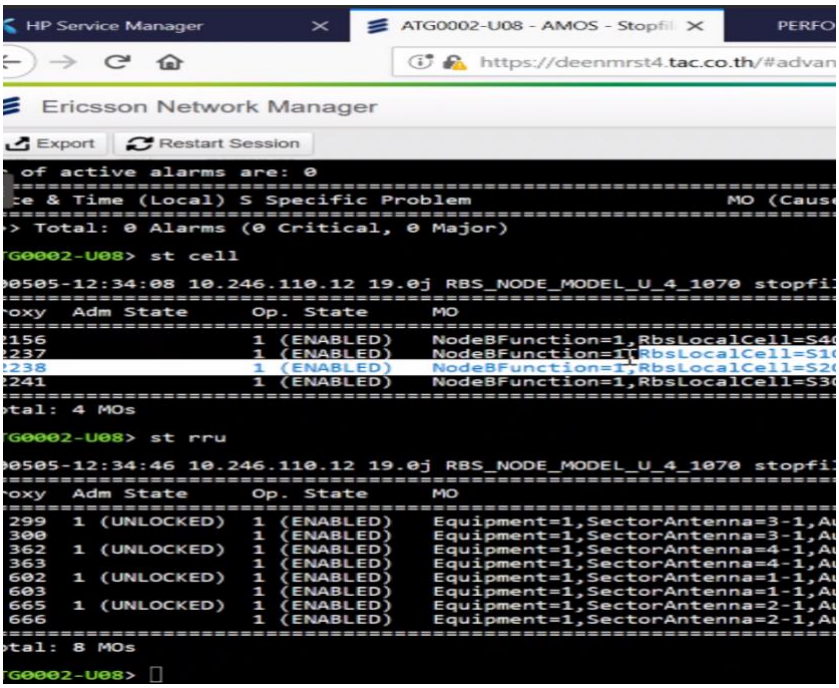
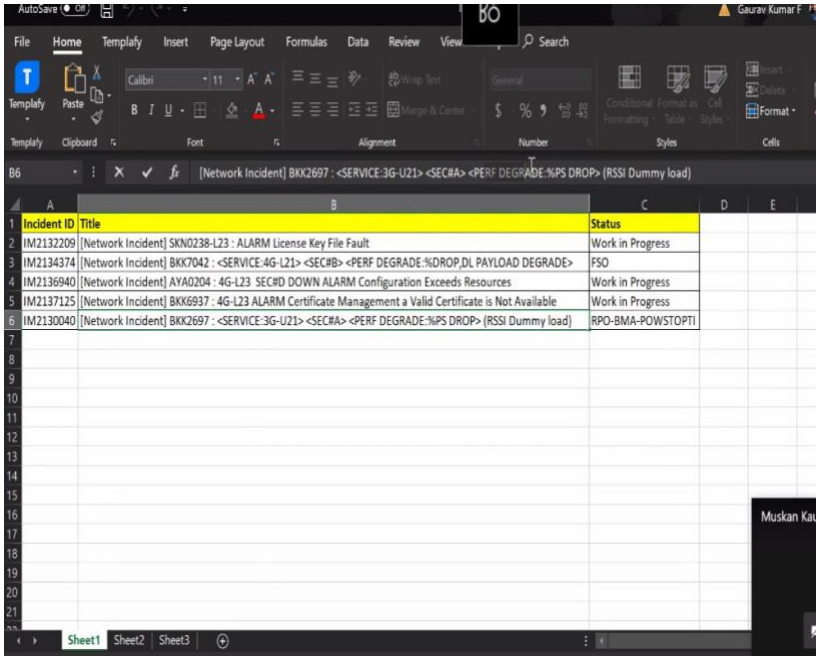


Fig (27) Health check

Input data:

The data is taken from thousands of alarms.



Incident ID	Title	Status
IM2132209	[Network Incident] SKN0238-L23 : ALARM License Key File Fault	Work in Progress
IM2134374	[Network Incident] BKK7042 : <SERVICE:4G-L21> <SEC#B> <PERF DEGRADE:%DROP,DL PAYLOAD DEGRADE>	FSO
IM2136940	[Network Incident] AYA0204 : 4G-L23 SEC#D DOWN ALARM Configuration Exceeds Resources	Work in Progress
IM2137125	[Network Incident] BKK6937 : 4G-L23 ALARM Certificate Management a Valid Certificate is Not Available	Work in Progress
IM2130040	[Network Incident] BKK2697 : <SERVICE:3G-U21> <SEC#A> <PERF DEGRADE:%PS DROP> (RSSI Dummy load)	RPO-BMA-POWSTOPTI

Fig (28) Input data

```
HLRE03> alt

200331-16:43:06 10.16.27.164 19.0c RNC_NODE_MODEL_U_7_1712 stopfile=/tmp/24392

Connecting to 10.16.27.164:56834 (CorbaSecurity=OFF, corba_class=2, java=1.7.0_141, jacoms=R101E06, jacorb=R100A02)
Trying file=/var/opt/ericsson/amos/moshell_logfiles/besanneg/logs_moshell/tempfiles/20200331-162919_24348/ior24348
Resolving the alarm service in OMS...
Simple Alarm Client initialized...
Starting to retrieve active alarms
Nr of active alarms are: 24
================================================================================================================================
Date & Time (Local) S Specific Problem                  MO (Cause/AdditionalInfo)
================================================================================================================================
2019-07-02 00:05:23 M UtranCell_ServiceUnavailable      UtranCell=U149004A20M (unavailable)
2019-07-02 00:05:23 M UtranCell_ServiceUnavailable      UtranCell=U149004A30M (unavailable)
2019-07-02 00:05:23 M UtranCell_ServiceUnavailable      UtranCell=U149004A10M (unavailable)
2019-08-02 14:19:52 M UtranCell_ServiceUnavailable      UtranCell=U149600A20M (unavailable)
2019-08-02 14:19:52 M UtranCell_ServiceUnavailable      UtranCell=U149600A30M (unavailable)
2019-08-02 14:19:52 M UtranCell_ServiceUnavailable      UtranCell=U149600A10M (unavailable)
```

Fig (29) Output of current alarm

- **Pre-activities and Pre-requisites:**

  - The Node should be in a healthy condition as per standards.
  - Activity must be performed during Low Traffic Hours.
  - A fresh backup must be available on External Media.
  - All involved RNCs and RBSs are verified working normally
  - The Switch must be fault free for at least 24 Hours

Pre health check operation:

In this operation, performance of multiple sites are checked through Mo (Managed Object) batch file. Initially single site is checked, and alarms are list through alt command. Then further Mo batch file is prepared through cell scripting on ENM server to check alarms of multiple sites as Mo shell cannot work on multiple sites. Command saved list is performed on batch file of sites on Perl batch scripting. Alarms of multiple sites are checked. Results will be stored automatically in pretext file.

• Perform and save health check for all interconnected network elements – Health Check on all concerned RNCs and save for post implementation comparison using the following commands:

• AMOS command:

• > cvls

• > strt

• > alt

• > bo

• > stip

• >dcgmk

• Check and save the current KPI performance stats in the RNC over a minimum of two 15 min ROPs:AMOS

• command

:>pmr -m

• 1)RNC Node Traffic Performance

3) RNC Node Traffic Performance, ROP by ROP

4) RNC Module Traffic Performance •

5) RNC Subrack Traffic Performance •

6)RNC UtranCell RRC Performance •

7)RNC UtranCell Speech Performance •

8)RNC UtranCell PS Data Performance •

9)RNC UtranCell HSPA Performance

Post health check operation:

After a small timespan operation on alarm list file will be performed. Results of this operation will be stored in post file automatically.

Comparison between pre and post file will be done through C programming language over Perl scripting.

Post-Check of the System:

• Perform and save health check for all interconnected network elements – Health Check on all concerned RNCs and compare with pre check commands output. Following commands:

• AMOS command:

• > cvls

• > strt

• > alt

• > lgar

• > st pp

• > bo

• > stip

• >dcgmk •

1)RNC Node Traffic Performance

3) RNC Node Traffic Performance, ROP by ROP

4) RNC Module Traffic Performance

5) RNC Subrack Traffic Performance

6)RNC UtranCell RRC Performance

7)RNC UtranCell Speech Performance

8)RNC UtranCell PS Data Performance

9)RNC UtranCell HSPA Performance

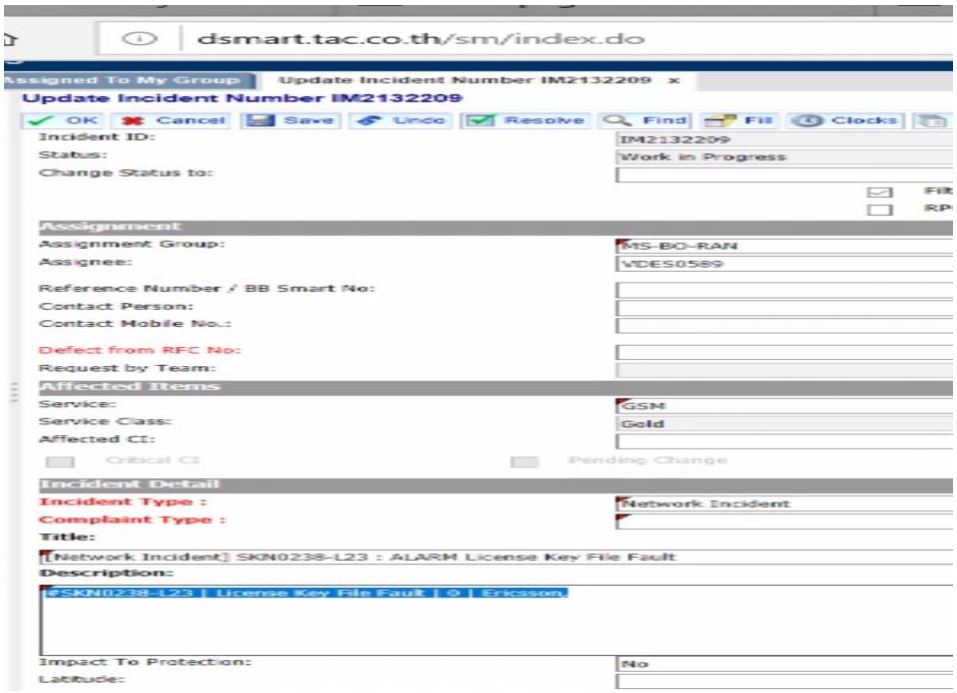
10)RNC UtranCell IRAT Performance

11)RNC UtranCell Uplink RTWP / RSSI

12) RNC Utrancell Soft HO Performance also consider •

13) RNC Worst 20 Utrancells for Soft HO Failure Contribution

Incident check: Each project has its one ways of working , incidents are solved by HP manager. Each morning a check for incidents is done to esove these tickets. A five step procedure is carried out to resolve them.



Fig(30) Incident check

➢ **Flowchart:**

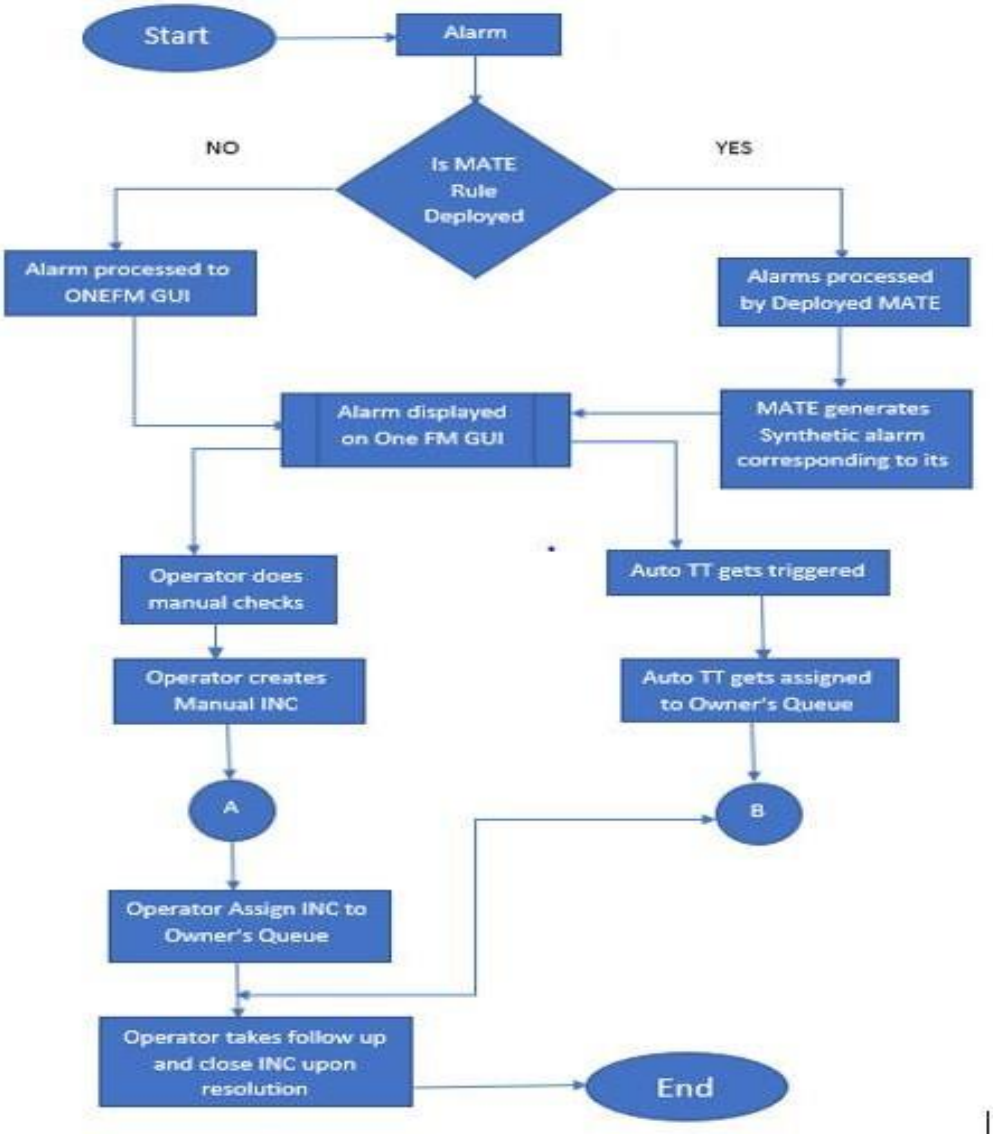


Fig (31) Flowchart of alarm management

➢ Algorithm:

1) Pre health check operation: command list will be performed on Mo batch file of multiple nodes.

Command List:

i. lt all: to load MO (Managed Object) in RNC/eNB/NB etc.

ii. alt: Print the list of active alarms

iii. st EUtrancell: status of cell

iv. invl: to check feature and license status

v. cvls: Check the CVs (Configuration Versions) on node

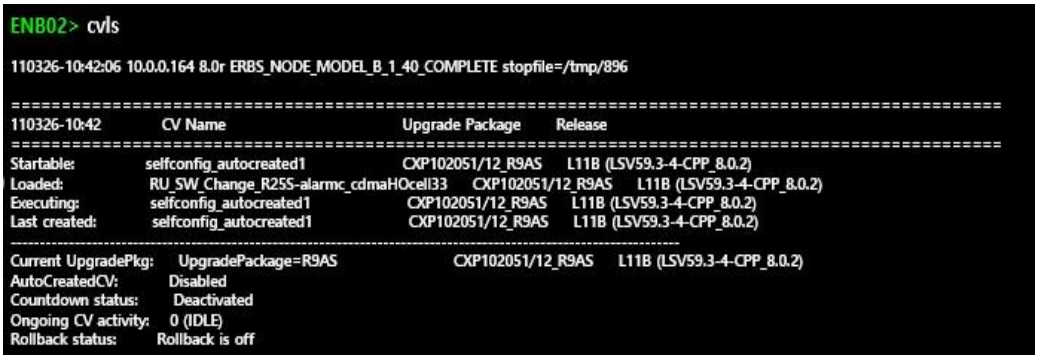


Fig (3.3) Output of cvls command

It has all Parameter and Version information for rollback to the previous status promptly in case of failure to reduce no service time. (Maximum number of CVs stored in each station is 50.). The list of CV types follows:

- Manual rollback point (Made by user)
- Installation rollback point (Automatically created during upgrade)
- System rollback point (Automatically created by system)

vi. cat: to read the file

vii. ue print -admitted: to check how many cells are in operation.

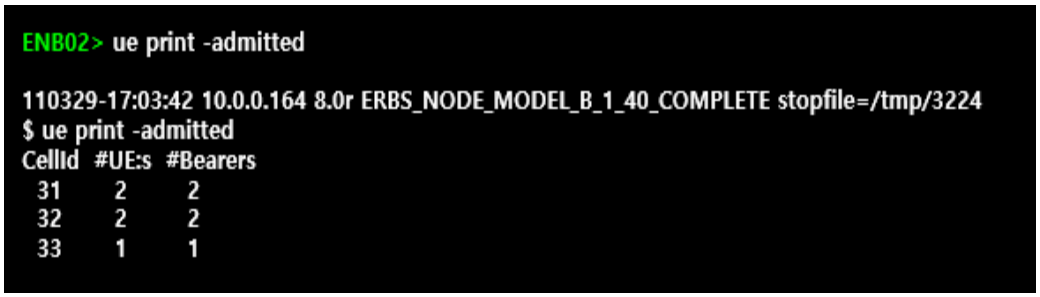


Fig (3.4) Output of use print admitted command

viii. vols: display disk usage and checks drive status in RNC

ix. Ft ree: connected radio status.

2) After a timespan health check command list will be performed on same Mo batch file

3) This post operation results will be stored in post_file_dir.

4) Comparison of both files will be done with Perl scripting.

   I. If else will be used for comparison

   II. Print command is used for printing results

   III. All the results are stored in files

Chapter 5

Performance Analysis

The health check of a node is performed to look for any critical alarms or to make any changes in the network. Earlier it was done as one node at a time and hence was time consuming. Now all the commands run on multiple nodes at the same time.

Consider a case when a pre health check is done on 100 sites. Each site would take 1 minute which means a pre health check on all the sites would take about 100 minutes. Now let's assume a network change is performed that takes about 30 minutes. After the change is done, the sites has to be checked if there is a new alarm and also check if the existing alarms are resolved. So now at the 100 sites we are required to do a post health check (one site at a time). This would consume a lot of time. Now imagine if there are 1000 such sites (it is a real scenario). This would take up a lot of time and manual effort to check those alarms and troubleshoot them.

With scripting in Perl, the results of a pre health check are stored in a server. After the required updates and network changes are done, the post check is performed and the results are stored in another server. Now the system looks at the pre and post results and checks for deviations. These deviations are then displayed and now the engineers know what alarms to work on without manually checking every node.

Screenshots taken:

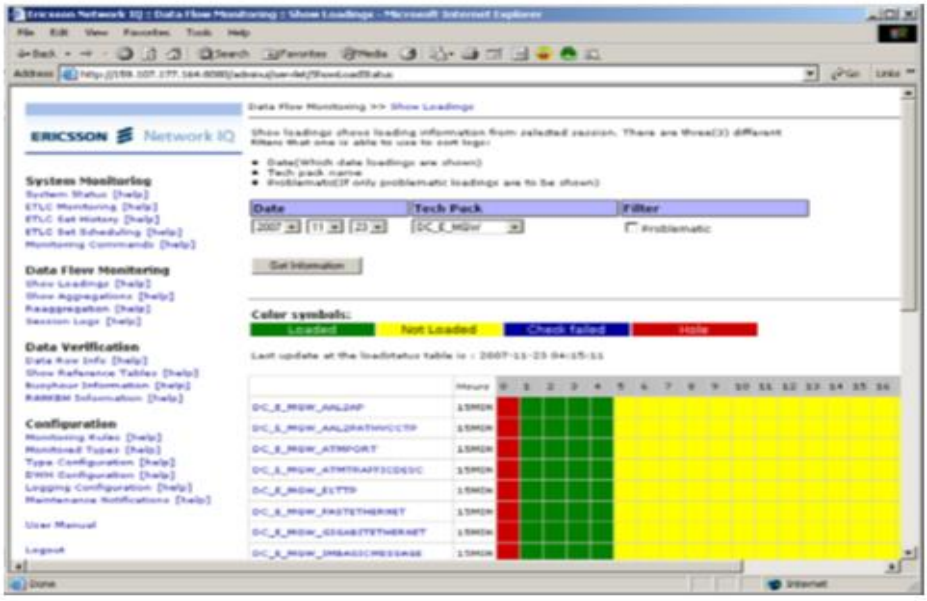


Fig (32) Health check performance

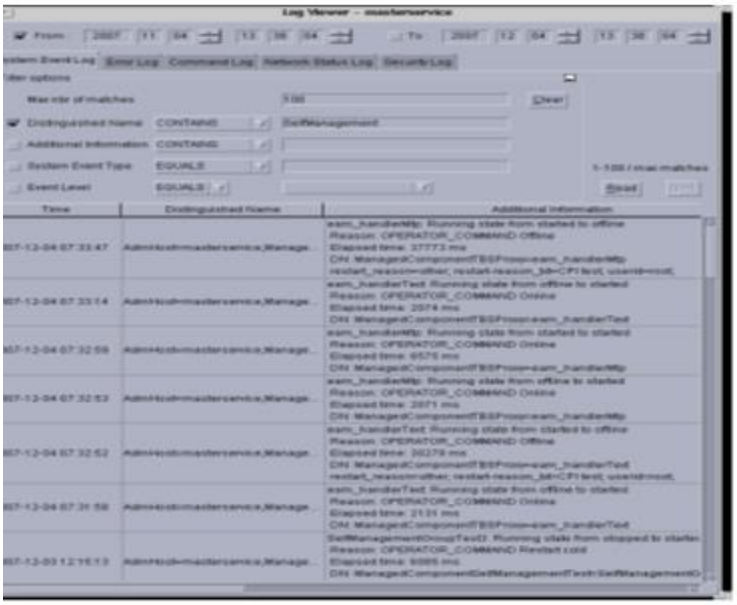


Fig (33) log viewer

4.1. Results:

```
[user@scp-1-amos(server) folder]$ ./LTE_automation_script Nodelist. txt

Running mobatch on 160 nodes...



Total mobatch duration: 6m31s
MOBatch log directory is: /server/log/amos/moshell_logfiles/user/logs_mobatch/date/nodelist/23-32

Thre are 0 nodes with no contact:

There are 83 alarms:
Major   minor   warning
|       |       |

               ABCD01 w Enclosure Product Data Mismatch Cabinet=1 (configuration_or_customizing_error)
       ABCD02 m Password File Fault Security=1 (configuration_or_customizing_error)
       ABCD02 m No Connection AntennaUnitGroup=BQAY_0,AntennaNearUnit=RET-3 (Timeout: Failed to get anuConnectIndication)
       ABCD02 m No Connection AntennaUnitGroup=BQAY_0,AntennaNearUnit=RET-4 (Timeout: Failed to get anuConnectIndication)
       ABCD02 m No Connection AntennaUnitGroup=BQAY_0,AntennaNearUnit=TMA-700-DUMMY2 (Timeout: Failed to get anuConnectIndication)
       ABCD02 m No Connection AntennaUnitGroup=BQAY_0,AntennaNearUnit=TMA-BQAY-700-2 (Timeout: Failed to get anuConnectIndication)
       ABCD03 m Password File Fault Security=1 (configuration_or_customizing_error)
               ABCD04w Enclosure Product Data Mismatch Cabinet=1 (configuration_or_customizing_error)
       ABCD05 m External Link Failure ENodeBFunction=1 (X2 link problem to one or several neighbouring eNodeBs. PLMN ID-eNB ID 1 : 5051-530296)
```

Fig (34) Pre health check performance

```
                       ABCD07 w Enclosure Product Data Mismatch Cabinet=1 (configuration_or_customizing_error)
                       ABCD08 w Enclosure Product Data Mismatch Cabinet=1 (configuration_or_customizing_error)
       )CD09 M Loss of Mains HwUnit=PSU-1 (Other nodes affected, Logical Name: 330001859)
                       ULCN15_ULVERSTONE_CENTRAL_530197 w PSU Output Power Failure HwUnit=PSU-1 (Other nodes affected, Logical Name: 330001859)
              ABCD09 m HW Partial Fault RbsSubrack=1,RbsSlot=2,AuxPlugInUnit=RU-1-2,DeviceGroup=ru (Not functional carrier HW resources [ DL/A ])
              ABCD09 m Service Degraded EUtranCellFDD=ULVNFM1 (performance_degraded)
              ABCD09 m Service Degraded NbIotCell=ULVNFI1 (performance_degraded)
                       ABCD09 w Enclosure Product Data Mismatch Cabinet=1 (Other nodes affected, Logical Name: TAS_ULVN25_ULVERSTONE_531798)
              ABCD10 m Password File Fault Security=1 (configuration_or_customizing_error)
       )CD11 M Emergency Unlock of Software Licensing Licensing=1 (Emergency Unlock has been activated and the alarm will remain till a new Emergency r
       set key is installed)
       )CD12 M Enclosure Door Open Cabinet=1 (enclosure_door_open)
                       ABCD13 w Enclosure Product Data Mismatch Cabinet=1 (configuration_or_customizing_error)

       )ere are 1 disabled cells:
       )CD13 1 (UNLOCKED) 0 (DISABLED) ENodeBFunction=1,EUtranCellFDD=SQEGEU0

       )ne
       )ser@scp-1-amos(server) folder]$
       )ser@scp-1-amos(server) folder]$
       )ser@scp-1-amos(server) folder]$
```

Fig (35) Results of pre health check

```
[user@scp-1-amos(server) folder]$ ./LTE_automation_script Nodelist. txt  /server/log/amos/moshell_logfiles/user/logs_mobatch/date/nodelist/23-32xt/23-32
```

```
Running mobatch on 160 nodes...


Total mobatch duration: 10m24s
MOBatch log direcotry is:
/server/log/amos/moshell_logfiles/user/logs_mobatch/date//nodelist/01-05
Comparing results with:
/server/log/amos/moshell_logfiles/user/logs_mobatch/date/nodelist/23-32

There are 0 nodes that have lost contact:

You have 0 disabled cells to deal with:

You have 4 alarms to deal with:
Major   minor   warning
|       |       |

        ABCD13 m No Connection AntennaUnitGroup=1,AntennaNearUnit=TMA-700-DUMMY (Timeout: Failed to get anuConnectIndication)
        AVCD14 m No Connection AntennaUnitGroup=3,AntennaNearUnit=RET-1 (Timeout: Failed to get anuConnectIndication)
        ABCD15 m No Connection AntennaUnitGroup=1,AntennaNearUnit=RET-2 (Timeout: Failed to get anuConnectIndication)
        ABCD16 m No Connection AntennaUnitGroup=1,AntennaNearUnit=RET-2 (Timeout: Failed to get anuConnectIndication)

Here are new crashes since pre-check:
ABCD25.log:2020-02-09 13:54:34 PMD   0001 DUS4101     Program restart Core=0 Proc=bbmcBbOmMeThread (bpai_basic_if.c:178) Block=CXC1725398%27_R81F08 (
bbomLm) Err=0xF0F0F0F2 (eri_api) PMD=20200209_135507_c_pmd_2_000100_0x80000001.pmd PC=00861CC0 Info=Recovery action, faultId: 0x301 (SwError), faultDescription: ULMA[0102
4]:<!UPCUL.3757!> ulmacce_calendarmgrfo.c:395: DBC: success
ABCD26.log:2020-02-09 13:54:49 PMD   0001 DUS4101     Program restart Core=0 Proc=bbmcBbOmMeThread (bpai_basic_if.c:178) Block=CXC1725398%27_R81F0
8 (bbomLm) Err=0xF0F0F0F2 (eri_api) PMD=20200209_135522_c_pmd_7_000100_0x80000006.pmd PC=00861CC0 Info=Recovery action, faultId: 0x301 (SwError), faultDescription: ULMA[0
1024]:<!UPCUL.3757!> ulmacce_calendarmgrfo.c:395: DBC: success
ABCD30.log:2020-02-09 13:32:06 PMD   0001 DUS4101     Program restart Core=0 Proc=cellHandler_main_thread Block=CXC1732823%27_R81F08 (lrhLm)
 Err=0x00900004 (ose_api) Desc=OSE_EFS_EABORT_CALLED PMD=20200209_133244_c_pmd_9_000100_0x80000003.pmd PC=00861CC0

There are 160 nodes with Software Incorrect:
```

Fig (36) Comparison with post health check

Chapter 5

CONCLUSION

We have evolved from wired to wireless network. A cellular network or mobile network is a radio network distributed over land areas called cells, each served by at least one fixed-location transceiver. In a cellular network, each cell characteristically uses a different set of radio frequencies from all their immediate neighboring cells to avoid any interference.

When joined together these cells tend to provide radio coverage over a wide geographic area. This enables a large number of portable transceivers to communicate with each other and with fixed transceivers and telephones anywhere in the network, via base stations, even if some of the transceivers are moving through more than one cell during transmission.

5.1 Future prospect:

Now as the automation of health check at a node is successfully done. The next aim is to reduce the number of alarms altogether.

Consider a case where a site is down due to power outage. The alarms that might arise are Mains Power Alarm, Battery Alarm, Service Unavailable, Heartbeat Failure and No Connection-RRU. The idea is to apply a logic that combines all these alarms to give us just one alarm. This alarm, obtained by correlating multiple similar alarms and combining them is called a synthetic alarm. This concept will be extremely beneficial during major storms/ cyclones when multiple sites (around 150-200) are affected all at once. This way we will be able to eliminate hundreds of alarms and save a lot of manual effort.

For all these similar alarms (synthetic alarms), only one ticket is generated and

now the Back office engineers have to resolve that one particular ticket. Moreover, 5G will resolve these problems.

5.2 The concept of 5G:

Europe's largest 5G research network, powered by Ericsson 5G products and solutions, has gone live in Aachen Germany.

Includng multiple partners, the 5G Industry Campus Europe aims to now develop and implement applications and solutions for digitized and networked production to benefit 5G production across Europe and beyond.

Various 5G industrial application scenarios be tested during the next three years – from 5G sensor technology for monitoring and controlling highly complex production processes to mobile robotics and logistics and cross-location production chains.

The 5G-Industry Campus Europe is funded by the German Federal Ministry of Transport and Digital Infrastructure (BMVI) - focused on the introduction of the new mobile communications standard in the manufacturing industry.

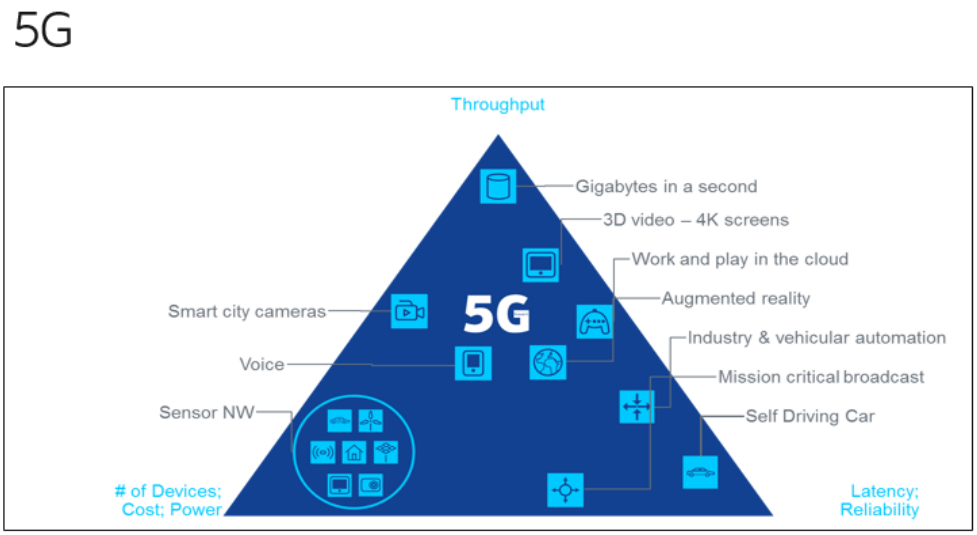


Fig (37) 5g Architecture,./

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