An Experimental Framework for Optimization of 5G Networks

Abstract—**We propose a unified framework for optimization (UFO) of 5G networks.**

Keywords: Root Cause Analysis, self-healing, LTE-A

I. Introduction

In spite of the various improvements in radio network diagnosis procedure is too slow and no longer viable

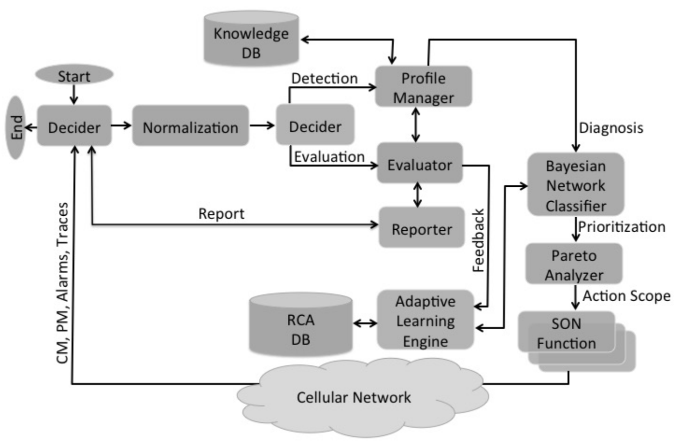

Fig. 1. Manual Root Cause Analysis

The lack of automation and scarcity of studies on automated fault detection and diagnosis applicable to emerging technologies such as LTE-A and 5G were the main motivational factors of this research.

While previous studies have made several contributions to self-healing, we feel that our work will significantly contribute to the field experience and practical solution development knowledge available to the industry and research community on this topic. Specifically, this paper makes the following key contributions:

I. An adaptive root cause analysis diagnosis algorithm based on Bayesian network theory.
II. A fault ranking algorithm based on Pareto principle used to prioritize the fault fixing order after diagnosis according to severity and business policies.
III. A reliable RCA result evaluation method based on Chi-squared hypothesis test.

The rest of the paper is organized as follows: Section II summarizes some common cellular network faults and relevant diagnostic methods investigated. Section **??** describes the proposed automatic detection and diagnosis solution while representative case studies and experimental results are presented in Section **??**. Section **??** summarizes relevant literature. Finally, Section V concludes the paper and gives some details about future plans.

II. Network Optimization

A. Common Cellular Network Faults

One of the main goals of SON is automation. As a part of SON, self-healing aims at automating fault detection and diagnosis. This section summarizes a representative set of typical cellular network faults which are currently detected and diagnosed manually, the section also compares some of the popular diagnostic methods which can be applied when developing automated detection and diagnosis solutions.

III. A Framework for 5G Network Optimization

IV. Current Development

The following KPIs were selected:

- *AvgUserThroughput*: Calculated as an average of user throughput (Tu) on the basis of their SINR through the following equation [4]:

$$T_u = (1 - BLER(SINR)).\frac{D_u}{TTI} \tag{1}$$

TABLE I. Simulation network setup

Parameter	Assumption
Carrier frequency	2000 MHz
Number of eNodeB cell sites	19
Number of cells per eNodeB	3, total (57 cells)
Inter-site distance	0.5Km
Cell layout	Hexagonal grid with wrap-around
Path loss model	L = 128.1 + 37.6 log10 (R),
	R is user distance from BS,in Km
Penetration loss	10 dB
Lognormal shadowing	Log Normal Fading with 10 dB
	standard deviation
UE distribution	Uniform density
Maximum BS TX power	46dBm
Maximum UE TX power	23dBm
Minimum UE TX power	-30dBm
Antenna gain after cable loss	15 dBi
UE Antenna gain	0 dBi
White noise power density	-174 dBm/Hz
BS noise figure	5 dB
UE noise figure	9 dB

where BLER is the block error probability that depends on the SINR of user u, Du is its data block payload in bits, and TTI is the transmission time interval.

A. Experimental scenarios and results

V. Conclusion

In this paper, we introduced a common solution for automated fault detection and diagnosis called ARCA.

The research was motivated by our finding that due to continuous increase in size and complexity, modern cellular networks are more prone to errors than ever before resulting in the current manual detection and diagnosis procedure performed during RCA becoming too slow, expensive and no longer practical.

ARCA uses Naive Bayes probabilistic classifier together with the EM algorithm to offer a simple and adaptive solution for automatic root cause analysis suitable for self-healing emerging cellular networks based on SON such as LTE-A and 5G.

Its main benefits include:

- Continuous and adaptive learning which increases RCA accuracy and expert knowledge reuse and improvement.
- ability to work with missing and uncertain data
- High performance and accuracy with large even with large datasets

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TABLE II. ALGORITHM PARAMETERS

Parameter	Operator Policy A	Operator Policy B	Parameter Description
Scope	57 cells	10 cells	Number of cells in test area
Exclusion scope	[ ]	[ ]	Ids of cells excluded from analysis
Schedule	Start now	Closed loop	Schedule
Action scope name prefix	ARCA_MAN	ARCA_CLOP	RCA output scope name prefix
Cure trigger strategy	Manual	Automatic	Mode of triggering SH SON functions
Data statistical validity	2 weeks	2 weeks	Minimum period of gathering network measurements
KPI summarization	Last hour	Last 15min	Measurement frequency
KPI Thresholds			Expert defined thresholds
RSRP [dBm]	-117	-117	Minimum signal strength required to get LTE service
RSRQ [dB]	-20	-20	Minimum signal quality required to maintain LTE service
SINR [dB]	-10	-20	Required minimum signal to interference and noise ratio
HOSR [%]	95	95	HO threshold
Retainability [%]	98	98	Retainability threshold
AvgCellThroughput [Kbps]	150	150	Retainability threshold
Distance$_{95}$ [%]	95	95	Distance$_{95}$ threshold
Adjust pilot power of neighbor cells	disabled	enabled	Neighbor cell optimization flag
neighbor cell pilot power of neighbor cell: %	-	-9 dB	$neighborCellMaximumPilotPowerAdjustmentRange$
Pilot power step down for neighbor cell dB	-	0,6	Neighbor cell adjustment step
Pilot power step up for neighbor cell dB	-	0,6	Neighbor cell adjustment step

TABLE III. ADAPTIVE ROOT CAUSE ANALYSIS DIAGNOSIS RESULTS

CM		Run 1				Run 2				Run 3			
Cell Id	LTE-1	LTE-2	LTE-3	LTE-4	LTE-5	LTE-6	LTE-7	LTE-8	LTE-9	LTE-10	LTE-11	LTE-12	LTE-13
Cell power	32.0	32.0	33.6	33.6	33.0	31.5	33.0	33.0	-	32.5	32.0	–	–
PM													
wcel.cell-downlink-load	70	70	50	40	50	70	50	10	40	40	70	10	–
wcel.uplink-interference-level	2	2	2	2	2	2	2	2	2	2	2	2	–
wcel.total-number-of-ishos	0	0	0	0	0	0	0	0	0	0	0	0	–
wcel.isho-rscp-ecno-share	0	0	0	0	0	0	0	0	0	0	0	0	–
wcel.cell-edge-ecno	5	5	5	5	5	5	5	5	5	5	5	5	–
wcel.average-active-set-size	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.2	1.7	–
Expert Additional Input	Code												
Code	C3	–	–	–	–	–	–	–	–	–	–	–	–
Diagnosis Code	1	3	–	5	20	20	50	5	20	20	50	5	–
Diagnosis Abbreviation	CH	MN	?	PP	OS	SC	50	5	20	20	50	5	OK