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Smart 4G network:-Implementation of SDR & SON with Automatic EM Radiation control

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Abstract*—With the rapid development of number of mobile technologies and air interfaces including GSM to WCDMA to HSPA to LTE & LTE advance, mobile operators are bound to follow the technology evolution paths. But as technologies evolve, existing hardware has to be replaced or additional components need to be added. SDR provides flexibility to add new functions or evolve new technology without changing existing hardware. It reduces the installation cost and ensures fast deployment of new technologies in existing network. Self organizing network is an approach of self configuration, self optimization, automatic fault detection & self healing of network. It enhance the QoS and can be a cause of energy saving by switching off few or part of network resources as per the observed load. This paper deals with SDR & SON implementation in 4G network to make it more flexible and intelligent from radio point of view. Cell tower radiation is also matter of concern for few researchers and most of the countries have norms related to upper threshold value of power density. Traditional methods of EM radiation control lacks with manual approach of EM radiation measurement & solution implementation. A New method of automatic measurement of EM radiations and radiation control is also proposed here.

***Index Terms*—SDR, SON, LTE Advance, Automatic Radiation control .**

I. INTRODUCTION

LTE advance is worldwide accepted as key technology of 4G and most of the operators are planning to install it in their network. But technologies are changing very rapidly and each operator wants to deploy the future proof technology that can provide compatibility with future systems up to some extent. SDR(Software define radio)[1] defines a telecommunication system where typical hardware components are implemented in software by mean of software components that run on flexible and powerful processing platform, usually Flexible Programmable Gateway Arrays (FPGA), Digital Signal Processing (DSP) chips and microprocessors. This flexibility allows new functions to be implemented without changing any hardware.

Telecom service providers want to provide good quality of services with less human intervention. SON (Self Organizing Network)[4] is an approach of intelligent radio network management which provides automatic configuration and intelligent optimization of network. It can automatically detect the faults & disturbances and can perform self healing of network. With implementation of SON in mobile network, QoS can be predicted at every instant and accordingly it can be improved also. SON also utilizes network resources as per the requirement of present load and rest of the resources can be switched off. This may be a cause of huge energy saving, that reduces the operational expenses and also it is good from environment point of view.

An automatic observation of cell tower radiations at particular point can be done by observing measurement reports transmitted by subscribers. Commutative power density can be estimated by compiling these reports with a consideration of receiver sensitivity of user equipment. Location of subscriber (where power density is to be measured) can be predicated by various methods like angle of arrival (AOA), uplink time of arrival (TOA), Time Differences of Arrival (TDoA), Enhanced Observed Time Difference (E-OTD), Timing advance based methods, tringularisation method, GPS Based method etc. A EM radiation server can utilize these data related to power density and can provide solution for radiation control without degrading the QoS.

II. IMPLEMENTATION OF SDR, SON & AUTOMATIC RADIATION CONTROL MECHANISM IN 4G NETWORK

A. SDR Implementation

SDR implementation presents a new future proof & easily upgradeable concept for mobile operators and allows them to have a simpler, more efficient & adaptive network. Several air interfaces in the same frequency band can be implemented using SDR. It offers upgradeable processing capabilities for future air interfaces. This is especially applicable to LTE, which is expected to require additional processing at the base station due to its low latency, higher bandwidth requirements. The SDR implemented network can easily converted in to LTE or other 4G compatible network just by software up-gradation or by adding a new base band processing card to the existing

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hardware platform. All 4G technologies use Orthogonal Frequency-Division Multiplexing (OFDM). OFDM involves transmission of QPSK, 16-QAM and 64-QAM symbols in parallel.

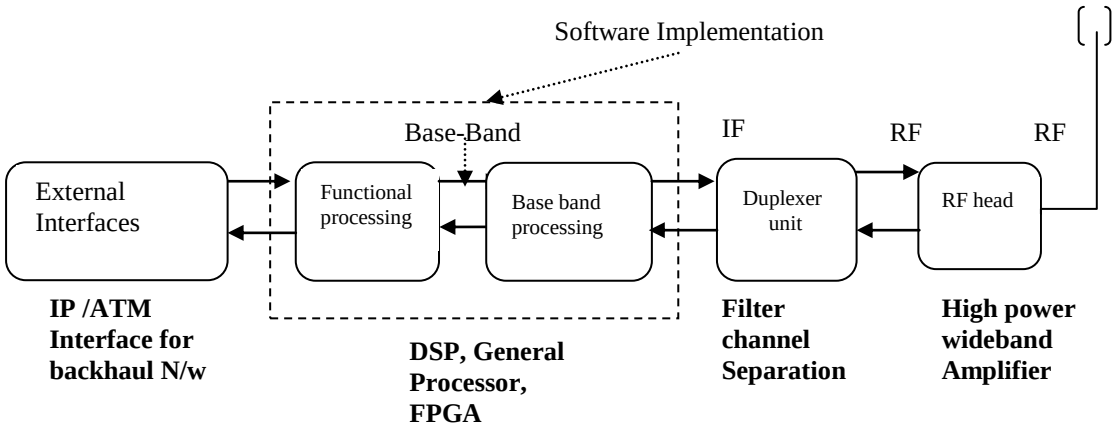

Fig.1 Typical SDR Base Station implementation [1] [2]

Typical SDR base station implementation (e Node-B) is shown in figure.1

As various 4G technologies almost share the same basic OFDM principles, a basic radio unit can be designed. Although parameters, like frame structure, reference signal locations and properties, sub carrier spacing, physical channel definitions and forward error correction schemes will be different for different 4G technology. Functional & base band processing units can be implemented in software through Flexible Programmable Gateway Arrays (FPGA), Digital Signal Processing (DSP) chips or microprocessors. Handover, cell selection and reselection & other base band processing is done by this software implementation. External interfaces are provided for connectivity with backhaul network, element manager & other IP/ATM nodes. Throughput of 4G standards is almost 10 times higher then 3G. In addition, usage of advanced MIMO techniques, cyclic prefix, adaptive modulation & coding, H-ARQ etc might increase required processing power exponentially and required computational load to be several times of Giga Complex Multiply-Accumulate (GCMAC) operations per second. Conventional DSPs cannot provide such processing power. As a result, close algorithmic and implementation challenges must be met when implementing the different 4G technologies. In such scenario, hardwired implementation is not enough and it is important to employ an SDR approach. As various 4G standards continue to evolve, SDR provides future proof benefit to operators by providing software-upgradeable products. Further, programmability allows powerful solutions for dynamic adaptation according to field conditions based on support of different algorithmic approaches as a function of channel conditions.

III. SON FOR RADIO NETWORK MANAGEMENT OF 4G

SON aims to configure and optimize the network automatically, so that the interaction of human can be reduced and the capacity of the network can be increased. The main functionality of SON includes: self-configuration, self-optimization and self healing [6]. Self organizing network (SON) is described as a part of 3GPP LTE [3] and it is a key feature for effective & automatic operation & maintenance (O&M) of 4G networks. It maximizes overall performance of network and reduces the cost of installation & management by simplifying O&M through self configuration, self optimization, self healing etc.

SON offers off loading of e NodeBs[5] and even switched off few or part of network resources on the basic of usages or load at particular time. It reduces the power consumption and result in far lower operational expenditures and produce environmentally friendly approach. It's functionality can be implemented in centralized and distributed manner. Distributed SON offers implementation of SON functionality on e nodes. Critical decisions from time point of view that do not require information from all network elements are taken by distributed SON locally. Centralized SON functionality is implemented over higher management layers. It deals issue related to over all performance of network which requires data from all network elements.

Network manager provide centralized SON functionality in 4G network. It collects data from all over and utilizes it for centralized management of network. It is implemented on management layer of network and provides SON functionality for multi technology, multi vendor solutions. Network manager node communicates with vendor

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specific network element manager (NEM) which collects statistics from e nodeBs. Standard interface among NEM can provide inter vendor communication and increase effectiveness of implementation. Network manager and NEM can be connected with automatic planning tool. When new element is added in the network, it automatically create logical path with planning/ configuration server and download basic configuration files by using NETCOF protocol. Then e nodeB can perform self test and learn about neighbors and other configuration with the help of NEM & network manager.

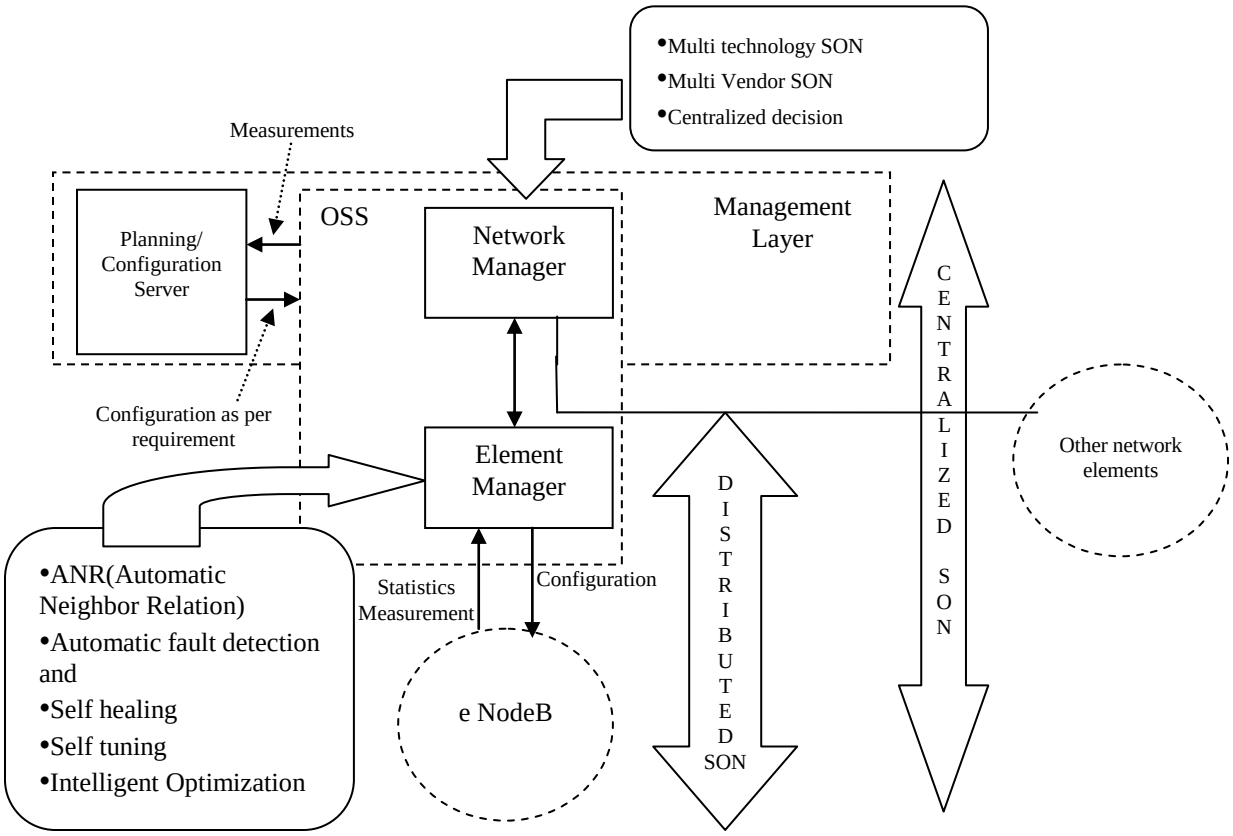

Fig.2 SON Implementation in 4G [4]

SON may be implemented at various levels of network and ambiguous response of NEMs can be obtained .To avoid conflict in network, the NEM should provided maximum harmony.

IV. AUTOMATIC EM RADIATION CONTROL

The effect of cell tower radiation on biological objects is subject of debate and study. Most of the countries have adopted non ionization radiation standards as per the International Commission for Non- ionizing Radiation Protection (ICNIRP) guidelines. Traditional method consists of manual measurement of radiation in near field region of antenna with broadband or frequency selective measurement [7]. Mitigation techniques are applied to control the radiation on the basic of observed radiation level. An interactive method of automatic measurement and control of cell tower radiation is proposed here. For intelligent / automatic measurement of radiation level at particular point, two things should be known i.e. location (point where radiation is to be measured) and commutative power density at that point. Measurement report transmitted by subscriber can be utilized to calculate commutative power density and with the help of various location finding methods, location can be estimated. As shown in figure- , location finder server predicts location of LTE subscriber. It may use various methods/ algorithms like angle of arrival (AOA) ,uplink time of arrival (TOA), time differences of arrival (TDoA), enhanced observed time difference (E-OTD), timing advance based methods, tringularisation method, GPS based method etc to predict the location of subscriber from the measurement reports send by the subscriber.

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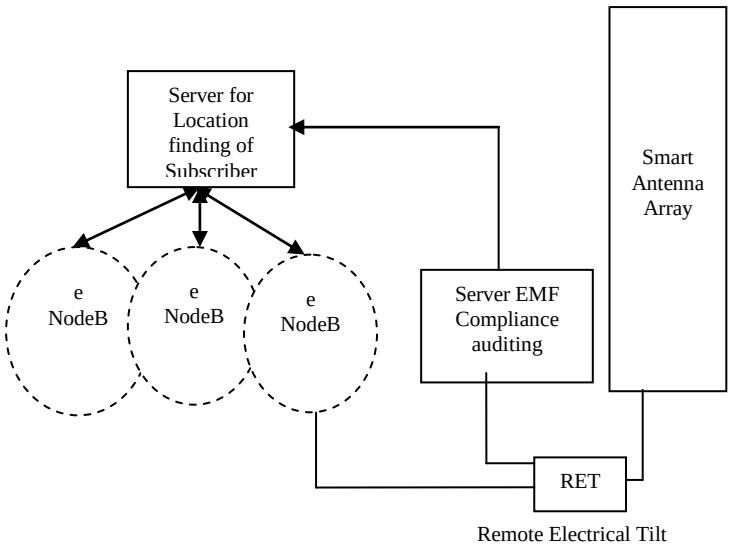

Fig.3 Proposed Intelligent EM Radiation Measurement and Control

EMF compliance auditing server analyzes the measurement reports transmitted by the subscriber from the similar places and consider receiver sensitivity in to account (As system is aware about equipment used by the subscriber on the basic of unique equipment identity transmitted by it) it may estimate commutative value of power density at that point. Here the system utilized smart antenna which can adjust its beam width, side lobe attenuation, vertical radiation pattern (VRP) etc. It is connected with radio unit via remote electrical tilt (RET) unit. After analyzing power density at particular point, EMF server may compare it with maximum allowable power density value and accordingly apply the mitigation techniques by changing transmitted power, tilt, vertical radiation pattern, beam width etc. At the same time network manager & NEM observe any adverse impact on QoS and coordinate with EMF server for optimum performance.

Figure 4 describe the smart 4G network with SON & SDR along with automatic EM radiation control mechanism as discussed in previous sections. It is shown in Appendix.

V. CONCLUSION

With the implementation of SON in centralized and distributed manner, self configured, self monitored, self optimized & self healing network can be realized. Less human intervention & auto power saving feature of SON reduce the operational cost. SDR provides flexibility to existing system that can be upgraded easily without investing too much. As various 4G standards continue to evolve, SDR provides future proof benefit to operators. Intelligent radiation control method may reduce the radiation level without degrading QoS.

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APPENDIX

Fig.4 Implementing SON, SDR & Automatic Radiation Control Mechanism in 4G [1][2][4][6]