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Impact of Spectrum Refarming for 4G Rollout

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Abstract:- Spectrum is an expensive resource and has to be efficiently used for rollout of any technology. Wireless spectrum is the backbone of the digital communication era, and a limited resource. LTE/4G technology has maximum flexibility to run on 25 different frequency bands e.g. 700MHz, 850MHz, 900MHZ, 1800MHz, 2300MHz etc. This feature of LTE/4G enables any telecom operator to use existing spectrum resource of 900 MHz or 1800 MHz through Spectrum Reframing. In addition, lower frequencies such as GSM 900/1800 propagate further and penetrate buildings better than higher frequencies, making them the preferred choice for LTE coverage. This work represents a practical scenario when a telecom operator having 2G spectrums of 6.9 MHz in 1800 MHz band and decides to rollout LTE/4G by extracting 1.4 MHz carrier from the existing spectrum resources. It presents a broad description of the practical settings in which the automatic frequency assignment is used in left out 5.5 MHz of 1800 MHz spectrum using ICDM for BCCH & TCH channels and it will help the operators to understand the importance of efficient use of spectrum.

Keywords: **- GSM, AFP Tool, BCCH & TCH.**

I. INTRODUCTION

Wireless spectrum is the backbone of the digital communication era, and a limited resource. Such a limitation only makes it obligatory that prompt initiatives are taken that would support use of available spectrum in most efficient manner.

Spectrum re-farming can be defined as a combination of present and future administrative, financial and technical measures within the limits of frequency regulation in order to make a specified frequency band available for a different kind of usage or technology. The measures may be implemented in the short, medium or long term. In simple terms, re-farming essentially means shifting operators from one frequency to another within the band or across the band.

Frequency Spectrum

The **radio spectrum** is the part of the electromagnetic spectrum from 3 Hz to 3000 GHz (3 THz). Electromagnetic waves in this frequency range, called radio waves, Spectrum are frequencies used to "make wireless" .The radio waves (aka **frequencies)** have been broken into chunks (aka **bands**).

Cellular Technology is independent of Spectrum bands, There are identified "preferred" bands of spectrum for each technology, and details are as follows:-

- 2G / 3G /4G / Wi-Fi are different methods (technologies) of using spectrum
- 2G runs on 900 MHz band and 1800 MHz band
- 3G runs on 2100 MHz band, 1800 MHz band, 900 MHz band and 850 MHz band
- LTE has maximum flexibility to run on 25 different frequency bands.

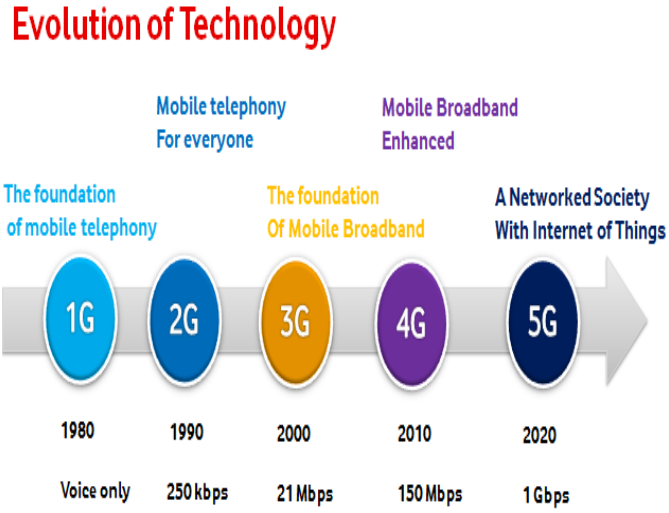

Fig.1

Through the auction process, the operator of a cellular system is given a limited frequency band to use in the area. This spectrum is divided in a number of carriers. A GSM radio network can include hundreds of cells in a city. Thousands of channels should be assigned to these cells. Therefore the carriers can be reused within an area. Any effort to lay down manual frequency plans promulgates inefficiency in the cellular radio systems. Automatic frequency planning is required for automatic generation and optimization of the frequency plan.

II. LITERATURE REVIEW

A lot of work is already in progress to smoothen the automatic frequency planning in GSM network, with minimal interference in a very limited allocated spectrum. Literature survey of the earlier work done on the topic is as follows:

Umar M et.al. presented a novel and ingenious algorithm for automatic generation and optimization of the frequency plan whereby curtailing the intra-system interference levels within the acceptable ranges of the key performance indicators (KPI's) defined for any real time cellular network. The automatic frequency planning and optimization has been done using the concept of Inter-Cell Dependency Matrix (ICDM) which contains cell correlations in terms of the affect one cell has on the other primarily with regards to the co-channel interference.

Venkateswarlu K et.al. Proposed an innovative process, which automatically assigns optimum frequencies for new network and also for new sites in an existing network. It has been shown that significant improvement over the current design methodology is achieved, with reduction in operational costs. Hence, the application of this process leads to an efficient and effective way for RF planning. Also, in coordination with Automatic Cell Planning algorithms, the new proposed process can function as a network advisory system that optimizes network resources efficiently

Zhouyun Wu et,al. used two IM generation algorithms based on source data fusion. Data fusion in one algorithm is to reinforce MMRs data, using the frequency domain information of Drive test data from the same region. Data fusion in another algorithm is to reshape Drive Test data, using the traffic distribution information extracted from MRs from the same region. The fused data contains more complete information so that more accurate IM can be obtained.

Aardal Karen. I et.al. Presented a broad description of the practical settings in which frequency assignment is applied. The solution methods are divided in two parts: Optimization and lower bounding techniques on the one hand, and heuristic search techniques on the other hand. From the mathematical perspective, there is still enough room for improvement of the solution and lower bounding techniques for all variants of frequency assignment problems. The still practical relevance of, in particular, the minimum interference and minimum blocking FAPs can be an additional motivation to do so.

Chen Lei et.al. Contributed in dealing with some planning and optimization problems in cellular networks. To master the complexity, the planning and optimization algorithms have to become more advanced, efficient, and automatic. The optimization process should become an integrated part of the network, and the work of manual tuning must be reduced as much as possible. The development of optimization tools integrating the models and algorithms for the problems is a natural follow-up to work.

III. CONCEPTS

The available frequency spectrum is very congested, with only narrow slots of bandwidth allocated for cellular communications. Spectrum allocated for GSM-900 &GSM 1800 (DCS1800) are:

System	Uplink	Downlink
GSM 900	890-915 MHz	935-960 MHz
GSM 1800	1710-1785 MHz	1805-1880MHz

Table 1

Spectrum flexibility in 4G/LTE

In LTE, Bandwidth will be divided into sub-carrier of 15 kHz which makes symbol time of 66.7 micro sec. The CP (Cyclic Prefix) is copy of the last part of the symbol and inserted in each symbol in order to preserve the subcarrier orthogonality. It is generally ¼ to 1/32 of symbol period.

- Total 7 symbols are there for Normal operation and for extended operation 6 symbols will be used.
- Resource Element is one OFDM sub-carrier during one OFDM symbol interval.
- Resource Block (RB) is 12 OFDM sub-carrier during one 0.5ms slot.
- Minimum unit that can be allocated by scheduler is 2 Resource Block which is sometime referred as Scheduling Block (SB) and is equal to the TTI of 1ms.
- LTE physical layer supports any bandwidth from 1.4 MHz to 20 MHz in steps of 180 kHz (resource block). Current LTE specification supports a subset of 6 different system Channel bandwidths. All UEs must support the maximum bandwidth of 20 MHz

Channel BW [MHz]	1.4	3	5	10	15	20
Number of RBs	6	15	25	50	75	100

Table 2

IV. NEED OF WORK

Study for Spectrum Refarming in any frequency band is needed so that the available resource has to be administered and reused carefully in order to control mutual interference. Impact analysis is required in a practical scenario when a telecom operator having 2G spectrum of 6.9 MHz in 1800 MHz band and decides to rollout LTE/4G by extracting 1.4 MHz carrier from the existing spectrum resources.

V. PROPOSED METHODOLOGY

Initially the area has to be selected where the operators running 2G/GSM operation at 1800 MHZ band and using both physical parameters sites will be plotted in Frequency planning tool. ICDM model will be generated using Mobile measurement reports collected from the BSC logs and different settings were applied for extracting 1.4MHZ spectrum for 4G rollout. The proposed method is more efficiently explained with the help of flowchart given below:

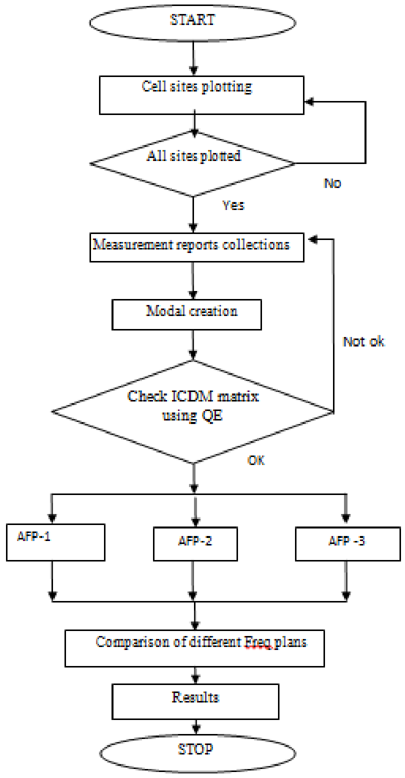

Fig 2

VI. IMPLEMENTATION

Firstly, a city with 1127 sectors was selected in MPCG where a Mobile service operator was providing their GSM services in 1800 MHz band with 6.9 MHZ of spectrum. In 6.9 MHz, operator currently has 34 ARFCN as 1 ARFCN is of 200KHz. Operator has divided these 34 ARFCNs in two bands i.e. 14 BCCH Band ARFCN & 20 TCH Band ARFCN.

With the rollout of new technologies in telecommunication domain, GSM is now becoming an old technology. So the telecom operator having 2G spectrums of 6.9 MHz in 1800 MHz band decides to rollout LTE/4G by extracting 1.4 MHz carrier from the existing spectrum resources. It leaves only 5.5 MHz for providing GSM services i.e only 27 ARFCN. Now the objective is to minimize the interference & Bad quality percentage by automatic planning of ARFCN assignments (AFP) with different setting of ARFCN allocation in BCCH & TCH Band.

VII. EXPERIMENTAL RESULTS

For optimum planning of 5.5 MHz or 27 ARFCN, three plans were generated.

1. Plan-1 10 BCCH & 17 TCH Plan: After more than 20 K evaluations, 11 best plans were found to minimize Affected Traffic to 2138 Erlangs.

KPI	Pre-Optimized	Last Best
Total Affected Traffic	375.62	2138.05
Interference Affected Traffic	222.14	945.64
BCCH->TCH Interference	3.19	8.11
TCH->BCCH Interference	1.02	4.27
TCH->TCH Interference	177.11	677.05
BCCH->BCCH Interference	40.82	256.21
Handover Affected Traffic	22.14	332.55
Accessibility Affected Traffic	131.34	854.76
User-defined Affected Traffic	0	0
Frequency-Restriction Affec...	0	0
Site-Separation Violations Af...	0	5.1
Forbidden Relations	1158	0
No. BCCH Frequencies	14	10
BCCH Spectrum 1800	628-641	628-637
No. TCH Frequencies	20	17
TCH Spectrum 1800	642-649, 678-...	638-649, 678-...

Fig 3

2. Plan-2 11 BCCH & 16 TCH Plan: After around 20 K evaluations, 24 best plans were found to minimize Affected Traffic to 1227 Erlangs.

KPI	Pre-Optimized	Last Best
Total Affected Traffic	442.25	1227.12
Interference Affected Traffic	269.93	628.89
BCCH->TCH Interference	3.14	7.13
TCH->BCCH Interference	1.32	4.45
TCH->TCH Interference	219.91	455.89
BCCH->BCCH Interference	45.55	161.43
Handover Affected Traffic	22.6	71.74
Accessibility Affected Traffic	149.08	524.14
User-defined Affected Traffic	0	0
Frequency-Restriction Affec...	0	0
Site-Separation Violations Af...	0.65	2.35
Forbidden Relations	1041	0
No. BCCH Frequencies	14	11
BCCH Spectrum 1800	628-641	628-638
No. TCH Frequencies	20	16
TCH Spectrum 1800	642-649, 678-...	639-649, 678-...

Fig 4

3. Plan-3 12 BCCH & 15 TCH Plan: After more than 20 K evaluations, 19 best plans were found to minimize Affected Traffic to 1048.24 Erlangs.

KPI	Pre-Optimized	Last Best
Total Affected Traffic	490.86	1048.24
Interference Affected Traffic	296.31	694.34
BCCH->TCH Interference	8.87	6.82
TCH->BCCH Interference	7.52	3.34
TCH->TCH Interference	231.19	586
BCCH->BCCH Interference	48.73	98.19
Handover Affected Traffic	42.7	29.29
Accessibility Affected Traffic	151.85	321.21
User-defined Affected Traffic	0	0
Frequency-Restriction Affec...	0	0
Site-Separation Violations Af...	0	3.4
Forbidden Relations	992	0
No. BCCH Frequencies	14	12
BCCH Spectrum 1800	628-641	628-639
No. TCH Frequencies	24	15
TCH Spectrum 1800	638-649, 678-...	640-649, 678-...

Fig 5

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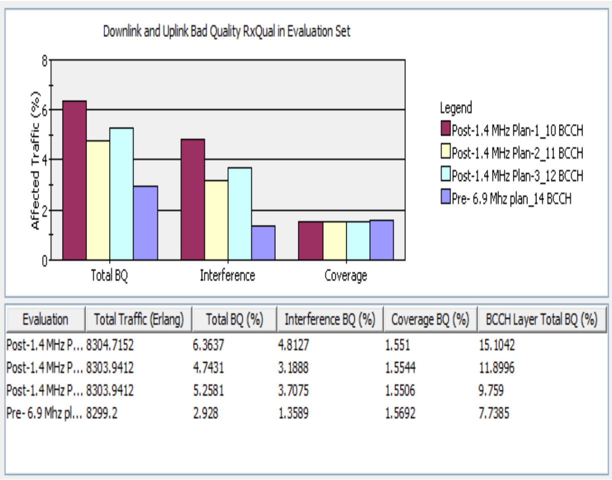
Comparison of Three Frequency Plan: By applying the Frequency Plan, the user will be able to compare QE results between 2 or more evaluation plans (before and after the Frequency Plan application)

- The graph section displays a graph that compares the two evaluations.
- The comparison table displays a table that compares the two evaluations in terms of total traffic, total bad quality, interference and coverage.

Calculation	Total BQ (%)	Interference (%)	Coverage (%)	BCCH Layer Total BQ%	Total BCCH + BQ %
Post-1.4 MHz Plan-1_10 BCCH	6.4	4.8	1.6	15.1	21.5
Post-1.4 MHz Plan-2_11 BCCH	4.7	3.2	1.6	11.9	16.6
Post-1.4 MHz Plan-3_12 BCCH	5.3	3.7	1.6	9.8	15.0
Pre- 6.9 Mhz plan_14 BCCH	2.9	1.4	1.6	7.7	10.7

Table 3



Evaluation	Total Traffic (Erlang)	Total BQ (%)	Interference BQ (%)	Coverage BQ (%)	BCCH Layer Total BQ (%)
Post-1.4 MHz P...	8304.7152	6.3637	4.8127	1.551	15.1042
Post-1.4 MHz P...	8303.9412	4.7431	3.1888	1.5544	11.8996
Post-1.4 MHz P...	8303.9412	5.2581	3.7075	1.5506	9.759
Pre- 6.9 Mhz pl...	8299.2	2.928	1.3589	1.5692	7.7385

Fig 6

VIII. CONCLUSION

The comparison results shows for the telecom operator, Plan no. 3 with 12 BCCH & 15 TCH ARFCN allocation is best to extract 1.4 MHz 4G carrier by minimizing the impact on existing 2G services. Plan-3 is providing lowest affected traffic of 1048, 24 Erlangs, and Overall Bad Quality % of 15%. Considering the practical scenario of a telecom operator having 2G spectrum of 6.9 MHz in 1800 MHz band and who decides to rollout LTE/4G by extracting 1.4 MHz carrier from the existing spectrum resources, in left out 5.5 MHz of 1800 MHz spectrum the 12 BCCH & 15 TCH ARFCN automatic frequency assignment provides the best results in minimizing the negative impact due to cut down of existing spectrum. This will enable the operators to understand the importance of efficient use of spectrum.

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