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The Service-Centric Perspective of Infrastructure Sharing for Multi-Operator Core Networks

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ABSTRACT

The number of cellular subscribers has always been increasing and opts to new services' contracts. The contracts commit, with subscribers, to provide high data rate, optimized network efficiency, data streaming services, and are held among mobile operators (MO). However, management and technical issues to implement these contracts are challenging for MOs which demands optimized approaches for infrastructure sharing among MOs. In this paper, we analyze and compare infrastructure sharing approaches such as, Multi-Operator Core Networks (MOCN) and Multi-Operator Radio Access Network (MORAN). The parameters like, bandwidth, the quality of service and coverage continuity are analyzed, for vendor-specified equipment, at MOs. Based on the statistical analysis, it is evident that adopting service-centric perspective of infrastructure sharing helps MOs utilize any N^{th} generation network at its full potential but, also can save their capital cost. In short, the paper serves a thorough review of infrastructure sharing approaches and proposes a way forward to achieve expectations through service-centric perspective, valid in all generation of mobile networks.

KEYWORDS: Infrastructure sharing, Network resource sharing, Mobile operators, service centric, multi-operator core network

1 INTRODUCTION

Increasing worldwide, the subscribers' demand for several services (video streaming, high data rates, optimized cellular network efficiency etc), leaving the technical and regulatory issues at mobile operators end. This mentioned trend of subscriber has always been challenging for Telco-Industry. The ICT (Information and Communication Technology) industry is already facing critical energy issues or budget overheads particularly, in Pakistan. According to the global statistics, the existing energy requirement of 600 TW by ICT industries will be increased by almost 1700 TW by 2030 [1].The huge energy consumption in cellular infrastructure is also a frightening factor in regular network services today. However, the energy management of cellular network infrastructure is a serious issue which directly relates to their revenue [1][2]. The migration of any nth generation network also increases the hardware devices on site levels and number of subscriber is meant of higher energy consumption. The telecom-industry also has some limitations to provide high data rate services in the metropolis and remote areas. High data rate services offered in metropolitan, but it is evident that coverage, the quality of services, broadband services over cellular networks is either limited or does not even exist in small villages. The (CAPEX) capital cost of the infrastructure and spectrum costs becomes tentative. In recent times, the business competitions among mobile operators also intensified the days have gone when operators were paying only the voice centric network as the data centric network developed gradually and in addition it offers value added services like faster downloading speed, apps etc. The subscribers' need to do multiple things with their phones video on demand control the home appliances, GPS and others, and all of above they desires on lowest possible tariff. This is going to be reality in forthcoming time because the vendors are looking to provide these services in collaboration with the cellular operator and smart phones. Hence, In developing countries, like Pakistan, the

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said transform from 2/2.5G to 3G and nth Generation demands the need of radio network co-operation among multiple cellular operators because an advent of next generation networks is only a time based solution to accomplish the subscribers demand of providing more services economical.

The section 2 is problem formulation, section 3 presents the drilled-down challenge to nth Generation networks and 4th section consist of details of the available multiple network operators in Pakistan and the proposal of network resource sharing, based on the service-centric approach. In section 5, analysis of MORAN and MOCN for vendor-specific equipment is given with adaptable recommendations.

2Problem formulation

The Tele-density of Pakistan including fixed, wireless local loop and mobile phone subscribers has reached in all the time high level of around 73.30% while total mobile service subscribers have reached 129.6 million across the country at the end of September 2013. The mobile Tele-density always reached all the time at high level up from 71% in July 2013 to 72.3% in up 2013 in Fig 1.

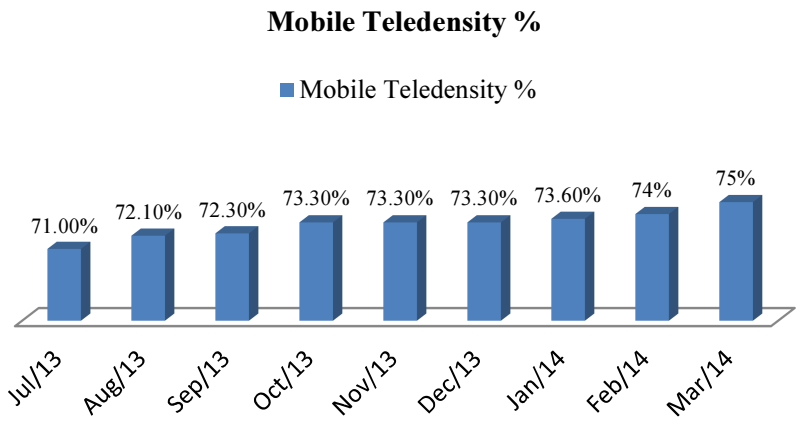

Figure 1. The annual cellular mobile Teledensity of different operators

The total number of cellular subscriber calculated all over Pakistan was 130,399593, at the end of Sep 2013. The Mobilink which is top market share holder counted the 37.37 million subscribers. The Telenor has 32.34 million subscribers, while Ufone recorded 24.80 million Zong 22.28 million counted subscriber although Warid grabs only 12.79 million subscribers at the end of 2013. According to the published report by pakistan telecommunication authority the mobile Teledensity has reached 73.30% at the end of nov-13 the cellular operators grabs 800,071 subscriber in that month [3]. However, the subscriber rate increased rapidly and the mobile Teledensity has reached now at 75% in March 2014. The mobile Teledensity for cellular subscribed always at high level which is quite amazing but it is surprisingly strange.This rapid growth of the subscribers demands the different network services with the passage of time. The cellular operators have to upgrade their networks in terms of the hardware, spectrum, and the land as well to deploy the new infrastructure. This would be after now an expensive decision for the cellular operators in the near future. The optimum solution for cellular operators is network resource sharing. The network resource sharing concept for different proposal started after UMTS license that was approved in Europe in the 2000s. The academia and Industry have contributed their significant thoughts regarding network resource sharing. Most of the work relates to the few single aspects of infrastructure sharing. The telecom industry association Europe prepared a report in 2001 on the sharing of 3G network infrastructure. The full resource sharing spectral sharing and infrastructure sharing among multiple operators is still a concept and therefore requires cycle of extensive research test and appropriate results. 3G (3^{rd} generation) and 4G-LTE (4^{th} generation-Long Term Evolution) networks have been launched recently in Pakistan by multiple cellular operators. The

cellular operators have been upgraded their networks to provide the immense benefits by adopting the next generations networks in terms of getting new services. The Telecom-industries has been constantly facing the fundamental issues by adopting all types of next generation networks. The service discrimination (remote and metropolis areas) due to the short number of subscribers, management of energy while deploying the infrastructure, efficient bandwidth utilization, equipped cost through deploying the new hardware to upgrade the networks, pressure on the total cost of ownership and return on investment etc. Taking the case study of Pakistan, we come to know that these are the current issues which occur in every nth generation's networks.

3RELATED WORKS

With the passage of time, the subscriber demands for more services on high data rates. Presently, cellular operators are enhancing the frequency-bands for accommodating more services and the subscribers. These services and subscribers' accommodation demands new sites and the broaden spectrum. The expansion needs the huge budget for per site development. Therefore, to keep the expenses in control, the resource sharing of a network has been in place. Few operators in the world with their technology partners are already in the process of implementation of different network resource sharing solutions in order to cut their per site operational cost. Nevertheless, not a single country-wide test-case exists for effective network-resource sharing for developing or developed countries which have been quickly advancing their telecommunication sector, e.g., China, Australia, Pakistan, India, U.A.E, or in Central Asia Europe or Africa. The network resource sharing improves the access of information and communication technology (ICTs) which generates economic growth and high quality of service life too [4]. The resource sharing helps the developing and developed countries to fulfill the demand of subscriber in terms of service centric perspective and meet to the objectives and goals established by world summit on information society (WSIS) .The infrastructure resource sharing is the cost-efficient principle for any new entrants in the emerging market and even best approaches for technology migration [4][5]. In addition to this, the compulsion relating to network sharing may manipulate the willingness of cellular operator for effective utilization to their resources in terms of investment and state-of-the-art services. In global market, the network resource sharing becomes a vital approach in order to maintain their presence in fast growing market by providing efficient network services not only need to be fast and reliable but also an affordable for the average ICT consumer.

The concept of the converged networks which delivers the voice image, video and generalized data types over the same networks using IP (internet protocol) has become a major part of the solution to speedy and low-cost public networks. Research into converged networks includes ways to make them simpler better and cheaper for the end-users as well as technology developers making more effective use of the infrastructure and minimizing operational costs for service providers [6]. Furthermore, user-centric networking enables the creation, compositions and dynamic management of services demanding high degrees of availability of network resources. The cellular operator requires primary resources for providing high data rate services in an nth generations' network, using; i) new investment for network up gradation, and iii) enhanced spectrum

Now, there can be only two possibilities left for an operator about switching next generation of networks, i.e., to upgrade preparing new investment plans for infrastructure or lose the market share. The way of upgrading can be the network resource sharing where multiple operators involve a joint network and share the resources. The sharing in terms of the capital cost i.e., approximately 75% of the budget obtained by the network elements, and the site-work that is construction, installation of network equipment and deploy the transmission lines. With the next generation network these fundamental issues will be more complex because to obtain the new sites becomes an expensive decision for an operator. Also, varying environmental challenges and local policies falls very expensive. In order to view these challenges faced by the cellular operators, an optimum solution is the network resource sharing in order to reduce the economic risks facing by the industry and thus improve time to time revenue [7][8]. Hence, an advent from 2G to 3G or 4G and n^{th} generation networks demands the need of dynamic management of network resource sharing among mobile operators.The dynamic management network resource sharing is a very multiple process. There are various approaches of network resource sharing which ranges from tower sharing and the other infrastructure

facilities to share intact mobile networks. The network resource sharing is divided into three basic categories (a) Active sharing (b) Passive sharing (c) Roaming based sharing as shown in the Fig. 2.

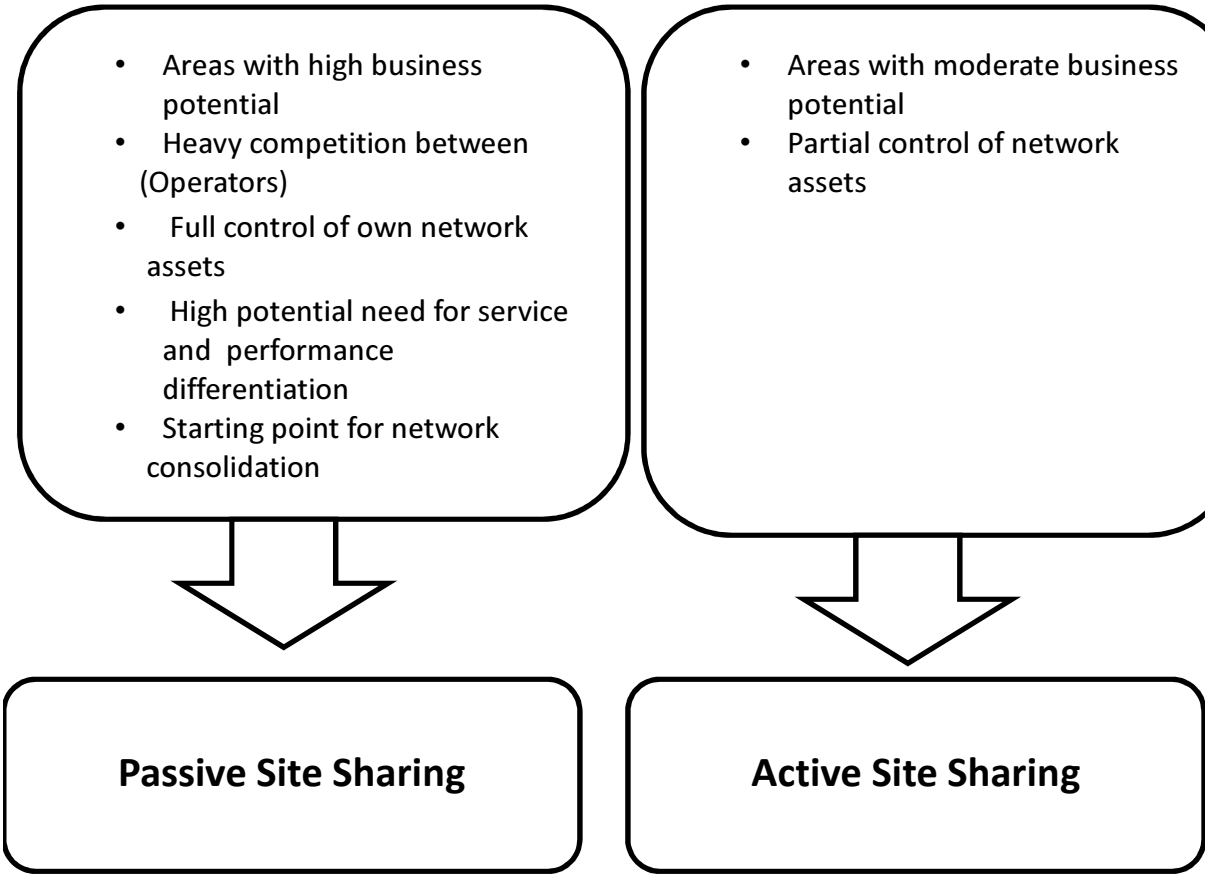

Figure 2. Dynamic management of network resources and business opportunities

- Passive sharing refers the sharing of physical space to deploy the infrastructure elements includes (building, premises, site, mast)
- Active sharing refers the sharing of network elements includes (antenna, power supply units, radio nodes, core networks back bone transmission)
- Roaming based sharing in the context to network resource sharing refers when one operator relies the coverage to another operator for a certain defined footprints on permanent basis

The network resource sharing is indisputably leads in the reduction of an investment by each operator. The network resource sharing helps operators to accomplish better coverage and brings considerable environmental remuneration by reducing the number of sites and improving the landscape [8][9]. Network resource sharing is critical for Telco-industry and also a feasible solution which customized to meet the demands of users as well from the prospective next generation's networks. The available solutions are MORAN (Multi-operators radio access networks) and MOCN (multi-operators core networks) which comes in the active site sharing category [10]. In MORAN multiple mobile operators share their network resources on different levels as shown in Table 1.

Table 1. The network infrastructure sharing in MORAN and MOCN

MORAN	MOCN
In NodeB, the radio and power amplifiers remain physically independent in order to allow operators to use their assigned frequencies.	Device dependent, requiring 3GPP release 6
The RNC and parts of the NB are partitioned between the sharing parties.	Share both RNC and NB and pool their frequencies
Frequencies are dedicated	Frequencies can be shared
There are common site level parameters but operators can control the cell level parameters. This allows the service differentiation. This may a regulator prerequisite for network sharing.	Spectrum sharing is the major limitation of this approach

The MORAN supports the network sharing at site level parameters which includes (base transceiver station, NodeB/eNodeB, radio network controller, Iub interfaces, sharing of an antenna, feeder cables, racks power supply at NB level) while having separated core networks (Circuit switched or packet switched) but frequencies are dedicated as shown in Fig 3 (a).

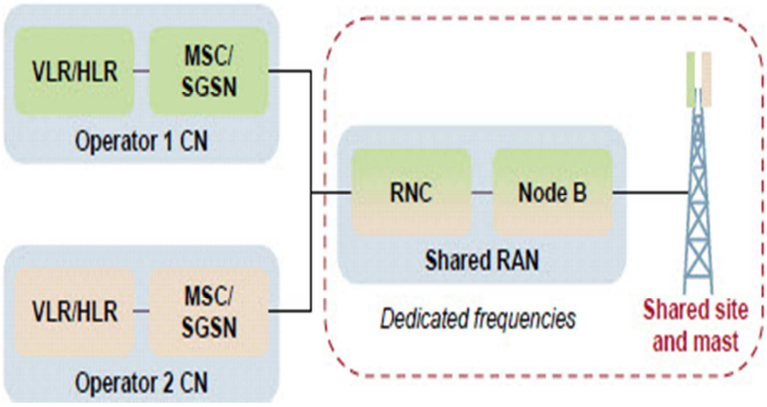

Fig 3 (a). Architecture of active site sharing network elements at NodeB and RNC level using 3G MORAN (Multi-operator radio access network) approach [3]

Another popular approach is MOCN where, frequencies can also be shared with the site level parameters. The same is shown in Fig 3 (b).

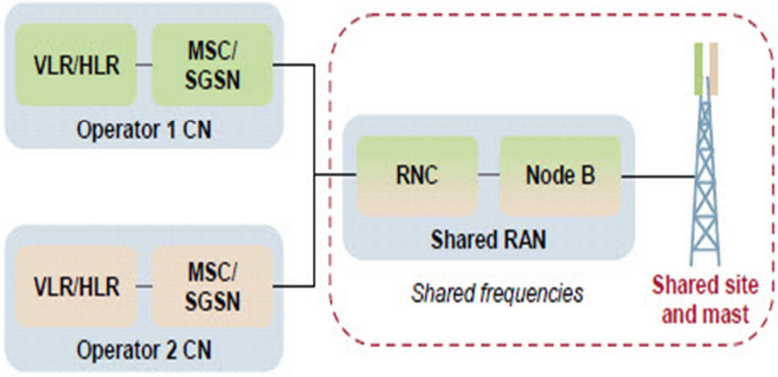

Fig 3 (b). Architecture of active site sharing network elements at NodeB and RNC level using 3G MOCN (Multi-operator radio access network) approach [3]

In the MORAN each operator can separately configure cell parameters and perform feature configuration and optimization to achieve the independent cell specific service management. On the contrary, with MOCN all operators configure parameters and perform feature configuration and optimization in a unified way to achieve the complete sharing of RAN resources [11][12]. The MORAN and MOCN will become essential where multiple operators involve the joint network infrastructure and share the cost on different levels of infrastructure. These solutions can also be migrated to individually owned networks in parallel with network capacity expansion and all invested infrastructure can be fully re-used [13][14].

4 The Win-Win Perspective with MORAN and MOCN

The innovation, business and needs have been converted from product-centric to consumer-centric. Now a day, the people's choice is always given priority. Even motivating a group of through today revolves around a central point i.e., public demands. This section provides a new perspective to look in adoption of strategies as consumers' demands. Subscribers of any network operators look for services committed to them through advertisements and publicity. Generally, people want to dive deeply in to micro details of penny calculations in billing unless operators compromise on quality of services. Hence, we analyze the radio network resource sharing solutions according to the win-win perspective for operators and subscribers. The model case is Pakistan's telecom industry and services which has emerged as the fastest growing telecommunication industry in the World. The Table 2 shows the general features information of network sharing resources in 3G and 4G-LTE. The MORAN and MOCN supports the common shared network resources at RNC levels and NodeB and eNodeB levels having the shared interface units Interface unit nodeB (Iub) used to connect the NodeB hardware to the radio network controller (RNC).

Table2. Type of network resources for deployment of MORAN and MOCN

MORAN solution Shared resources	**MOCN solution Shared resources**	**MORAN solution Non-shared resources**	**MOCN solution Non-shared resources**
Radio Network Controller (RNC) **Iub interface (Interface unit nodeB) Connect the shared nodes to RNC)** **NB HW (Node B hardware) - base transceiver station** **Sharing of antenna @ NB level** **Racks @ NB level** **Power supply / Feeder cable @ NB level**		Core Network Elements Interface unit (Iu interface) Connect the core network to RNC)	
X		Licensed frequencies	X
X	Licensed frequencies	X	X

The licensed frequencies/ spectrum sharing will not be supported by MORAN approach but with MOCN solution all the frequencies can also be shared at the cell levels. Each solution supports radio infrastructure sharing from two up to six operators and even more for specific situations. These solutions apply on different scenarios based on the customers' requirements.

4.1 Basics of the win-win perspective

As obtained earlier every country that every country/ regions has varying subscribers requirements and different regulatory policies. Therefore the adoption of MORAN and MOCN requires a fresh study. In this research it has been thoroughly reviewed the different existing challenges faced by the cellular operators as well for subscribers. The proposed win –win perspective facilitates the both the subscriber as well the operators. In the case of existing cellular network, there is the variations in the demands of operators as well the subscribers; some constraints have to be analyzed as shown in the Table 3.

Table 3. Analysis of subscribers and cellular operators in the Win-Win perspective

Cellular Subscriber	**Cellular Operator**
Always connected: Broader network services	High revenue: Save more instead of earn more
Services' mobility: Seamless network portability	Bandwidth utilization; Lend, if you have one
Last mile services: Promised last mile solution	Optimized QoS: Bench-mark services while avoiding revenue losses

It is clear that the value of services/ goods is a major factor for people to make decision of subscribing. The subscriber/user relies on cellular services according to the data statistics all over the world and they always demands for more services on higher data rates at the minimum cost with the satisfactory quality of service. On the contrary, the focus for all network operators now is getting revenue from their large investment by an advent of the next generations networks. Cellular operators needs the effective utilization of their resources (bandwidth utilization in terms spectrum, cells/sectors per site for accommodate number of user in an allocated channel etc) and providing high quality of services to the subscriber but above all they desire to get the high revenue as shown in the table. The Fig 4 shows the primary needs of subscribers as well the operators in terms of win-win situation. The subscriber desires for high data rate services with their mobility is the meant of always connected while avail the services of any cellular operators. The focus of the operators is on generating revenue, effective utilization of their resources in terms of spectrum at cell levels and other hardware elements of infrastructure and all of above the optimized network services which fulfill the desires of a subscriber.

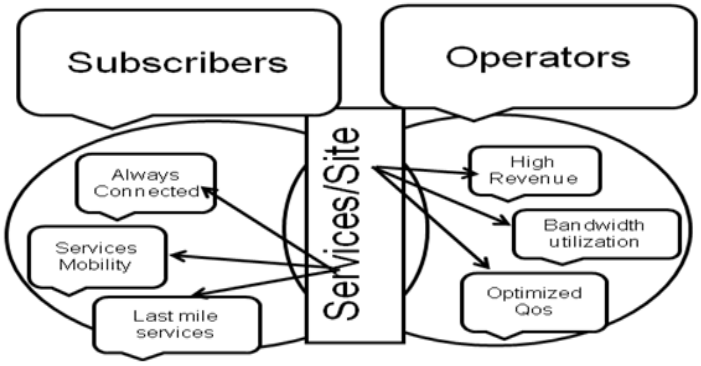

Fig 4. Need analysis of the subscribers / operators in Win-Win perspective

Currently some of the mobile operators have certain limitations to provide high data rate services with a constant connection in the metropolis and remote areas. The high data rate services offered in metropolis areas, but it is evident that coverage, Optimized quality of services (Qos) and the broader services over cellular networks are either limited or even does not exist in rural areas leaving the short number of subscribers. Probably, the service limitation is due to the high operational cost of the deployed infrastructure and the available spectrum. The only option for reducing the cost and provide the last mile services in low population areas with satisfactory Qos is the radio network co-operation by using MORAN and MOCN approaches. Therefore, there emerges a need of customization of these mentioned approaches including option for joint the network deployment, fully or partially and finance sharing.

6Analysis of MORAN and MOCN for Win-Win Perspective

The objective of this section is to evaluate the different operators sharing resources at different levels of the infrastructure. As we have seen the technical approaches that appears viable from today's perspective, considering currently available technology and showed how to align these concepts with business and geographical strategies. The economic impact of described approaches on operational and capital expenditure of operators is significant. The Table 4 shows the current status of 5 MOs having different vendor specific equipment.

Table 4. Network sharing opportunities as per view of vendor-specific equipment in Multiple Operators for MORAN

OPERATOR VENDORS	ZONG (4G) (V-D)	MOBILIK (3G) (V-A)	TELENOR (3G) (V-B)	UFONE (3G) (V-C)	WARID (4G) (VA)
CORE ELEMENTS	NO	NO	NO	NO	NO
NODEB (HARDWARE)	NO	YES	NO	NO	YES
SPECTRUM SHARING CELLS/SECTORS	NO	NO	NO	NO	NO
RNC	NO	YES	NO	NO	YES

Using the MORAN approach for network resource sharing model the vendor specified operators can share their network elements on different levels of infrastructure as shown in the table 4. The hardware resources like base transceiver stations, antenna at the NodeB level and the radio network controller equipment can also be shared, while the core network is separated and maintain by each operator with using the MORAN approach.

The table 5 shows the different operators vendors having shared network resources. The country is divided into three main areas Urban – sub urban and rural having different number of users and service profiles. Taking the case study of Pakistan, if the multiple cellular operators are followed by the same vendor then the operators can share their network resources as well at different infrastructure levels.

Table 5. Network sharing opportunities as per view of vendor-specific equipment in Multiple Operators core network for MOCN

OPERATOR VENDORS	ZONG (4G)(V-D)	MOBILIK (3G) (V-A)	TELENOR (3G) (V-B)	UFONE (3G) (V-C)	WARID (4G) (VA)
CORE ELEMENTS	NO	NO	NO	NO	NO
NODEB (HARDWARE)	NO	YES	NO	NO	YES
SPECTRUM SHARING CELLS/SECTORS	NO	YES	NO	NO	YES
RNC	NO	YES	NO	NO	YES

The spectrum sharing of MOCN with core network sharing between similar vendors' product makes MOCN, an optimized solution for the countries which are rapidly growing in telecom sectors. The adoption of MOCN in 3G / 4G LTE, as stated in the proposal, may eliminate financial risks and remove barriers of service areas of the network operator. Now operators can utilize our findings while developing economics of next generation of network in rural and metropolitan areas without the services' discrimination. The radio access sharing approaches also mean that there will be a considerable reduction in the revenue for an infrastructure vendor like Alcatel, Ericson, Nokia Siemens etc at hardware level but any such saving could be beneficial for a subscriber in the form of enhanced capacity expansion where needed and better service level agreements in terms of performance. The MORAN and MOCN are two different sharing models are used for network resource sharing among multiple mobile operators. Firstly, in UK T-Mobile and Hutchison combine their 3G network by using MORAN solution from Nokia Siemens Network. The MORAN technology can support four heterogeneous network cellular operators in a single base station which allow the significant reduction in operational cost. On the contrary, MOCN solutions offer the frequency shared with the network elements from two up to six multiple operators. In the comparison to MORAN the MOCN is more efficient model for the operators with satisfied quality of service at sustainably reduced cost for the subscriber too. These solutions also viable to avoid the discrimination of survive in both regions the Metropolis and Remote areas. Adoption of these different approaches depends upon requirement of subscribers in the region. Taking

the case study of Pakistan, in this paper, we observe that MOCN is an optimized solution for radio network optimization in 3G among cellular operators. This is because of the sharing opportunities, e.g., frequencies/ spectrum sharing at cell levels with the sharing hardware at NB level. As a result of an adoption the 3G MOCN approach for network resource sharing in cellular operators can offer high data rate services, optimized network efficiency, avoid service discrimination, reduced energy consumption, reduced operational cost, wide cellular coverage, effective sharing of network resources, lower service tariff.

7 Conclusion and future work

This paper helps to present a drill-down the rapidly advancing telecommunication sector of Pakistan. A thorough review has been made of famous optimized network resource sharing schemes for 3G and 4G. Here, an impact analysis of the facts, in countries with similar telecom infrastructural growth, is taken into consideration. Our analysis proposed new perspectives of rephrasing the current problems and reviewing solutions to the world's telecom industry. Based on the analysis, discussion and statistics from cellular operators, the MOCN (Multi-operator core network)is recommended as only advanced feasible solution. The reduction of operational/ recurrent expenses is also huge. The adoption of the proposed strategy is beneficial for operators and subscribers as it's meant for the economy. MOCN is capable to keep the operational cost low without compromising the services discriminations among rural and metropolitan areas. This would not only serve the subscribers with desired quality at par, but would definitely increase the operator's revenue proportionally. Adoption of MCON at the eve of 3rg and 4th generation in Pakistan shall surely help operators to overcome the existing challenges. The adoption of the proposed strategy is beneficial for operators and subscribers in terms of economy. The reduction of operational/ recurrent expenses is also huge due to dynamic resource sharing. The research aims to the current policy infrastructure by the Telecommunication Authority offered to cellular operators. This can also be useful for drafting resource sharing frameworks among cellular network operators.

In near future, we are planning for statistical evaluation of the 3G-MOCN approach for dynamic network resource management using case study of Pakistan. We may distribute the country's cellular network subscriber or services on the basis of three regions, namely, Urban – sub-urban and rural. These regions may have different number of users and service profiles. The traffic from each region then will be associated to the independent RNC. We believe that our model can be applied in existing telecom developing countries effectively.

REFERENCES

[1] Tao Han, Nirwan Ansari et.al. "On Greening Cellular Networks via Multi-Cell Cooperation", IEEE Wireless Communication Magazine, Vol.20, Issue. 1, Feb 2013, pp.82-86

[2] N. Faruk, A.A Ayeni et.al, "Techniques for Minimizing Power Consumption of Base Transceiver Station in Mobile Cellular Systems" International Journal of Sustainability Vol. 2, Issue1.1, 1st June 2013

[3] Pakistan Telecommunication Authority, 'Statistical report – September 2013', published by PTA - , http://www.pta.gov.pk. Cited 13th December 2013

[4] Osman Aydin, TorstenFahldieck, et.al. "Resource Sharing Between Operators" White Paper by European Consortium SAPHYRE, 13-03-2013, pp. 12-16

[5] Nokia Siemens Networks "Network Sharing Methods MORAN and MOCN in 3G" Mobile Broadband Network Sharing 2013, pp. 04-24

[6] SadathKalolo, Anael Sam et.al. "A Price Based Spectrum Sharing Scheme in Wireless Cellular Network" Journal of Information Engineering and Applications ISSN 2224-5782 Vol.3, No.8, 2013, pp. 1-7

[7]Khan, M, Ahmad, A. & Park, G. "Computer Network Protocols Convergence Under Secure and Non Secure Environment"VAWKUM Transaction on Computer Sciences, 1(2), 2013.

[8] FIDA, M. R, “Survey Of History Based Routing Protocols In Delay Tolerant Network”, VAWKUM Transaction on Computer Sciences, 2(1), 7-17, 2013

[9]B. M. Bakmaz, et.al. "Network Selection Equilibrium in Heterogeneous Wireless Environment", ElektronikaIrElektrotechnika, ISSN 1392-1215, Vol.19, No.4, 2013, pp. 91-94

[10] JosipLorincz, TonkoGarma, GoranPetrovic,"Measurements and Modeling of Base Station Power Consumption under Real Traffic Load "Journal Sensors Vol.12 Issue.4, 28 March 2012

[11] Chandramani Singh, SaswatiSarkar et.al, " Cooperative Profit Sharing in Coalition Based Resources Allocation in Wireless Communication", IEEE Wireless Communication Magazine, VOl.20 Issue.1 Feb 2012

[12] NasirFaruk, Mujahid Y. Muhammad, Olayiwola et.al. “Energy Conservation through Site Optimization for Mobile Cellular Systems (Base Transceiver Station Optimization)" Webs Journal Epistemic in Science, Engineering and Technology, Vol.2, No.1, 2012, pp.1-4

[13] Leonardo Militano, AntonellaMolinaro, Antonio Iera, et.al. “Introduction Fairness in Cooperation among Green Mobile Network Operators", Software, Telecommunication and Computer Networks (Soft Com), 2012, 20thInt'l Conf on 11-13 September 2012

[14] Djamal-EddineMeddour,TinkuRasheed, et.al, "On the Role of Infrastructure sharing for Mobile Network Operators in Emerging Market", France Telecom Orange R& D, Lannion, France 2CREATE-NET Research Center, Trento, Italy