A Review on: Cooperation between MNOs for Green and Efficient Communication
Prateek Singh¹, Jaya Dipti LaG, Anjulata Yadav³
SGSITS, Indore,
Sir M.Visvesvaraya Marg, Vallabh Nagar, Indore, Madhya Pradesh, India

Abstract:
In this paper we focus on the need of cooperation between the mobile network operators due to the enormous growth of mobile data traffic and also the power requirement of Base Station which leads to the idea of Network and Base Station sharing or the need of cooperation between MNOs and also the paper focuses on the benefits of the technique.

Keywords: Base station, Sleep modes, Mobile Network Operators and Wireless Networks.

I. INTRODUCTION
Wireless data communication has gained high popularity in recent years. The advent of smartphones, tablets and laptops has enabled the widespread use of new bandwidth intensive applications like web browsing and video streaming in mobiles. Due to this, there is an enormous growth in the mobile data traffic. According to the widely accepted forecasts by Cisco and Ericsson, mobile data is being expected to be increased with the annual growth rate of 60% in next five years [12]. As a result of this an unprecedented strain will be placed on the mobile network operators such as the increment in their operational and maintenance expenditures challenging their economic viability. According to Cisco, traffic from WLAN and mobile devices combined will more than triple between 2013 and 2018. As more and more wireless data are being transported, the speed at which these data can be transmitted also shows an impressive growth: data transmission rates in cellular networks have been rising by a factor of about ten every five years[3]. To offer good QoS (Quality of Service), Mobile Network Operators will have to deploy more and more number of cellular base stations per unit area, which will increase their energy consumption [2], [3]. In November 2007, every second inhabitant of this planet possessed a mobile telephone [4]. During the same time span, the number of internet servers rose by roughly a factor of 1000 [5]. Behind these two developments, the driving force was, and continues to be, “Moore’s Law”, according to which both the capacity of mass storage devices and processing power of CPUs doubles every 18 months. Direct impact of this enormous growth will be on price paid for the required data rate and QoS.

In Figure.1, the rise of the power consumption of 16-20% per year can be seen in last years, which nearly get doubles every 4-5 years.

II. POWER CONSUMPTION AT BASE STATION
Today it is commonly agreed that one of the most critical cost factor for cellular networks is the energy consumption of their active network components [6], [7]. Up to 90% of this cost is realized at the Radio Access Network (RAN), and specifically it is induced by power consumption of base stations (BSs). The power consumption of BTS depends on the type of base station like macro base station (MBS), micro base station (mBS) and depends upon base station sectoring. Usually the power consumption of macro base station (power consumption ranging from 800 W to 2 kW) is higher than micro base station (300 W) even when mBS does not serve any traffic [8].

Base station comprises of few elements such as DC power supply, cooling systems, radio unit and base band unit.

A. DC power supply
Basic function of power supply is to fulfil the power requirement of the whole equipment of base station transceivers. DC power supply is required to provide the suitable DC supply to Radio equipment and Base band unit in Base station cabinet. Capacity and the size of DC rectifier (takes AC supply as input and produces DC voltage as output) depends upon several of base station cabinet size like small system, medium system and large system. Approximately 11% of power consumption by BS is due to power supply [9].

B. Cooling System
Power consumption of base station is much larger than any other public institute because of a large amount of heat is generated from telecom components and environmental requirement for their suitable operation. Approximate 25% of energy consumption is due to air condition ring or cooling system out of the whole energy consumption of base station.

C. Baseband Signalling Unit
Baseband transmitter and receiver and cooling fan are the components of base band unit. Baseband unit is used for the processing of digital data. The data feeded into Radio unit is produced by baseband units. This equipment also consumes more energy.

D. Power consumption due to Radio unit
RF unit comprises of power amplifiers and cooling fan. Digital signal is converted into radio frequency signal by this component. Feeder cable is used to connect this component to antenna. More than 60% of the energy of base station cabinet is consumed by this unit.
E. Power consumption due to propagation path losses

Path loss propagation relates the communication attenuation between transmitting and receiving end. Propagation losses are caused by the natural expansion of RF signal front free space that takes the shape of an increasing sphere, absorption losses. When RF signal is passed through different media, it is affected by reflection, diffraction, scattering due to the obstacles which causes the loss in received signal strength.

Hence it can be seen that large amount of power is required at the BTS for the proper maintenance of their Radio Access Network infrastructure. It can be clearly seen that large amount of power is wasted when BTS is in inactive mode i.e. when the traffic load is low then the power required for its operation is higher than the power required for servicing the users.

Many schemes have been adopted for increasing the efficiency of BTS like improving the efficiency and linearity of RF power amplifier, reducing the power consumption by removing the Feeder Cable Losses, Baseband site optimization and by using some alternative energy sources where there is no electricity grid off or remote base station for low and medium capacity sites like solar power, wind power, fuel cell etc. which can be used to provide power supply to BTS. But the approach which has gained much interest in recent years is Base Station Sharing. This scheme is implemented in such a way that some base stations are switched off putting them into sleep mode, when the traffic in their area is relatively low and thus can be transferred to neighboring base stations (in case of same MNO). The motivation behind such schemes are (a) cellular traffic most of the time follows a periodic pattern and (b) in most of the cases coverage area of base stations overlap so that there is possibility to use only subset of them in peak hours.

III. NETWORK SHARING

Different network sharing methods are:

(a) Intra-network sharing.
(b) Inter-network sharing.

Intra-network sharing:

In intra-network sharing, some base stations of a MNO get into the sleep mode when traffic in their area is low and thus the traffic can be transferred to neighboring stations of the same MNO.

Pictorial explanation of intra-network sharing is shown in fig 2

In this approach, some base stations are made to be switched off during low load period transferring their traffic to adjacent or neighboring base stations, remembering that all base stations belong to the same MNO. Sometimes the base stations coverage area overlap which makes possible to use only a subset of them in peak-off hours. However if the coverage area of the base stations do not overlap then the extension of coverage of base stations takes place to make this approach possible. As shown in figure there are many users and five base stations. The dashed lines show the transmission ranges of base stations. If the sharing or cooperation between cells is not allowed then all BS must operate in such fashion that they can guarantee the required coverage. However if there is cooperation between the neighboring base stations then the users of one BS can be served by the neighboring base stations allowing that BS to be switched off so that the energy saving can be made by eliminating the additional power required for its operation. In figure 2, BS1, BS2, BS3, BS4, BS5 are candidate base stations and it is also shown that all three users of BS1 are being served by adjacent base stations and BS1 can be switched off to save energy.

Inter-network sharing:

Our basic concern is on inter-network sharing which has gained much interest of the researchers in the recent years and has already been adopted by several operators [10] by using the fact that their BSs are very closely located or even co-located.

In inter-network sharing, the traffic of some base stations of a MNO is transferred to the base stations of other MNO providing coverage in that same area. In this scheme cooperation between MNOs tends to share their whole RAN infrastructure in some geographical area.

The idea of latter approach is to switch off the multiple base stations of a MNO in a certain area when their traffic load is low and then their users can be served by roaming their traffic to MNOs that provide coverage in the same area.

The basic scenario of RAN sharing schemes is depicted in figure 3.

Inter-network sharing scheme offers a large set of solutions with possibly higher benefits but this scheme also brings some new challenges as the MNOs need to coordinate and agree on several issues like:

(a) They need to jointly adopt the switching on/off policy which will reduce the total energy servicing cost.
(b) They must find the technique to roam the traffic of operators that will switch off their infrastructure to those that will remain active.
(c) Cooperation between MNOs should be done without compromising the quality of service(QoS).
(d) They must find a solution for the fair service charge distribution among the MNOs for that service.

It is clear that operators which will serve additional traffic will ask for higher compensations, whereas the operators that will switch off their networks should agree to charge as low as possible for this service.

Hence the implementation of this scheme basically depends upon the facts that (a) an optimal solution must be identified in terms of aggregate energy saving for all MNOs, (b) a charging policy must be adopted to provide adequate incentives for the cooperation of all MNOs.

IV ENERGY BENEFITS OF NETWORK SHARING

In this section we will define the energy saving which is obtained by the cooperation between MNOs, where some of
the base stations of a MNO are put in the sleep mode and their traffic has been routed to the BSs of other MNOs. Hence there will be difference in power consumption of BSs with and without cooperation. We concern the weekly traffic profile given in [11]. Here we assume that the three MNOs are having similar architectures but have difference in terms of the used BS technology. Therefore they will have different energy consumptions.

Figure 4 represents the power consumption (per hour) over one week for each MNO and the users which are roaming between the MNOs during the cooperation. Actually the figure displays the power consumption with (right) and without (left) the cooperation strategy implemented, for each MNO. Figure is showing that MNO 2 and MNO 3 are switched off during low traffic period, and their traffic has been migrated to MNO 1.

In some occasions, it can be observed that MNO 1 consumes more power than remaining MNOs during cooperation because it absorbs traffic from remaining MNOs and hence it has to increase its power consumption to satisfy the traffic. Flat intervals in the power consumption of MNO 2 and MNO 3 indicate that the users served during that time interval have been migrated to MNO 1. The decision that to which MNO the users should be roaming is taken on the analysis that which MNO has the lowest joint opening and servicing cost per unit of traffic, and if that MNO gets congested then another MNO is being searched with the lowest joint opening and servicing cost and then the traffic will be roaming to that MNO.

Now we represents the aggregated energy savings in Table III over one week period in fig 5, for the conditions where all three or parts of them participate in cooperation, all three in first row, 1 and 2 in second row, 1 and 3, 2 and 3 in third and fourth row respectively. The minus sign shown in percentage column represents increase in energy consumption when cooperation is implemented. It will be observed that when all MNOs co-operate then large energy saving is obtained since in this scenario the two out of three MNOs are set in sleep mode. In general, about 40%-50% of energy savings can be observed by implementing the cooperation between MNOs. Individual MNO energy saving can reach 74% for considered representative scenario [1].

V. CONCLUSION

The enormous growth of data traffic makes the MNOs to find the techniques by which the large number of users can be served with adequate quality of service (QoS) and also the consumption of energy can be limited. Network sharing so far has been evolved as an optimal solution for the above problem. Such approaches have a huge potential in terms of cost savings, and despite the fact they haven’t received adequate focus from the research community.

In this paper we have tried to show that, in previous years there is a significant increase in the data traffic and is still increasing. So to reduce the carbon emission, MNOs need to find the way by which energy saving can be made as much as possible. We compared the power consumption by the BSs of MNOs with and without cooperation between them and the analysis shows that there is a significant increase in the energy savings for each MNO participating in the cooperation. However there are some challenges to meet while implementing the scheme i.e., switching on-off policy, fair distribution of the benefits among the MNOs obtained from the scheme.

But it has been shown that about 40%-50% Energy savings can be made from the approach making it a very viable approach.

REFERENCES


Figure 1: Development of data rates in wireless networks over time. Ten fold increment can be observed every five years.

Fig. 2 Intra network sharing

Fig. 3. A set of MNOs, which own and manage different Radio Access Network (RAN) infrastructures, provide service to common area. Each MNO can decide to switch off its RAN for a certain time period and roam its traffic to another MNO. The process is transparent for end users.
Fig. 4. Power consumption of three MNOs for a weekly traffic profile. From top to bottom: MNO 1, MNO 2, MNO 3. Figure (a): Non-cooperation scenario where each MNO serves its own traffic and incurs a different power consumption. Figure (b): Cooperation scenario where traffic from MNO 2 and MNO 3 is routed to MNO 1 in certain time slots. Note that the lowest values (flat intervals) for MNO 2 and 3 represent zero consumption.

<table>
<thead>
<tr>
<th>Coalition</th>
<th>MNO</th>
<th>Cost-No Cooperation</th>
<th>Cost- Cooperation</th>
<th>Savings(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>{1,2,3}</td>
<td>i=1</td>
<td>221</td>
<td>239</td>
<td>-8</td>
</tr>
<tr>
<td></td>
<td>i=2</td>
<td>415</td>
<td>243</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>i=3</td>
<td>801</td>
<td>202</td>
<td>74</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>1437</td>
<td>685</td>
<td>52</td>
</tr>
<tr>
<td>{1,2}</td>
<td>i=1</td>
<td>221</td>
<td>239</td>
<td>-8</td>
</tr>
<tr>
<td></td>
<td>i=2</td>
<td>415</td>
<td>161</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>636</td>
<td>392</td>
<td>38</td>
</tr>
<tr>
<td>{1,3}</td>
<td>i=1</td>
<td>221</td>
<td>239</td>
<td>-8</td>
</tr>
<tr>
<td></td>
<td>i=3</td>
<td>801</td>
<td>303</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>1022</td>
<td>535</td>
<td>47</td>
</tr>
<tr>
<td>{2,3}</td>
<td>i=2</td>
<td>415</td>
<td>425</td>
<td>-2</td>
</tr>
<tr>
<td></td>
<td>i=3</td>
<td>801</td>
<td>303</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>1216</td>
<td>728</td>
<td>40</td>
</tr>
</tbody>
</table>

Table.1 Overall energy savings during cooperation[1]