INCREASING ENERGY EFFICIENCY OF BASE STATIONS IN MOBILE COMMUNICATION SYSTEMS

U.K. Matyokubov, D.A. Davronbekov

Tashkent University of Information Technologies named after Muhammad al-Khwarizmi
otkir_matyokubov89@mail.ru, d.davronbekov@gmail.com

Abstract
The workload of the base stations of the failed mobile communication systems can be transferred to the neighboring base stations for a certain period of time (until the fault is rectified). As a result of this scheme, energy savings can be achieved, especially in rural areas. It is recommended to switch certain base stations to “Sleep” mode when data traffic is low.

Keywords: base station, energy saving, mobile communication systems, survivability, reliability.

Introduction.
There is a growing demand for more base stations (BS) in the regions due to the growing demand of the society for services provided by mobile communication systems, the organization of quality services by mobile operators and the expansion of residential areas. Clearly, as the number of BSs increases, so does the amount of electricity consumed by them. As a result, we can see the following negative processes:
1. Certain economic costs incurred by mobile operators.
2. Damage to nature in the process of electricity generation.
3. Decreased viability and reliability of communication networks due to power outages. Of course, the list goes on and on. In order to prevent this, we propose the introduction of “Sleep” mode in certain parts of wireless networks. The BS larga receives a different load during the day. These downloads vary depending on the location of the BS, the scope of service, and the function of the network. Our observations show that certain BSs exchange relatively little data traffic at certain times of the day. During this time, the selected BS can be put to sleep without affecting the quality of service.

The main part
Demand for broadband services is growing as new technologies in the communications industry are constantly emerging and information and communication technologies are fully integrated into our daily lives. Especially nowadays, any data can be easily and quickly transferred via mobile phones. According to researchers, the traffic of data transmitted via mobile phones (smartphones) is now growing faster than the traffic of computers [1]. In 2015, data transfer via smartphones and tablets accounted for 20% of total traffic, today this figure is 52%. The figure for computers was 67% in 2015, down from 32% today. These figures suggest that mobile operators need to expand their networks by deploying more BSs in the regions. For example, the mobile operator Uzmobile, the number of BSs is growing almost 1.5 times every year. It should be noted that in addition to the above considerations, there are small objective reasons for such a rapid increase in the number of BSs:
1. Uzmobile mobile operator in Uzbekistan has significantly expanded its GSM network over the past five years.
2. In 2017, the decision of the Government of Uzbekistan to allocate the same channels to all mobile operators in order to increase competition among mobile operators and regulate mobile channels was also important.

It is known that these BSs require an uninterruptible power supply for normal operation. With the rapid increase in the number of BS, energy consumption also increases in direct proportion. While there are different ways to power BS, most BSs are connected to national grids. This can be a problem in areas with poor electricity supply. In some areas, the quality of communication is reduced due to various restrictions on electricity or malfunctions in electrical equipment. The government is trying to solve such problems as necessary. For example, JSC «National Electric Networks of Uzbekistan» has reached an agreement with the State Electric Corporation of Turkmenistan «Turkmenenergo» on the import of electricity in 2019-2020.
We propose the following theory to reduce energy consumption in BS: To ensure the quality of communication, we propose an algorithm to put certain BS to «Sleep» mode when network traffic is very low and return to normal state when network traffic reaches a certain limit. We analyzed the faults observed in the regional BTS in cooperation with the Khorezm regional branch of the Uzbektelecom JSC. Thanks to this cooperation, it was possible to analyze data from 193 GSM standard and 49 CDMA standard base stations, which are distributed throughout the Khorezm region, corresponding to almost a year of observation days. According to the analysis, almost 75% of the faults are caused by electricity.

Table 1. Information on the BSs that received the most fault signals in the study area

<table>
<thead>
<tr>
<th>№</th>
<th>BS name</th>
<th>Number of faults</th>
<th>Used as nodes in the network</th>
<th>Number of connected BS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Besharik Bagat_2G (6074)</td>
<td>265</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Xadra Kushkupir_2G (5927)</td>
<td>178</td>
<td>+</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Xiva Okyop_4G (6037)</td>
<td>157</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Durvadik Xanka_2G (5913)</td>
<td>145</td>
<td>+</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>Mirishkor Bagat_3G (6068)</td>
<td>139</td>
<td>+</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>Dashyok_2G (6038)</td>
<td>110</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Xitoy_2G (5968)</td>
<td>111</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Okdarvand_2G (5919)</td>
<td>106</td>
<td>+</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>Gandimiyon_SEZ_2G (6031)</td>
<td>85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Urgench Gaybu-2_2G (6008)</td>
<td>75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Bagat RUT_4G (5900)</td>
<td>24</td>
<td>+</td>
<td>13</td>
</tr>
<tr>
<td>12</td>
<td>Xiva RUT_4G (5931)</td>
<td>24</td>
<td>+</td>
<td>15</td>
</tr>
</tbody>
</table>

To switch to sleep mode, each BS calculates the distances of all its UEs, and at the same time receives similar UE distance data from neighboring BSs via the X2 interface. BS then uses this information to calculate the average distance of the traffic load. The BSs are then placed in descending order according to the average distance value. After entering the minimum data traffic, the selected BS enters the “Sleep” mode. Neighboring BSs need to increase their bandwidth to cover the scope of service of a BS that has passed the “Sleep” state. Of course, this can increase the noise level by increasing the number of overlapping adjacent cells. In addition, this does not lead to overall energy savings, as neighboring BSs also consume more energy by increasing capacity. But it is possible to back up the weakest BS in the network in this way. Attention should be paid to the general transport condition and coverage area of the BS when switching to sleep mode. If there is a large number of BSs in the designated areas, then the BSs in the network are active and ready to receive the faulty BS load. A neighboring BS that is capable of carrying the load of this BS is identified. Once the “sleep” mode is approved, neighboring BSs will expand their coverage areas [4,5,6]. This process is shown in Figure 2.

The solution provided. In the proposed solution, the cellular network is divided into 7 cell groups. Within the cluster, the central BS becomes the central manager. Control is responsible for BS within a cluster, and depending on the number of clusters in the network, there can be multiple controllers within the mobile network.
Figure 1. Location of BSs
The small cells should then be installed in a 7-cell cluster where large volumes of traffic are available. Intra-cluster macros provide uninterrupted mobile coverage of users within a cluster, and chips deal with traffic volume. The central controller switches the low-load BS to Sleep mode. This enhanced system upgrade provides energy savings as cellular traffic increases exponentially. We present the algorithm sequence as in Figure 4.

Where: $\alpha_{th}$ - normalized traffic limit; $\alpha_{max}$ - maximum normalized traffic load to achieve a certain required QoS; $\alpha_{load}$ - normalized traffic load; $\beta_{on}$ - active BSs; $\beta_{sleep}$ - BS going into sleep mode; $\beta$ - BS set in one sector, $\beta_{macro\ i}$ - i macro BS; $\beta_{macro\ j}$ - j macro BS; $\beta_{neighboring\ i}$ - neighboring i macro BS; $\alpha_{load\ \rightarrow\ \alpha}$ - transport to be delivered; $\alpha_{UE\ i}$ - UE i traffic load.

Neighboring BSs calculate the specific energy they need when they receive information about a BS that is going into a “sleep” state. Specific energy (ME) is a measure that is very sensitive to the transport load controlled by a particular BS. This is the amount of energy required to transfer one bit of data from one point to another.
The controller sorts the MEs in descending order. The UE is also arranged in descending order according to each traffic used. High ME - This means that BS will process low traffic load. This means that the UE with the highest load will be handed over to the BS that handles the lightest load for easy access to the high QoS service.

Suggestions to consider when designing a proposed algorithm. There are four BS in the experimental set. Mobile phones will be connected to these BSs as usual. Initially, no BS went to sleep. In this case, VoIP packets are allowed to be distributed within the network and measurements should be taken on the following parameters: Delay to the end; General transition; Channel quality indicators; Loss of packages; Total power consumed.

In the simulation, the main focus should be on maintaining an optimal QoS when switching the BS to “Sleep” mode in the event of a fault in the mobile network.

If the termination delay is too large, real-time applications are not supported by mobile networks, and as a result, potential subscribers of the network refuse to use the network. It is very important to check the packet delay when switching to BS “Sleep” mode. When the BS goes into “Sleep” mode, the proposed solution can be applied if the delay to the end of the VoIP packets does not change much and the effect on QoS is not observed. There may be some small expectations due to changes in the way VoIP packets are received. These expectations are mainly observed at the beginning of the simulation, because the queue length is slightly longer at the beginning of the simulation. This can be explained by the fact that at the beginning of the simulation the network elements do not work at maximum power. Maximum power is achieved after all elements of the network have successfully passed the start-up phase.

Conclusion. Using the proposed scheme, the BS in case of failure can be transferred to the neighboring BS for a certain period of time (until the fault is rectified). It is also possible to achieve energy savings as a result of this scheme, especially in rural areas. This is because network access in these areas is mostly high in the first part of the day, and in the second part of the day (from 23:00 to 06:00) the number of requests from users decreases sharply. With this in mind, it is possible to put certain BSs into “Sleep” mode when data traffic is low. Network operators can use this offer to reduce operating costs and improve their image.

References
7. Z. Niu, Y. Wu, J. Gong & Z. Yang, “Cell zooming for
