Energy Optimization through Load Forecasting in Heterogeneous Mobile Broadband Networks

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Contribution

We introduce a method for energy savings in heterogeneous mobile broadband networks (MBN) based on forecasting. The term energy consumption covers the energy used for powering radio equipment at the service provider's side. Energy savings are based on the possibility to have MBN equipment switched off with no quality of service reduction. Forecasting is used to show future network traffic trends according to historical network traffic information. The results of forecast can be used to evaluate which parts of the network have low traffic and are running inefficiently. By turning off mobile network equipment during low traffic periods and turning on when traffic increases can save energy used for powering equipment.

Mobile broadband network

Mobile broadband networks (MBN) have changed during last 10 years. Increased numbers of MBN subscriptions [1] lead to increased requirements for service providers. To fulfill needs, the MBN structure has been updated by allocating new antennas. Higher amounts of generated network traffic requires actions for service providers. Old MBN equipment provides coverage for bigger areas - known as macro cells. New solutions that cover smaller areas - mirco cells are presented. Micro cells consumes less energy, however coverage area is smaller. Sites most often have 3 antennas allocated with 120 degree angle. In figure 1 three macro sites C1, C2, C3 and three micro cells C4, C5, C6 are visible.

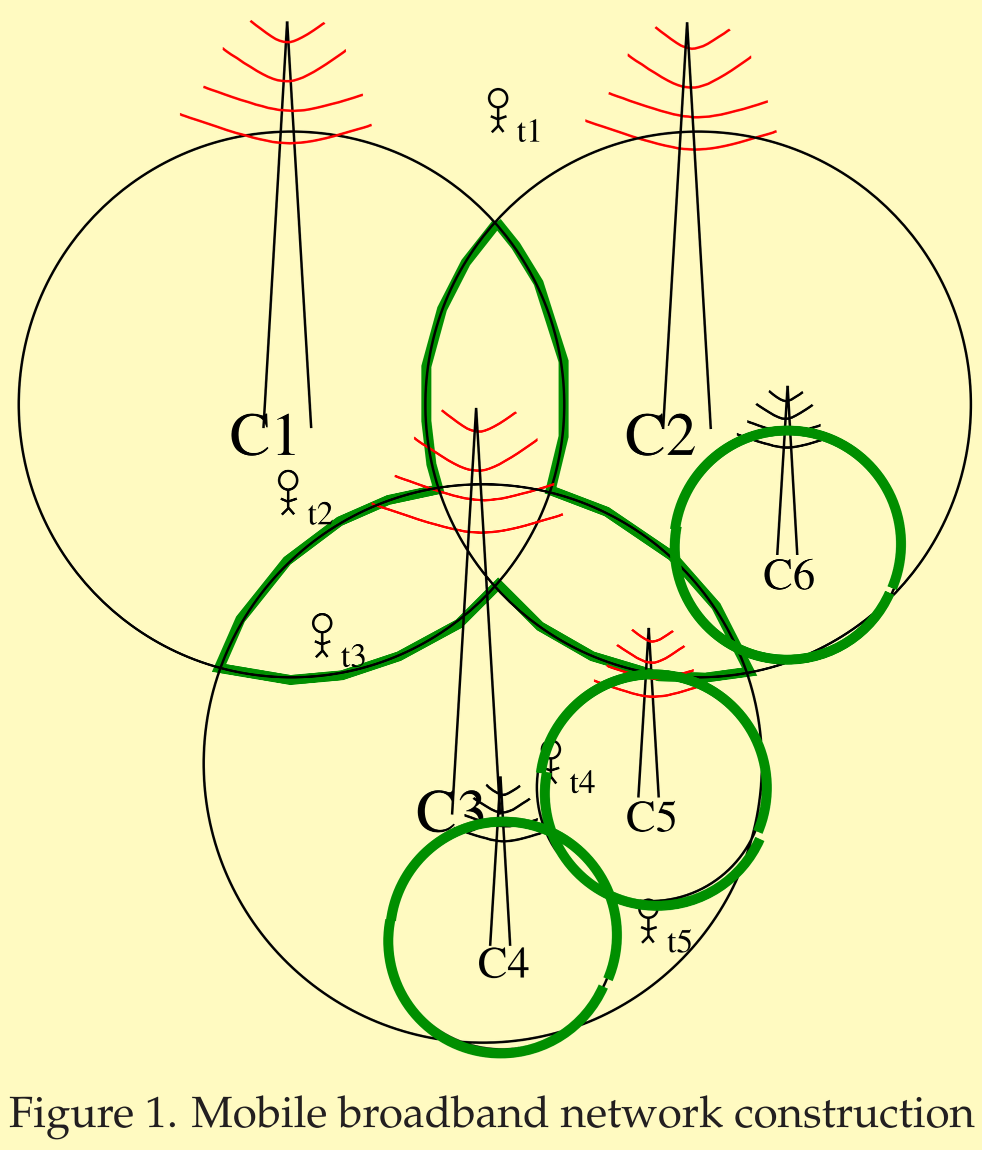

Figure 1. Mobile broadband network construction

Dense allocation of antennas results in multiple coverage areas, i.e. marked green line. Minimizing of overlaping areas would give more efficiently equipment use and result in energy savings.

References

[1] Cisco, Cisco visual networking index: global mobile data traffic forecast update, 2010-2015, White Paper.

[2] G. Micallef, P. Mogensen, H.-O. Scheck, Cell size breathing and possibilities to introduce cell sleep mode, in: Wireless Conference (EW), 2010.

[3] Ramu Ramanathan and Robert Engle and Clive W. J. Granger and Farshid Vahid-Araghi and Casey Brace, Shorte-run forecasts of electricity loads and peaks, 1997.

Energy consumption in MBN

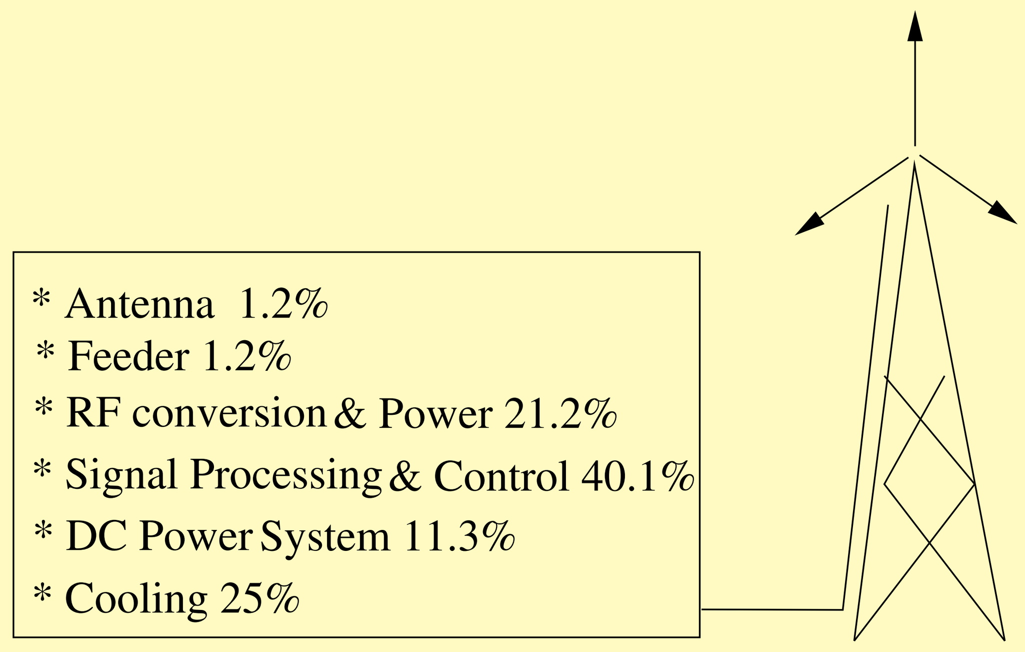

Figure 2. MBN energy consumption by parts

The basic parts of MBN equipment with energy use in % are provided in the figure 2. Consider a site with 3 antennas, each supplied with 20W. According to the figure, antenna consumes only 1.2% of total energy, required to power MBN site. The remaining 98.8% is used to power additional parts. To power one antenna around 1,6kW is required, one site, i.e. C1 - around 5kW. Some of network equipment can be turned off separately, i.e. antenna, however cooling system is a common part and is shared among site equipment.

Traffic in MBN

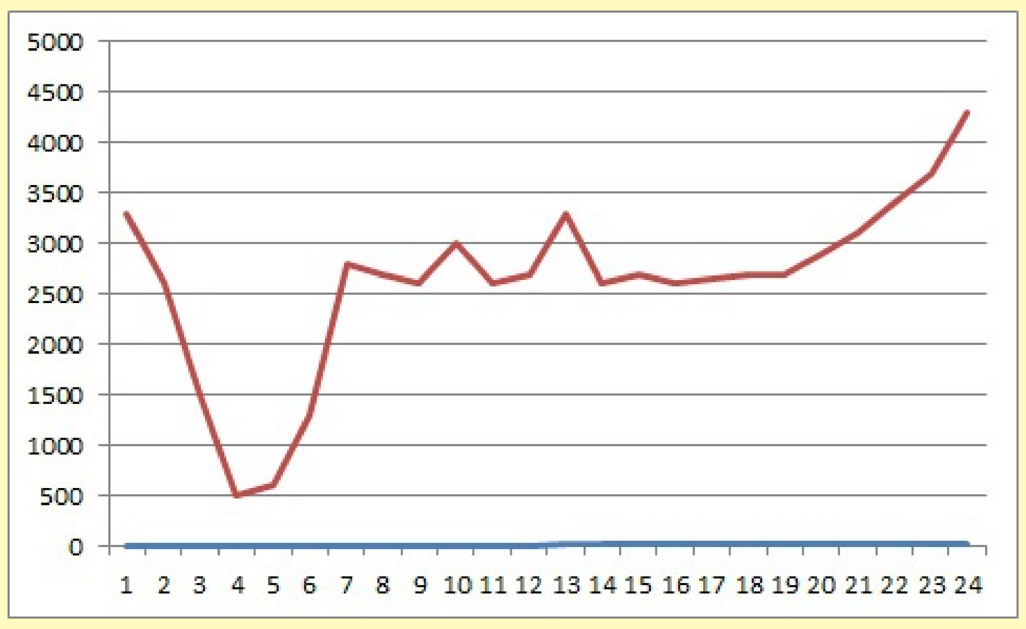

Figure 3. Average network traffic during a weekday

An overview of MBN network traffic variations during 24 hours period for a site is shown in figure 3. The brown line represents average traffic trend during a weekday. In the morning (from 7AM) traffic is increasing. Throughout the day traffic is steady. In the evening, traffic goes up and reaches highest transfer amounts. After the peak traffic decreases. In the morning traffic is low therefore some MBN equipment could be turned off, i.e. from 3 AM to 6AM or 7AM. However this traffic trend varies day from day for every cell.

Results and future work

Traffic in MBN differs for every antenna, therefore accurate forecasting model is very important. As we have noticed, some of the antennas during the week period can be turned off for periods longer than 1 hour. If antennas are at the same site, higher energy savings are possible. ARIMA and other different forecasting models will be modified to fit MBN traffic and evaluated. The best model will be selected using our proposed accuracy measurement metric. Network optimization based on turning off and on equipment has to be evaluated if at all MBN areas sufficient network coverage is available, when part of equipments is turned off.

Forecasting

Forecasting is a solution for estimating numbers or actions that might occur in the future based on historical data. Various forecasting techniques and methods have been developed and used in different areas. Basic steps that apply for forecasting models are:

- Data gathering and preprocessing.
- Forecast model building (identification, estimations, forecasting).
- Results evaluation

Data used for the research is real MBN traffic collected in Copenhagen every hour. To forecast traffic, ideas from EGRV [3] forecasting model are used. Average weekly hour traffic is used for predicting traffic for any hour in the day time. Instead of average more conservative solutions could be used, i.e. maximum traffic. To evaluate forecasted values, accuracy measuring method is presented.

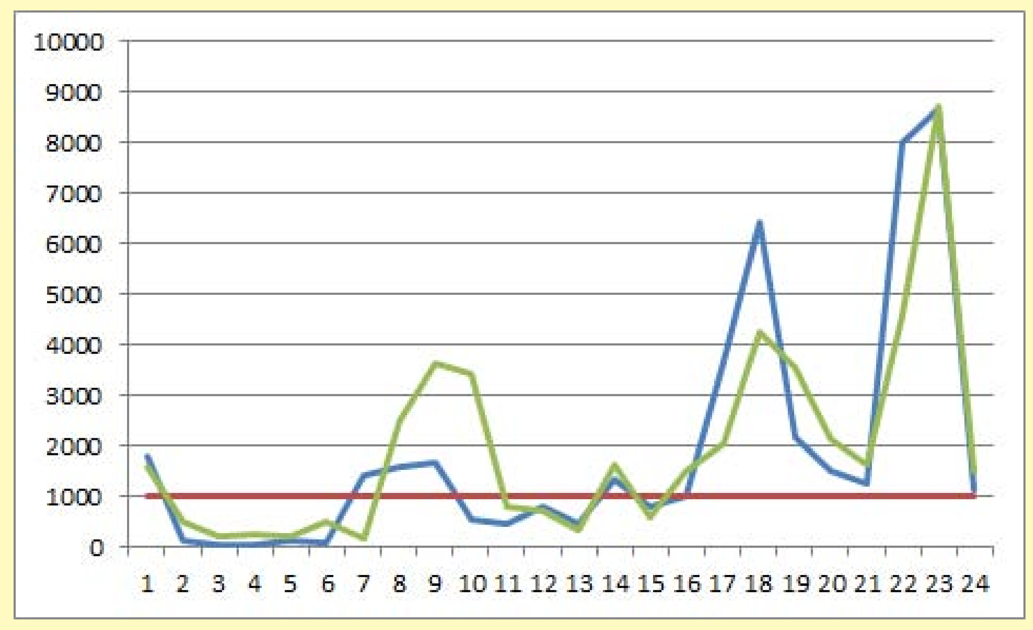

Figure 4. Real vs forecasted traffic

Forecasted MBN traffic trend line is green, real traffic - blue, threshold is show as red line, see figure 4. As we can see the real and forecasted values are different. By setting threshold value, a range used for measuring accuracy is defined, i.e. real and forecasted values are compared only for periods where traffic values (forecasted or real) are smaller than threshold, therefore higher traffic values are skipped. Time periods when real and forecasted values are below the threshold are assumed to be potentials for switching off. In figure 4 threshold is set to 1000. Both real and forecasted values are below the threshold 9 hours during 24 hours period, i.e. from 2AM to 6AM, 11AM to 1PM and at 3PM. However not all cells have periods with low traffic (as seen in figure 3). This means that some of the cells will be busy most of the time and shutting down is impossible.

Energy saving

Energy optimization and savings are achieved by turning equipment off and on based on forecasted traffic. [2] covers energy saving possibilities, however forecasting is not considered. Turning one antenna off for an hour saves 4% of daily energy used for powering one antenna, therefore savings are directly. As seen in figure 4, 37.5% of energy used for powering antenna could be saved. As seen in the picture, cells could be switched off for periods longer than 1 hour. If few cells that are located in the same site have low traffic for longer periods, whole site could be turned off.