Optimizing the energy consumption of LTE micro-cell infrastructure

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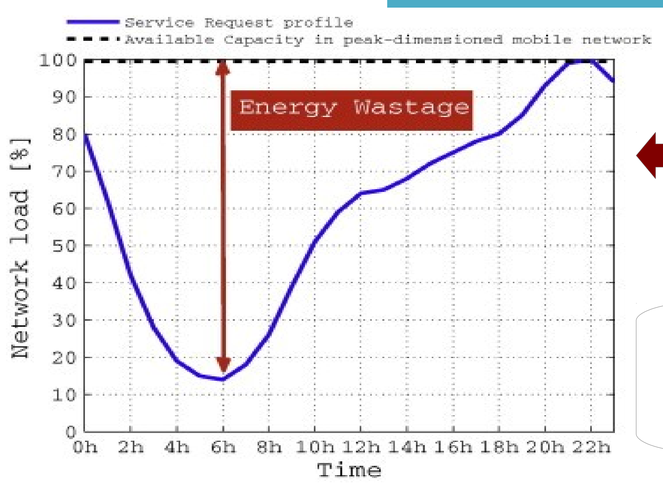
Abstract

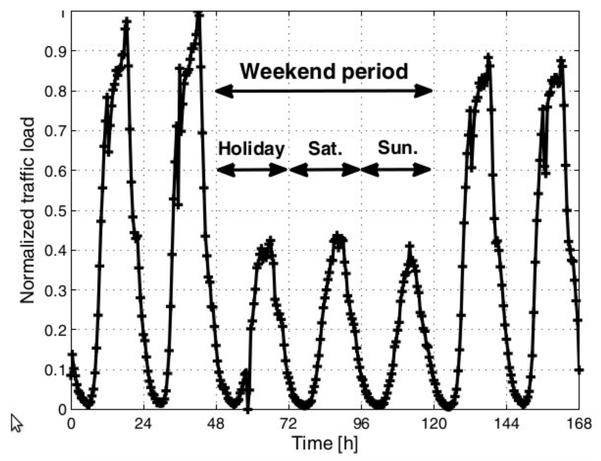
Mobile communications witness an exponential growth of data traffic. Consequently, the energy consumption of cellular networks is increasing, which makes the OPEX (operating expenditures) more challenging for operators and increase ICT carbon footprint. Energy contributes up to 50% of an operator's OPEX. The central point for improving network energy-efficiency is the radio access network which accounts to 80% of the whole network energy use. Base stations are the main network energy-consuming component which consists of cooling system, power amplifier and RF circuits etc.
In this context, different “green” projects have emerged to investigate the feasible energy saving gain and develop green technologies for mobile communications. GreenTouch, EARTH, Trend,OperaNet2...are all promising initiatives that contributes a lot to identify the key technologies and trade-offs for reducing energy wastage.

Energy saving opportunities



Average data daily Profile in Europe

Normalized real traffic load during one week recorded by an anonymous cellular operator



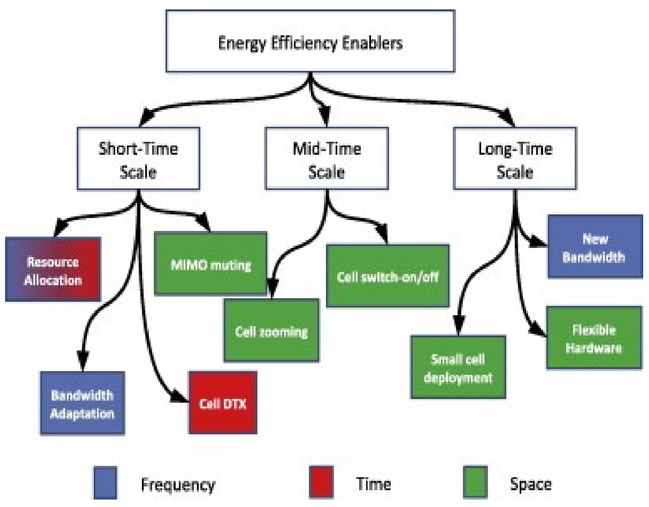
Designed for peak traffic demand BSs are under-utilized!

Adapt BS activity to the traffic variations pattern

Energy efficiency enablers

Energy reduction in BSs can be achieved through different technologies:

- Novel hardware designs
- Resource management schemes (power control, energy aware scheduling...)
- Smart topological designs from deployment to operation(using small cells, dynamic BS switching on/off, cell cooperation CoMP...)



BS Switch on/off algorithm

The most straightforward way to reduce network power consumption is to turn off BS in a coordinated manner so their traffic load is distributed to neighbors under low traffic durations.
A general paradigm has been noticed through studied BS switch off algorithms in literature. It is described as follows:

BS Switch off paradigm:

1. State collection
   - Full /approached / estimated knowledge of the BS and/or its neighbors state (On/Off, system load, remaining capacity)
   - Beaconing: frequency (trade-off between algorithm overhead and precision of exchanged information)
2. Decision
   - Static / adaptive system load threshold
   - Traffic prediction
3. Action
   - Handover: Cell wilting / Forced Handover
   - Coverage extension: Cell breathing / CoMP (cooperative beamforming)

Perspectives

Energy will become one of the driver of future network operators business model. Switch on/off of base stations can saves up to 80% of energy consumption in low traffic scenarios,but it still has some challenges to leverage in better defining switch on procedures that is usually described as symmetric to the switch off operations. Different level of sleep deepness can be defined that takes into account the wake up time of the BS. Also, defining the system load threshold is challenging and may cause ping pong effect if it is not well defined. Ongoing work is focused on quantifying the signaling cost related to a switch off algorithm.