A Rewheel insight paper:

Are cellular operators running out of spectrum?

Introduction

There is a common view in the industry that 3G operators have congested networks because of technology and spectrum limitations.

In this paper we explore if this really is the case. We frame the scarcity of the available spectrum resources by determining the maximum monthly data traffic per subscriber that the operators could deliver to the total addressable subscriber base in Helsinki, Berlin and Cairo, utilising their existing spectrum holdings.

Methodology

To assess the sufficiency of MBB (mobile broadband) spectrum we used our standard methodology for high level network dimensioning, which captures:

- Demand: number of subscribers, monthly data volume/sub, bitrate target
- Network topology and characteristics: number of base stations, spatial and temporal traffic distribution
- Technology and spectrum: capture operators' real spectrum assets and possible technology roadmap

We capture the targeted user experience by the minimum user bitrate and the probability of achieving it during the busy hour. By taking into account the spatial and temporal traffic distribution we ensure that the network is dimensioned for the highest demand. In our calculations the busy hour share of daily traffic is assumed to be 7% (1.7 times the average hour) and the spectrum sufficiency is checked for the highest load sites – typically 15% of the sites carry 50% of the traffic, see Figure 1.

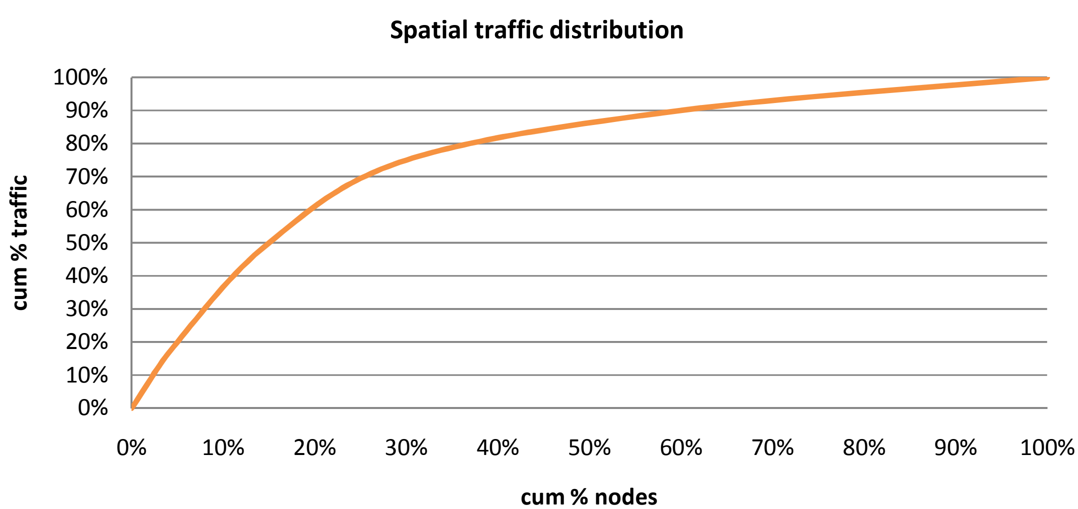

Figure 1: Spatial traffic distribution

Real operator environment is captured with corresponding spectrum assets. For 900MHz and 2100MHz band we assume HSPA+ Rel.8 with DC-HSDPA, rest of the bands – if auctioned already in the market – are used for LTE Rel.8. GSM bands are also refarmed for mobile broadband if it is reasonable to assume such development in the analysed market. All the terminals are modelled to support the mentioned technologies, and no voice traffic is modelled. The analysis thus shows an optimistic near future scenario.

RESULTS

HELSINKI – FAR FROM CAPACITY CRUNCH

Helsinki, the capital of Finland is apparently very far from running out of spectrum. The 800MHz band is not yet auctioned but even without those frequencies the incumbent operators could accommodate average usage of 16.8 GB/month/sub for 90% of the subscriber base assuming 5Mbit/s with 90% probability. The key reasons for such high monthly usage figure are:

- Fairly low population density
- High amount of spectrum
- Three service providers with equal spectrum allocations – low spectrum fragmentation
- MHz x Sites / Population = 0.11

BERLIN – NO IMMEDIATE SPECTRUM SHORTAGE

Compared to Helsinki, Berlin is more advanced in spectrum auctions with the digital dividend band already allocated for the service providers. The population density is however somewhat higher and the spectrum is more fragmented as there are four operators compared to three in Helsinki. The maximum accommodated traffic for 90% of the population is 12.1 GB/month/sub. Key characteristics of Berlin:

- Moderate population density
- High amount of spectrum
- Four service providers with unequal spectrum assets – fragmented allocations
- MHz x Sites / Population = 0.075

CAIRO – SOON OUT OF SPECTRUM

While Helsinki and Berlin represent mature markets in Europe with high incumbent spectrum resources, the case of Cairo is different. The population density of Cairo is 10 times higher than Berlin's. The market is heavily underserved with only 60MHz of available 3G spectrum. 900MHz and 1800MHz are available but fully utilised by GSM, thus refarming for MBB cannot be considered.

Assuming a very low mobile broadband PCC (PC connectivity) market penetration of 10% and target bitrate of 1Mbit/s, the incumbents can accommodate 3.9 GB/month/sub. Key characteristics of Cairo:

- Extremely high population density
- Very low amount of spectrum

- 900 & 1800 spectrum fully utilised and regulated for GSM usage
- MHz x Sites / Population = 0.0021

MONTHLY DATA VOLUME'S SENSITIVITY TO TARGET USER DATA RATE

For Helsinki we calculated that with HSPA+ and LTE technology the operators could provide 16.8 GB/month/subscriber for 90% of the population. Taking the LTE 800MHz band (3 operators, each having 2x10 MHz LTE FDD) in the calculations the figure climbs up to 18.2 GB/month/sub. For these values we assumed 5Mbit/s user data rate target achieved with 90% probability. But if the bitrate target can be relaxed we will see that the offered data volumes can go notably higher, on the other hand increasing the bitrate target will yields significantly lower monthly data volumes, see Figure 2 for details.

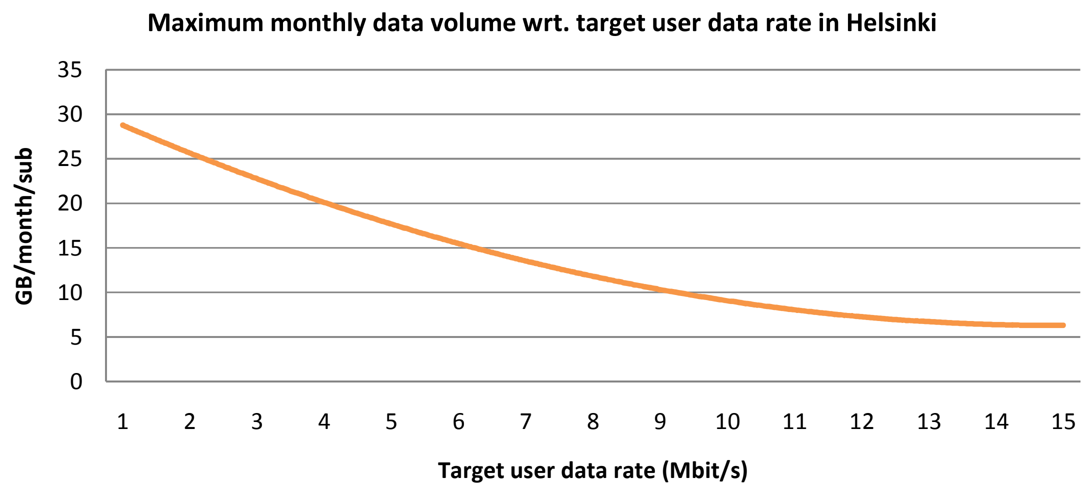

Figure 2: Network capacity's sensitivity to user data rate target

Beyond 16Mbit/s the accommodated volume drops drastically to 1.7 GB/month/sub as the 20MHz LTE FDD layer can only support one single simultaneous user per cell and the rest of the layers cannot offer such high bitrate at all.

This also emphasises the importance of using technology that can utilise high spectrum blocks. In the study we assumed HSPA+ Rel.8 with dual cell operation (42Mbit/s "nominal bitrate") that can offer 11.8 Mbit/s average downlink cell capacity using 2x10MHz spectrum. If we would have modelled the network with Rel.7 HSPA+ using 2x5MHz spectrum, the bitrate target could not be so high. The average cell capacities of 5MHz HSPA+ are just slightly above 5Mbit/s, thus targeting for 5Mbit/s the network utilisation would need to be very low.

SUMMARY

Our analysis showed that from spectrum point of view the incumbent 3G/HSPA+ service providers are not reaching capacity limits in mature markets.. Double digit monthly gigabytes can be offered to the whole customer base. This of course assumes full configurations (HSPA+ & LTE) in the high load sites and full terminal support for the features. Figure 3 summarises the results of the spectrum study, note that for Helsinki the LTE layer at 800MHz is now also taken into account. The breakdown of the spectrum calculation analysis is presented below.

	Helsinki		Berlin		Cairo	
Population	584 420		3 429 870		7 500 000	
PCC penetration	90%		90%		10%	
Adressable subs	525 978		3 086 883		750 000	
Cell sites / operator	269		1115		260	
N. Operators	3		4		3	
Mean subs / site	652		692		962	
Bitrate target	5		5		1	
Target %	90%		90%		90%	
Band	**DL MHz**	**GB/month**	**DL MHz**	**GB/month**	**DL MHz**	**GB/month**
HSPA 2100 FDD	60	2.4	60	2.1	60	3.9
HSPA 900 FDD	30	1.2	10	0.1	0	0.0
LTE 2600 FDD	60	6.6	65	4.5	0	0.0
LTE 1800 FDD	60	6.6	65	4.8	0	0.0
LTE 800 FDD	0	0.0	30	0.8	0	0.0
Total	**210**	**16.8**	**230**	**12.1**	**60**	**3.9**

The high monthly usage figures of Helsinki and Berlin are the result of LTE layers. But even with HSPA+ alone the accommodated traffic could be as high as 3.8 GB/month for 90% of the population of Helsinki. Corresponding figure for Berlin is somewhat lower, 2.2 GB/month.

Helsinki & Berlin: Operators have large reserve of unutilised 3G/LTE spectrum for future needs

- The markets are advanced in terms of spectrum allocation & technology
- In Helsinki there is still 50% more spectrum than in Berlin with respect to demand

Cairo: Reaching capacity limits

- Incumbents can accommodate very little traffic to the addressable market even with extremely low market penetration and target QoS assumptions
- Relative to demand there is 50 times less broadband spectrum compared to HEL

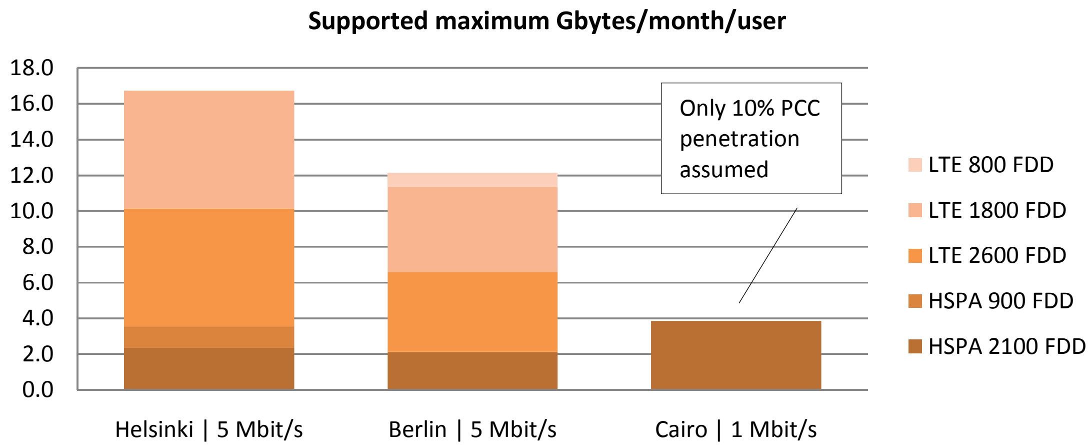

Figure 3: Spectrum limitation study – supported maximum GB/month/subscriber in selected markets

The study showed that neither spectrum nor technology limits the MBB capacity in more advanced markets. The results obtained are in line with what we can see in the industry. Many 3G/HSPA operators have 15-20 MHz of 2.1 GHz FDD spectrum for HSPA, still very few have activated 3rd or 4th WCDMA carriers in their networks – the reasons being financial rather than technical.

The real problem is the cost of capacity, namely the expensive hardware as well as software licences required for capacity upgrades. And furthermore many networks are still running on outdated E1-based transmission creating a capacity bottleneck.