On GERAN Speech Capacity with Different Quality Criteria

1. INTRODUCTION

Previously, both static and dynamic simulations results have been shown for the network level performance of Quarter Rate speech channels. In [1], static simulations showed additional capacity gains (compared to Half Rate) between 13% and 85%, depending on the cell radius and reuse. In the same contribution, dynamic simulations showed gains between 17% and 40% for Quarter Rate. These dynamic simulations were run with 1% FER limit and using both micro and macro cellular environment.

Since then there has been discussion about different simulation parameters and especially about different quality criteria for both an individual call (acceptable FER) and for the whole network (percentage of *satisfied users*).

In this document, new dynamic simulation results are shown for Quarter Rate with assumptions that follow recommendations in [2], however some parameters in this study differ from those. The capacity gains are shown with several different quality criteria.

Main difference in the simulation set-up compared to [1] is that now the modelling of lost speech frames due to handovers (intra- or intercell: 4 lost frames/HO) have been added, power control is not used and simulations were run both in non-hopping and RF-hopping network with equal spectrum.

2. STATIC SIMULATIONS

No new static simulations were made, for reference the results from [1] are collected in Figure 1 below.

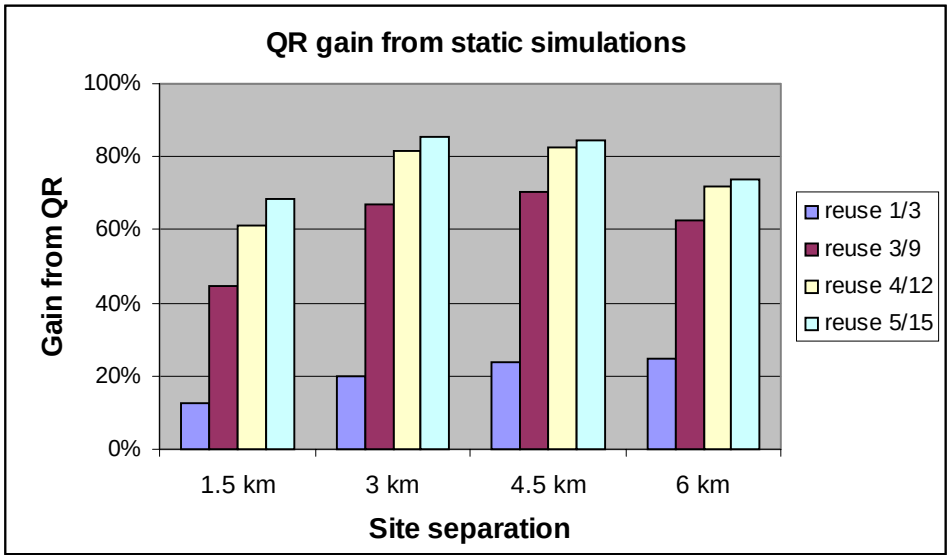

Figure 1. QR gain from static simulations.

3. DYNAMIC SIMULATIONS

3.1 Modelling

Dynamic simulations were run in standard hexagonal macro cell environment. Complete description of the layout, propagation and mobility models etc. can be found in [3]. TDMA frame resolution (4.615 ms) was used and the link/system level mapping was according to [4].

Simulations were run with equal 7.8 MHz spectrum for both non-hopping and RF-hopping (3.0 MHz for BCCH and 4.8 MHz for non-BCCH) case. Frequency hopping scheme was 4/12 random radio frequency (synthetic) hopping using MAIO management to avoid collisions inside one sector (between TRXs) and inside one site (between sectors). Naturally, the BCCH TRX does not hop and the modelling is also otherwise as realistic as possible. First time slot for the first TRX in the cell was always reserved for signalling. Whole network is simulated, i.e. both uplink and downlink and BCCH and non-BCCH layer.

Only MS speed of 3 km/h was considered and during intra- or intercell handover 4 frames are lost on both up- and downlink*. The effect of HO losses was found to be significant only in the case of the tightest criteria (1% FER limit).*

Fixed AMR7.4 codec mode was used. Channel mode adaptation was C/I-based with fixed thresholds, hysteresis and penalty timers.

Simulation parameters were according to [2], except (due to practical issues) the parameters that are listed in Table 1.

PARAMETER	VALUE	UNIT
Cell radius	500	m
numberOfFrameLossesDuringHandover	4	
handoverMargin	6	dB
DTX	Not used	

Table 1. Main parameters deviating from [2].

3.2 Absolute capacity results

Figures 2 and 3 show the network capacity with 3 different FER criteria (1%, 3% and 5%) and with 3 different network QoS (ratio of satisfied users, the yellow label) for the non-hopping and hopping case, respectively. Note also that especially Figure 2 shows that the combination of 99% network QoS and 1% FER limit is unrealistically tight criteria (the capacity is close to zero also with Full Rate).

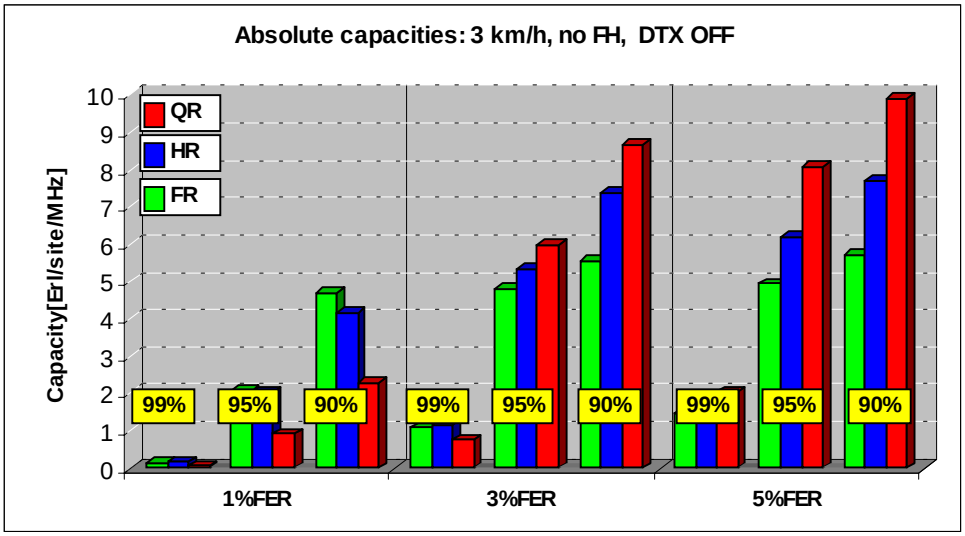

Figure 2. Performance of FR (no-LA), FR+HR (LA-HR) and FR+HR+QR (LA-QR) modes in macro cell network; 3 km/h, no FH.

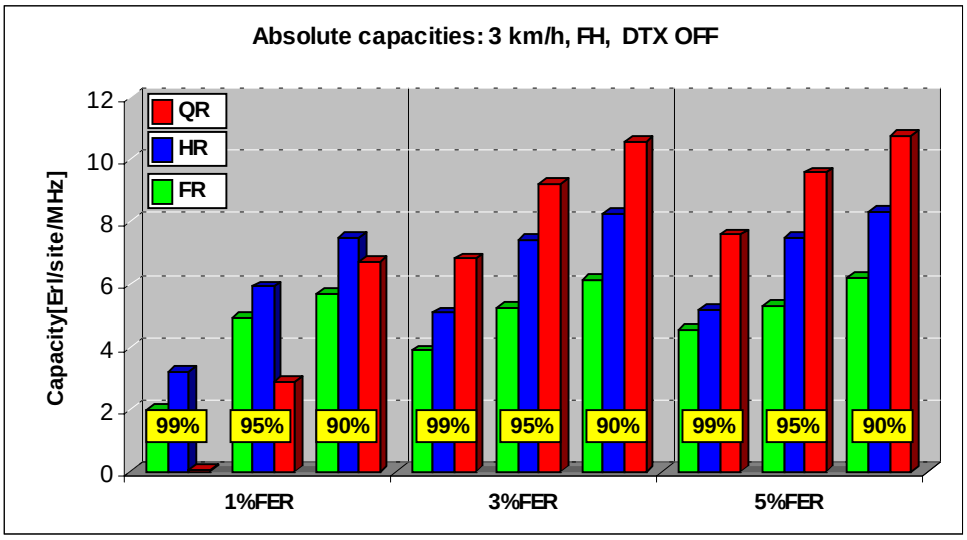

Figure 3. Performance of FR (no-LA), FR+HR (LA-HR) and FR+HR+QR (LA-QR) modes in macro cell network; 3 km/h, RFH.

3.3 Relative capacity gains

Figures 4 ad 5 show relative capacities of HR and QR are compared (against FR), based on the results presented in the previous chapter.

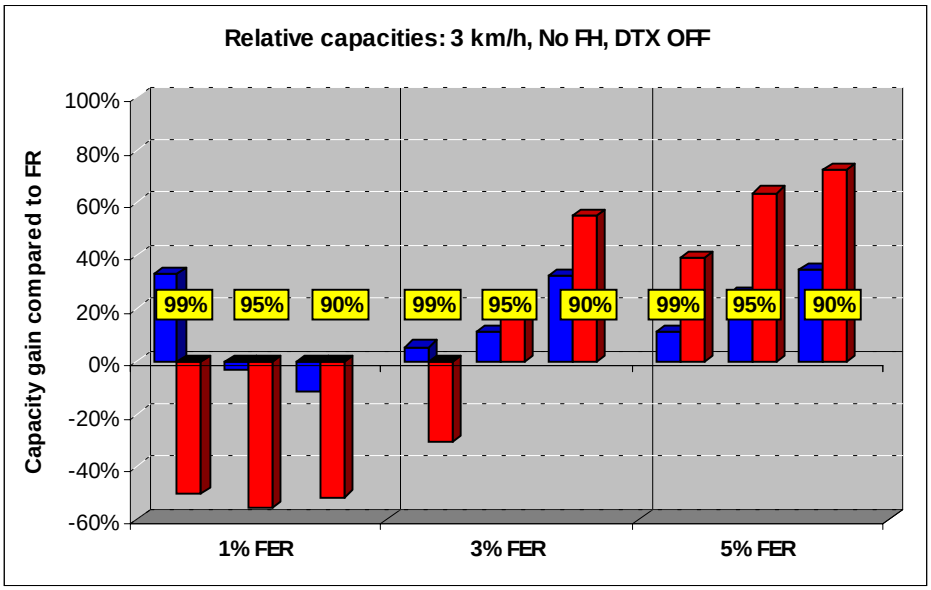

Figure 4. Relative capacities of FR+HR (LA-HR) and FR+HR+QR (LA-QR) modes in macro cell network; 3 km/h, no FH.

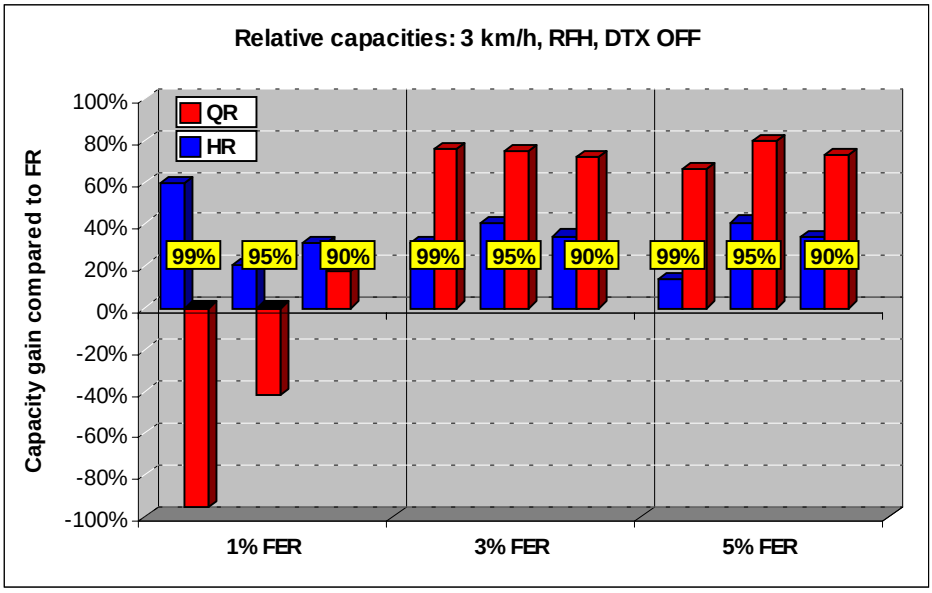

Figure 5. Relative capacities of FR+HR (LA-HR) and FR+HR+QR (LA-QR) modes in macro cell network; 3 km/h, RFH.

From the above figures it is clear that the QR gain is a function of the quality criteria. **However it should be noted that the simulated capacity losses up-to 100% with QR using 1% FER criteria are due to the behaviour of rate switching algorithm** - same CIR thresholds were used in all cases for simplicity. Ideally, the QR performance should always be at least the same as FR or HR performance (switch to QR only when acceptable quality is maintained).

4. CONCLUSIONS

The accurate network level simulations presented in this document show considerable network capacity gain for Quarter Rate channels with the used simulation assumptions. The potential theoretical capacity gain shown easily by static simulation analysis can also be realized in dynamic network environment.

There was clear capacity gain (up-to 47%) from QR for all network QoS operating points when using FER criteria of 3% and 5%. With the tightest FER criteria of 1% the QR performance was bad especially in the non-hopping case. However, it is clear that the used rate switching (Channel Mode Adaptation) algorithm was not at all suitable for 1% FER operating point. The simulated capacity losses for the 1% FER are easily avoidable with proper switching algorithm.

With very tight overall quality criteria the QR speech seems not to be feasible. Also, the results presented here did not yet take into account DTX interworking with QR.

On the other hand, the gains can be improved for example with better adaptation algorithms, power control and more intelligent channel allocation (especially DCA which can help to guarantee certain channel quality).

5. REFERENCES

[1] Tdoc 3GPP TSG GERAN #1, TSGG-000256, "Performance analysis of Quarter Rate Speech Channels", Nokia, 28th August -1th September 2000, Seattle, USA.

[2] 3GPP TSG GERAN #3, Tdoc GP-010284: "Simulation Assumptions for Quarter Rate Speech in GERAN". Boston15th-19th Jan 2001, Massachusetts Source: Ericsson, Nokia.

[3] Selection procedures for the choice of radio transmission technologies of the UMTS. ETSI Technical Report 101 112 V3.2.0 (1998-04).

[4] J. Wigard, T.T Nielsen, P.H. Michaelsen, P. Mogensen: BER and FER Prediction of Control and Traffic Channels for a GSM Type of Interface. Proc. VTC'98, pp.1588-1592.