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SAIC System Level Evaluations based on GERAN System Simulator

In this contribution we present SAIC system level capacity evaluations for two SAIC algorithms. These system level capacity evaluations are based on system simulation parameters that have been agreed upon in past GERAN meetings [1].

The Feasibility Study (FS) on SAIC is currently trying to come to agreement on interference profiles for link level SAIC performance characterizations. However preliminary interference profiles have been defined [2], which have been used by some companies to develop estimates of long-term average performance as a function of average C/I [3]. The next step in the process is to define link to system level mappings, which we believe is a two-stage process. In the first stage of this process average burst level bit error rate (BER) is determined as a function of burst level C/I and DIR. In the second stage of this process the frame error probability (FEP) of a speech frame is determined based on the average and standard deviation of BER over the speech frame. System level simulators will use this two-stage mapping process to generate SAIC voice capacity estimates with respect to a certain user satisfaction criterion such as 95% users experiencing less than 2.5% frame error rate (FER).

In this contribution we present system level SAIC capacity results based on burst level BER mappings generated by two companies, viz. Philips Semiconductors and Trellisware Technologies, and BER to FEP mappings generated by Cingular. The results of this analysis indicate that SAIC can support capacity increases of about 40% to 100% depending upon the algorithm used. The specific assumptions used to generate these link to system level mappings are described below along with the generated mappings.

Figure 1 shows burst C/I versus burst BER results for conventional and SAIC receivers generated by Philips Semiconductors. These results are based on the following interference profile.

- GERAN profile for 40% FL = [6 10 9 14 15]
- Uniform distribution of interferer delays ranging from –1 to +4 GSM symbols
- TSC assignment based on GERAN definition [2]
- Frequency offset = 0 Hz

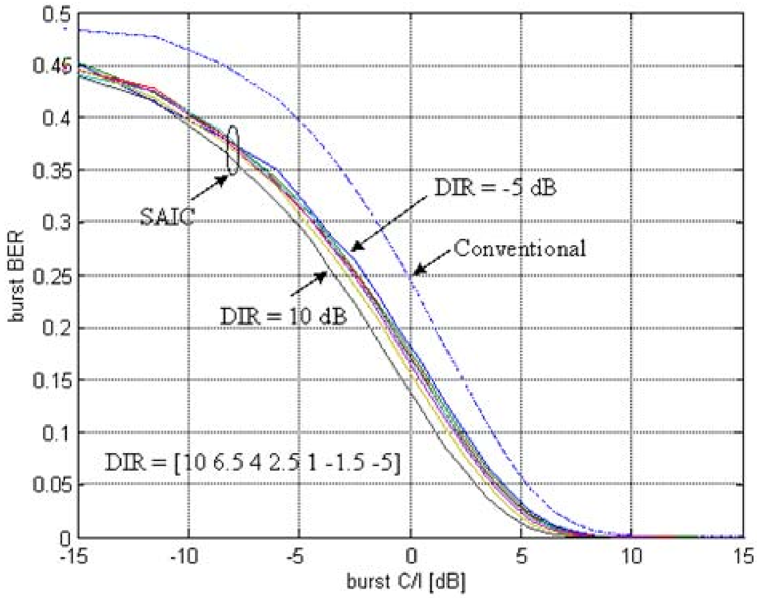

Figure 1: Burst C/I vs. burst BER Mappings from Philips Semiconductors

Figure 2 shows burst C/I versus burst BER results for conventional and SAIC receivers generated by Trellisware Technologies. These results are based on the following interference profile.

- GERAN profile for 40% FL = [6 10 9 14 15]
- Distribution of interferer delays based on [4]
- TSC assignment based on GERAN definition [2]
- Frequency offset = random +- 100 Hz for C; +- 50 Hz for dominant CCI

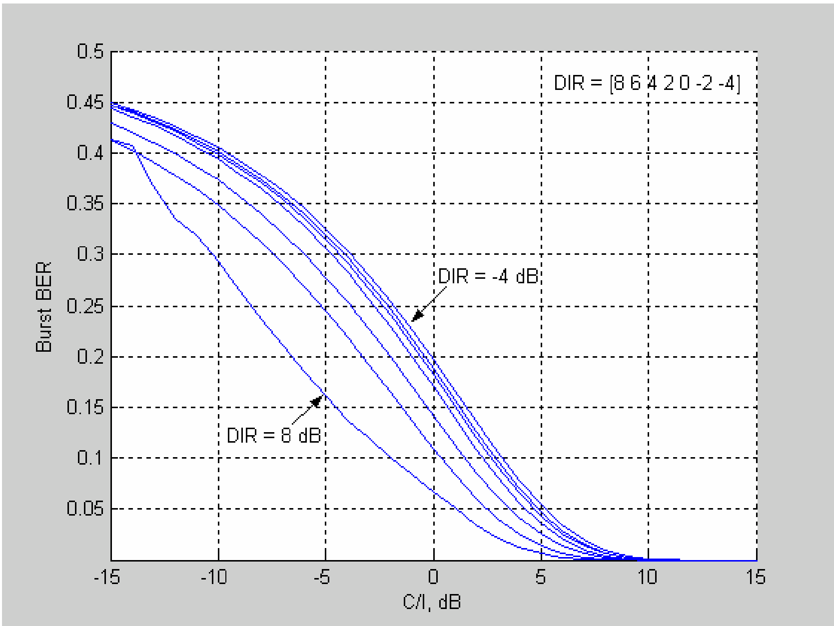

Figure 2: Burst C/I vs. burst BER Mappings from Trellisware Technologies

Even though the above burst level BER mappings have been generated for the 40% FL interference profile, we have used these burst level BER mappings for the entire range of FLs required to generate system level capacity results. This is because we have observed very little difference in the burst level BER mappings generated for the 40% and 70% interference profiles and believe that for the range of FLs that are of interest to us, the burst level BER mappings are fairly constant with respect to FL.

Figure 3 presents the link level BER to FEP mapping generated by Cingular. This mapping is used in the second stage of the link to system level simulation mapping process. Note that this mapping is based on average BER and does not account for the standard deviation of BER. Cingular is in the process of generating new mapping curves that take into account standard deviation of BER as well. It is expected that including the effect of standard deviation of BER will improve the capacity estimates (% satisfied users) presented in this contribution by about 3-4%.

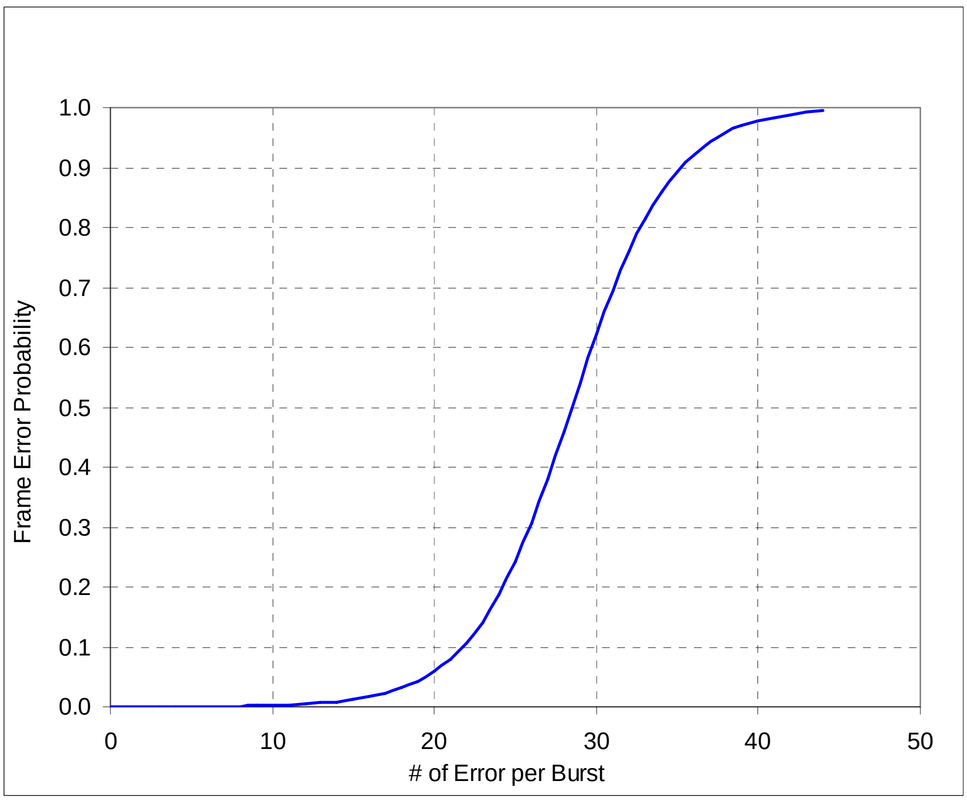

Figure 3: Average Errors per Burst vs. FEP Mapping (AFS59, TU3, Ideal FH, Random Interferer).

Using the burst level BER mappings and the BER to FEP mapping described above, system level simulation results were generated for conventional and SAIC receivers to estimate the capacity gains for SAIC. The system level simulation results presented in this contribution have been generated using the dynamic event-driven GSM system level simulator described in an earlier contribution [5]. Table 1 below shows the simulation model parameter settings used. The simulation parameters have been set according to configuration scenario 3 in [1]. While our prior contributions have presented results without the effect of Rayleigh fading, all results presented in this contribution include the modeling of Rayleigh fading.

Table 1: Simulation Parameters Based On Configuration 3

Parameter	**Value**
Reuse pattern	1/1
Spectrum	2.4 MHz (hopping layer only)
Carriers	12
System timing	Synchronous system
Frequency hopping	Synthesized random hopping with MAIO management
Cell layout	Cloverleaf pattern (corner-excited cells)
Sectors per site	3
Propagation model	UMTS 30.03 (120.9 + 37.6 $\log_{10}$d)
Propagation frequency	900 MHz
Log normal fading STD	6 dB
Correlation distance	110 m
Noise floor	-110 dBm
Adjacent channel interference attenuation	18 dB
BTS output power	20 Watts or 43 dBm
Minimum coupling loss	80 dB
Antenna pattern	UMTS 30.03
Cell radius	0.75 km
Tiers of interferers	2
Wrap around	ON
Channel profile	TU3
MS speed	3 km/h
Mean call duration	90 seconds
Minimum call duration	5 seconds
Handover margin	3 dB
DTX voice activity factor	0.6
Downlink power control	RXLEV + RXQUAL based with 14 dB dynamic range and 2 dB step size
Call dropping algorithm	RXQUAL based leaky-bucket type algorithm – Turned OFF
Handover algorithm	RXLEV and RXQUAL trigger based algorithm
Inter and intra site lognormal correlation	Not modeled
Rayleigh fading	ON

Figure 4 below shows cumulative distribution functions of burst level CINR for 40% FL obtained from the system level simulations. Figure 5 shows burst level results for the below defined interference power ratios for those bursts that experienced CINR<10dB.

The received signal strengths (RSSs) of "m" co-channel interferers are denoted as c_1, c_2, c_3, …, c_m, arranged in decreasing order. Similarly, the RSSs of n adjacent channel interferers are denoted as a_1, a_2, a_3, …, a_n, arranged in decreasing order. Based on these notations, the following interference power ratios are defined:

- c_1/c_2 – Ratio of the RSS of the dominant co-channel interferer and the second dominant co-channel interferer
- c_1/c_3 – Ratio of the RSS of the dominant co-channel interferer and the third dominant co-channel interferer
- c_1/c_r – Ratio of the RSS of the dominant co-channel interferer and the rest of the co-channel interferers ($c_4 + c_5 + \ldots + c_m$)
- c_1/a_1 – Ratio of the RSS of the dominant co-channel interferer and the dominant adjacent channel interferer
- c_1/a_r – Ratio of the RSS of the dominant co-channel interferer and the rest of the adjacent channel interferers ($a_2 + a_3 + \ldots + a_n$)

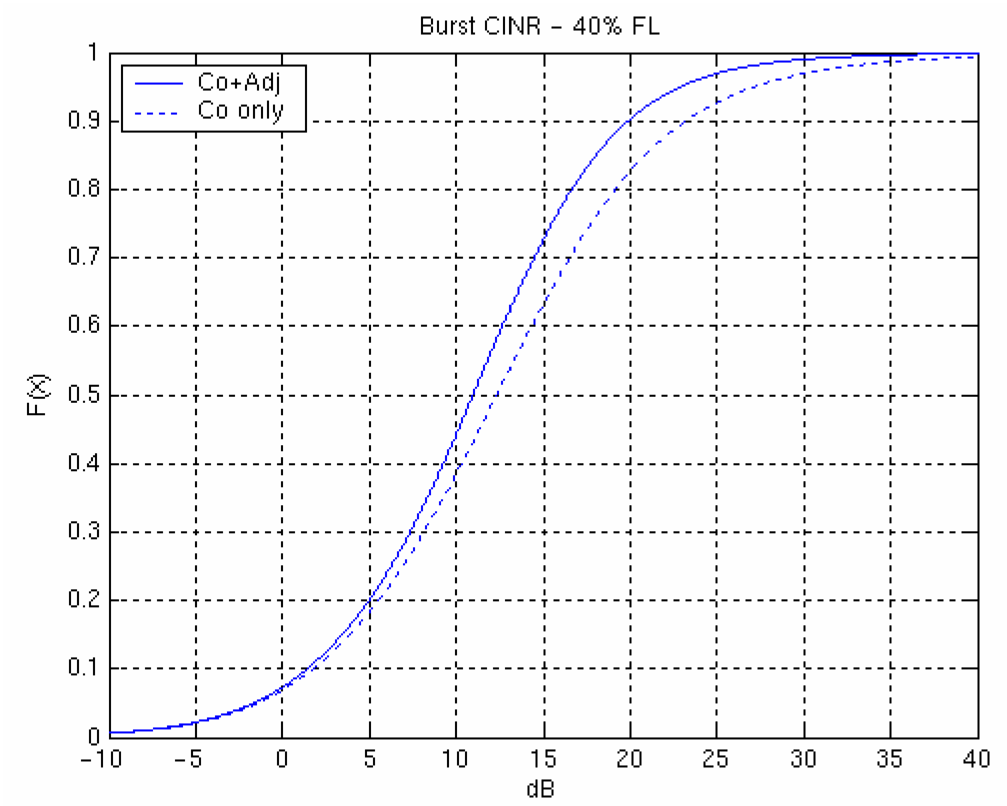

Figure 4: Burst CINR CDFs for 40% FL

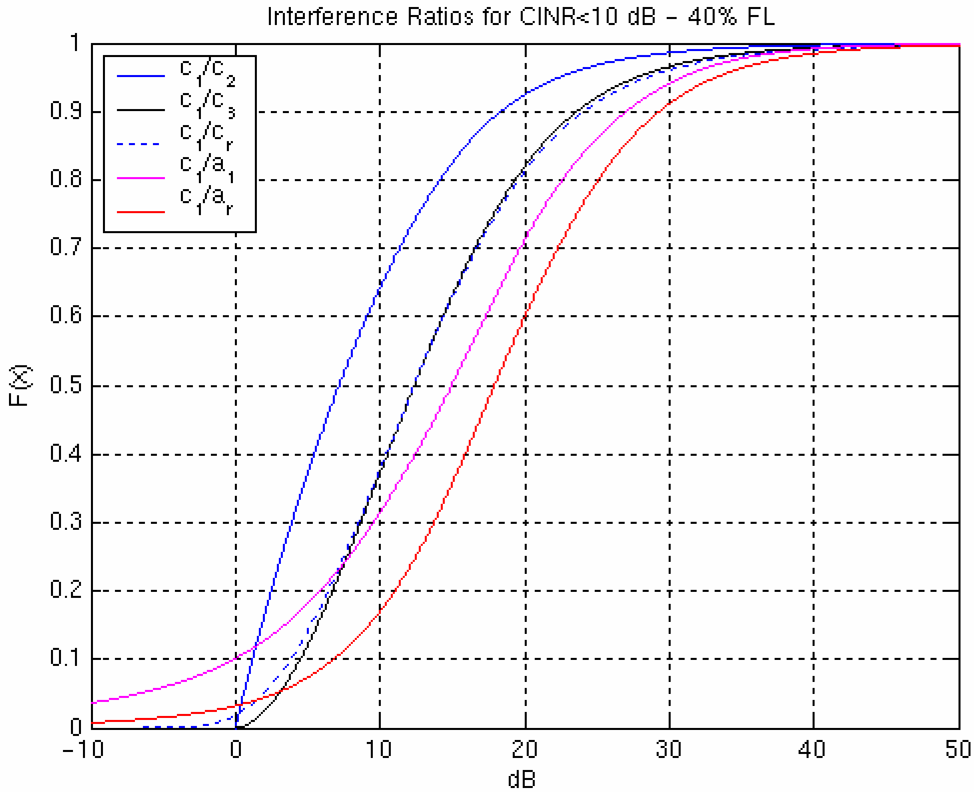

Figure 5: Interference Ratios for CINR<10 dB for 40% FL

Median values of the above presented interference power ratios for configuration 3 at 40% FL are compared in Table 2 with median values defined in GERAN for configuration 2 at 40% FL.

Table 2: Median values for interference power ratios

	Cingular 40% FL for configuration 3	GERAN 40% FL for configuration 2
c1/c2	7.1	6
c1/c3	12.3	10
c1/cr	12.3	9
c1/a1	14.9	14
c1/ar	17.9	15

It is apparent that our 40% FL values for configuration 3 differ somewhat from the 40% FL values for configuration 2 defined in GERAN even though it has been assumed in GERAN that the 40% FL values for configuration 3 and 2 should be the same. In spite of the difference in values observed in Table 2, we believe that if burst level BER mappings are generated based on the two profiles given in Table 2, there will be almost no difference between the mappings.

In the following section we present system level SAIC voice capacity estimates based on the Philips and Trellisware burst level BER mappings and the Cingular BER to FEP mapping. Capacity is measured at the FL at which 95% of the users in the system experience less than 2.5% FER, where FER is measured over a 1.92 second duration. Figure 6 plots percentage satisfied users based on the above criterion versus percentage FL for the Philips conventional receiver, Philips SAIC receiver, and the Trellisware SAIC receiver for the GERAN configuration 3 set of simulation parameters. Table 3 presents capacity estimates for the above three receivers at the 95% satisfied user criterion.

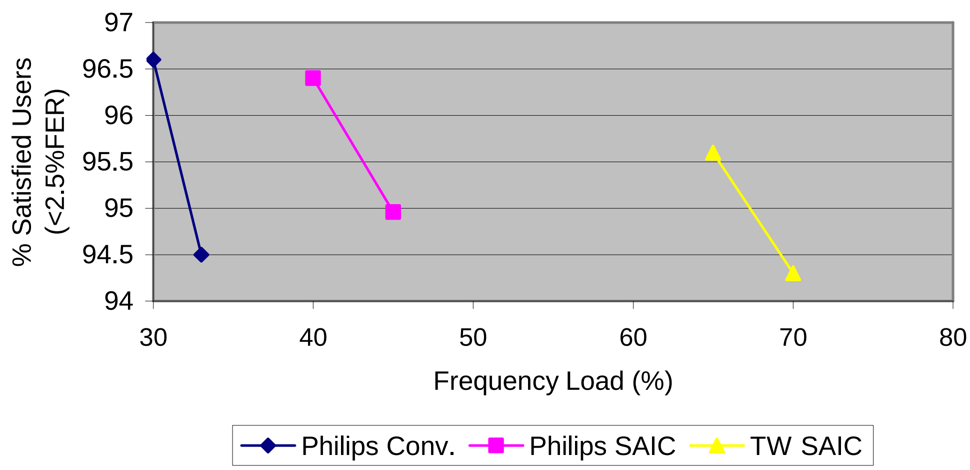

Figure 6: Frequency Load versus % Satisfied Users Results

Table 3: Capacity Results – Homogenous Network Simulator

	FL supported at 95% satisfied users at 2.5% FER	Gain w.r.St. Philips conventional receiver
Philips conventional	32.3	-
Philips SAIC	44.9	1.39 x
Trellisware SAIC	67.3	2.08 x

It can be observed that the Philips SAIC receiver gives a 1.39 times increase in system capacity with respect to the Philips conventional receiver at the above described performance criterion. The Trellisware SAIC receiver gives a 2.08 times increase in system capacity with respect to the Philips conventional receiver. Based on these preliminary results, we are quite encouraged that SAIC will provide significant gains in synchronous GSM networks.

References

[1] GAHS-030015, "SAIC System Simulation Parameters for Characterization of Link Level Scenarios", Rapporteur.
[2] GP-030861, "Summary of SAIC Workshop #2", Rapporteur.
[3] GP-030910, "SAIC Link Performance Simulations", Philips.
[4] GP-030794, "Interference Statistics for SAIC Link Level Evaluation", Cingular.

[5] GAHS-030020, “Interference Characterization for SAIC Link Level Evaluation,” Cingular.