New implementation of CDMA UPLINK in SEAMCAT

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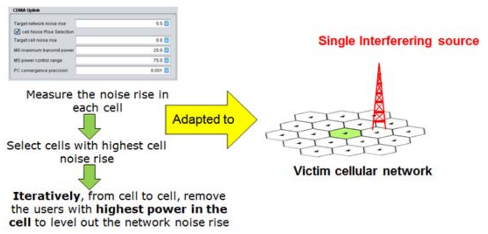
We describe the way of modelling compatibility between cellular networks interfered by a single or a clustered (limited number) powerful interferers. A new SEAMCAT algorithm was developed in order to give user more flexibility to evaluate interference coming from different types of services/applications.

SEAMCAT (Spectrum Engineering Advanced Monte Carlo Tool) is based on the Monte Carlo simulation method, to enable statistical modelling of different radio interference situations. It has been developed to deal with a complex range of spectrum engineering and radio compatibility problems. SEAMCAT is developed within the framework of the CEPT/ECC Working Group Spectrum Engineering (WGSE) within its sub-entity SEAMCAT Technical Group (STG).

In the course of studying interference from MSS User Terminals (UT) into CDMA network (Base stations), it was discovered that the results from SEAMCAT simulation tool using the conventional CDMA algorithm was not adapted when considering interference from a single or a clustered (limited number) powerful interferers to a UMTS network as it may underestimate interference received by a UMTS BS. Conventional algorithm adapted mainly for the cases considering compatibility between two similar types of network.

The original algorithm remains valid however for scenario where the interferers are distributed over the geographical area of the victim CDMA network.

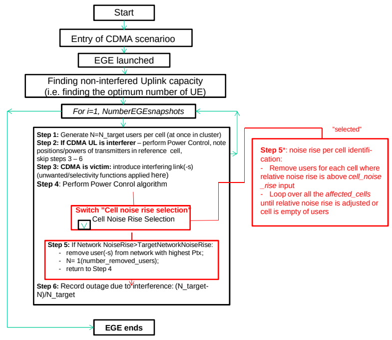


Step-by-step description of the new algorithm is shown in the figure to the left and block diagram to the right. In connection with the development of the enhanced algorithm, two new inputs have been created:

- Cell noise rise selection which is disabled by default.
- "Target cell noise rise" value. User is expected to type in this value.

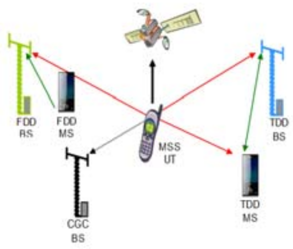
One can see that the latest tab is only available when Cell noise rise selection is chosen. It is set by default to 0.1 dB corresponding to an I/N = -17dB.

The user has the freedom of choosing a different value. The algorithm will assess whether to drop users from any cell in which the noise rise is more than the lower threshold indicated above. The default value has been chosen to ensure that the analysis does not disregard any cases of interfered cells, since users may also be dropped as the consequence of a low noise rise.



Overview of the "new" implementation (in red) with respect to the "old" CDMA UL (in black)

Interference scenario



Interference scenario

MSS UT (Mobile Satellite System User Terminal) is transmitting to a satellite in the 1980-2010 MHz band. The following Electronic Communication Network (ECN) components may be interfered due to unwanted emissions of MSS UT and blocking depending on the adjacent channel selectivity of the receiver:

- ECN FDD Base Stations (BS) receiving in the 1920 1980 MHz band;
- ECN TDD Base Stations (BS) receiving in the 2010 2025 MHz band;
- ECN TDD User Terminals (UT) receiving in the 2010 2025 MHz band.

The green line on left figure represents the wanted signal paths meaning the path of the victim system. The red line on the same figure illustrates the interference from the MSS UT. The solid and dashed black line depicts the established connection between the MSS UT with the satellite and the CGC BS respectively. In this study, the victim is the CDMA BS (FDD operation only).

Methodology of study including description of the new algorithm

Main parameters of land-based UMTS systems used in SEAMCAT calculations were taken in accordance with ECC report 197. In addition to those, several other secondary yet important parameters needed for SEAMCAT simulations were assumed as follows:

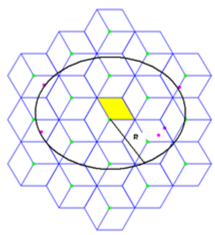
PARAMETERS USED TO DEFINE VICTIM UMTS SYSTEMS TABLE STYLES

Parameter	Value
Voice activity factor	1(Note a)
Receiver noise figure: Macro BS	5.4 dB
Voice bit rate	12.2 kbps (Note b)
Link Level Data sets	W-CDMA/UMTS: SEAMCAT: 1900MHz; 1 % FER
Target network noise rise for CDMA Uplink	6 dB
UMTS BS' adjacent channel selectivity/blocking rejection	See Table 3 of ECC Report 197
UMTS cell radius	See Table 3 of ECC Report 197
Cell type	3 - sector antenna
Initial UMTS capacity, MS per sector	Generated and optimized by SEAMCAT

When the victim is a CDMA system, it may use its inherent power tuning mechanism to try to compensate for the interference received, up to a point when relevant network resources reach their limits and the victim system starts to disconnect some of the earlier associated users. The interference here is therefore measured not in terms of probability of exceeding the C/I criterion, but in terms of probability of exceeding a certain capacity loss. In order to model this power tuning process correctly, the SEAMCAT tool builds a cluster of 19 CDMA sites (57 cells) and further complements it for the effect of "endless network" by applying a certain "wrap-around" technique.

In this setup MSS UT's are interfering into victim CDMA BS receivers (uplink). The physical outline of this scenario was derived by randomly positioning 1 (or 5) UT within an area with radius of 16.9 km for rural environment from the central (reference) cell of an ECN. A snapshot taken from the status window of a SEAMCAT simulation is shown to the right. The magenta dots indicate the location of the MSS UTs, while the green dots indicate the location of the ECN BS.

For each event, SEAMCAT randomly positions 1 (or 5) interfering transmitter(s), depending on the considered scenario.



Outline of SEAMCAT simulations

AVERAGE CAPACITY LOSS OF THE STATISTICAL STUDY

Scenario	Interferer	Whole network	Reference cell	Worst cell
A	Wideband, rural, 1 high gain UT	0.3%	0.4%	11.5%
B	Wideband, rural, 5 high gain UTs	0.9%	1%	37.6%
C	Wideband, rural, 1 low gain UT	0.7%	1.7%	29.7%

Results of statistical calculations

Taking into account assumptions, the following additional parameters have been used for defining the various workspaces relative to the interference assessment of MSS UT to ECN Uplinks:

- Number of snapshots for a single simulation = 2000 events;
- High gain MSS UT elevation angle = 20 deg
- Target cell noise rise = 0.8 dB (corresponding to an I/N = -7dB)

For simplification reason, in the scenarios for the low gain, narrowband UTs, the Adjacent Channel Leakage power Ratio (ACLR) we took values are actually those applicable to the high gain narrowband UTs (i.e. 11 dB ACLR in the first adjacent channel).

The following vectors available as the output vectors in SEAMCAT after enabling new algorithm. Those vectors have then been used for determining the required statistics:

- "Average Capacity Loss, system" for determining the system capacity loss;
- "Average Capacity Loss, Reference cell" for determining the capacity loss in the Reference cell;
- "Average Capacity Loss, Worst cell" for determining the capacity loss in the Worst cell for every snapshot.

ECN Uplink average capacity losses for the scenarios from A to C are summarized in the TABLE to the left and show that:

- For the same type of MSS terminals, the ECN UL capacity loss is dependent on the number of interferers, For example, the system capacity loss in scenario B (5 MSS UT) is higher than that of scenario A (1 MSS UT).
- The average ECN UL whole network capacity loss varies from 0.3% to 0.7% depending on the scenario. For the ECN UL case, the Reference cell average capacity loss varies from 0.4% to 1.7%, depending on the scenario.

For the ECN UL case, the Worst cell average capacity loss varies from 11.5% to 37.6%, depending on the scenario

Conclusions

SEAMCAT is a valuable tool to provide solutions to spectrum engineering problems in the very efficient and flexible manner. This software is platform independent and can be downloaded at: www.seamcat.org

Statistical analysis has been performed with the SEAMCAT tool for studying the interference effects into ECN macro base stations and ECN UT.

Before new enhanced CDMA UL algorithm was developed and introduced the results obtained with conventional implementation of CDMA UL shown that average capacity loss in the victim CDMA network is quite low while logically it should be higher if victim BS located very close to the powerful interfering transmitter. Analysing results obtained with new algorithm one can see that overall network capacity loss increased while affected by a strong single interferer.

We based our considerations on the fact that MSS terminal interference to the UMTS network is considered sufficiently low if the capacity loss is no more than 5 % on average over the different snapshots.

The results in TABLE "Average capacity loss of the statistical study". for scenarios A, B and C (MSS UTs into ECN BS at 1980 MHz) show that for the worst cell analysis, the 5 % criterion is exceeded in all cases. For every time the MSS transmits will at least one UMTS cell be affected with the average worst cell outage value and that the system average values is a calculated value that is based on few interfered cells and many non-interfered cells.