DARP – new receiver technologies boost network capacity

With a steadily increasing number of mobile radio subscribers having to share limited frequency resources, operators are looking for economical ways to expand their network capacity. An obvious approach is to use the available frequency spectrum as effectively as possible by employing a reuse factor of 1:1. This, however, involves considerable adjacent-channel interference, which would diminish the desired effect. One solution can be found in a new receiver technology: DARP (downlink advanced receiver performance).

Reuse factor 1:1 – pros and cons

Ideally, each cell of a network would transmit at each available frequency, meaning a reuse factor of 1:1. This option would provide maximum network capacity. But there is a drawback: In such a scenario, a mobile phone would receive a number of different signals from neighboring radio cells. These signals would be superimposed on the wanted signal, thus causing interference. A reuse factor of 4:12 is therefore currently employed in many mobile radio networks.

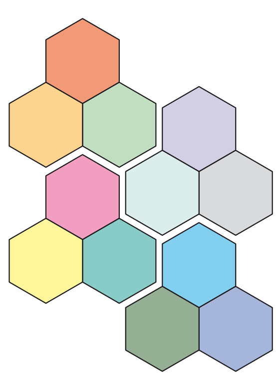
FIG 1 illustrates the scenarios for the reuse factors of 4:12 and 1:1. With a reuse factor of 4:12, the 12 frequencies available for a base station are allocated to the station's four cells, i.e. one frequency to each of the three sectors of a cell. This means that each sector can utilize only 1/12 of the available frequency resources. The reuse pattern repeats after every fourth cell.

With a reuse factor of 1:1, by contrast, all 12 frequencies are available in each cell, i.e. the network provides the maximum capacity.

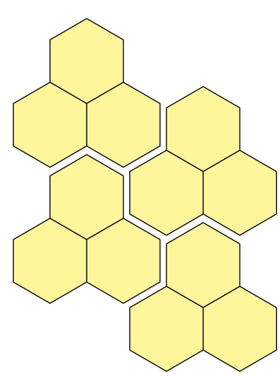
New techniques for expanding network capacity meet with great interest among network operators and mobile radio manufacturers. Initial approaches aimed at handling adjacent-channel interference by implementing appropriate features in the mobile phone led to the use of additional antennas (antenna diversity). However, this solution would have necessitated considerable hardware and software changes in the mobile terminals.

The solution: DARP

The solution offered by DARP increases network capacity by employing lower reuse factors, and at the same time suppresses interferences. The new technique requires no multiple antennas and works at the chip level (baseband) by



Reuse factor 4:12
Four cells with three sectors each and a total of 12 frequencies. Each sector is allocated a separate frequency and can, therefore, use only 1/12 of the available frequency resources.



Reuse factor 1:1
The ideal case: Each cell and each sector use the same frequency; the maximum network capacity is available.

FIG 1 Different reuse factors in mobile radio networks and their effect.

means of signal processing in the mobile phone. It allows network capacity to be expanded and base station transmit power to be reduced at the same time. DARP is used synonymously with the term SAIC (single antenna interference cancelation).

The DARP technique operates with the antenna integrated in the mobile phone and is based on a knowledge of GSM modulation, which makes it possible to suppress as effectively as possible adjacent-channel interference that differs from general noise. Simulations and field trials have shown that optimum interference suppression, and thus maximum increase in performance, are achieved with a synchronous network structure.

The currently relevant DARP algorithms can be divided into two basic categories.

Joint demodulation (JD)

The JD algorithm is based on a knowledge of the GSM signal structure in adjacent cells in synchronous mobile radio networks. Using this algorithm, one or several interference signals can be demodulated in addition to the wanted signal. This capability of retrieving interference signals allows the suppression of specific adjacent-channel interferers.

Apart from GMSK-modulated signals, JD is also capable of demodulating 8PSK (EDGE) signals. However, the fact that interfering signals are demodulated at the same time makes this technique considerably more complex to implement and thus dramatically increases the required computing power.

Blind interferer cancelation (BIC)

The BIC algorithm only demodulates the GMSK signal of the wanted carrier; the receiver has no knowledge of the structure of any interfering signals that may be received at the same time. In other words, the receiver is "blind" to any adjacent-channel interferers that may occur, and attempts to suppress the interfering component as a whole. Given this characteristic, BIC is suitable only for GMSK-modulated speech and data services, but can also be used in asynchronous networks.

Reference test scenario	Interference sources	Relative interference level	Training sequence	Delay of interference signal
DTS-5	Co-channel 1	0 dB	None	74 symbols
	Co-channel 2	–10 dB	None	None
	Adjacent channel 1	3 dB	None	None
	AWGN	–17 dB	–	–

FIG 2 Reference test scenario with several asynchronous interference sources.

Speech channels (TCH/FS, TCH/AFSx, TCH/AHSx)	FER ≤1%
Signaling channels (FACCH/F, SDCCH)	FER ≤5%
Packet-switched channels (PDTCH)	BLER ≤10

FIG 3 Requirements of DARP conformance tests.

Status and test strategy of 3GPP specifications

In early 2005, the 3GPP TS 45.005 (Radio Transmission and Reception) and 3GPP TS 51.010-1 (MS Conformance Test Specification) standards were extended to include DARP-compatible mobile phones. The 3GPP standard defines five DARP reference test scenarios (DTS) for synchronous and asynchronous networks and specifies the required performance values in each case.

FIG 2 shows an example of test scenario DTS 5 with four interference sources. The interferers are configured with a different level, delay and training sequence code (TSC). A uniform fading profile (TU 50) is superimposed on all interferers as well as on the carrier signal.

Sixteen new test cases were created on the basis of the DARP reference scenarios. Using these test cases, DARP-compatible mobile phones can be checked for conformance with the requirements listed in FIG 3.

DARP test solutions from Rohde & Schwarz

The R&S®TS 8950, R&S®TS 8952 and R&S®TS 8955 RF test systems support all currently available DARP test cases. Existing test systems can be upgraded to provide test functionality covering the additional interference signals specified in the test cases.

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More information and data sheets for the test systems at www.testsystems.rohde-schwarz.com

REFERENCES
– 3GPP TS 45.005
– 3GPP TS 51.010-1
– 3GPP TR 45.903