GSM FUNCTIONALITY AND PARAMETER FINE-TUNING: A CASE STUDY

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Abstract *– This paper documents the effect on the performance of an Ericsson™ global system for mobile communication (GSM) network realized by evaluating functionality and fine-tuning parameters after completing the pre- and post-launch optimization phases. These actions were carried out during a base station subsystem (BSS) performance optimization project attempting to further improve the quality of service (QoS) because network traffic was increasing. Each feature changed is addressed separately, followed by a short technical description of the philosophy of the changes performed, the exact settings selected, and a statistical evaluation of the results. This paper demonstrates that network performance gains can be achieved from optimum use of the available functionality and parameter tuning. This paper can also serve as a reference for optimizing Ericsson CME20*[1] *systems.*

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INTRODUCTION

Since first deployed in 1992, European global system for mobile communication (GSM) networks have become a major commercial success. Currently, penetration levels approach 100 percent in some European countries. The rapid increase in subscriber numbers prompted network operators to increase investment in network infrastructure by embarking on aggressive network rollout projects aiming to expand system coverage and capacity. Increasing demand for mobile services and competition for market share led many operators to dedicate most of their resources to network deployment. Under these circumstances, the industry eventually developed the mindset of "roll out now and optimize later."

Until the late 1990s, most network operators competed purely on coverage, considered the most important differentiator among the offered services. Having "signal bars" on phones was all that mattered, even though calls were failing in many cases. Users expected to see signal bars on their phones everywhere. Focused mainly on an agressive buildout strategy, several operators continued to use default parameter values without fully exploiting the available functionality of the given system.

Network pre- and post-launch optimization is a useful mechanism to ensure good performance after commercial launch of the service. However, as the network expands and traffic increases, the benefits of post-launch optimization may be lost.

Ongoing changes in functionality and parameter settings are necessary to provide optimum and constant quality of service (QoS). All system vendors continuously seek to improve functionality by adding improved features with every base station subsystem (BSS) software release. If fully exploited, this continuous evolution of functionality can result in significantly improved QoS and more efficient use of network infrastructure.

This paper describes a review of the functionality and parameter values of an Ericsson™ GSM network containing approximately 150 base transceiver stations (BTSs) with three cells per BTS and main sector configuration of 0-120-240 degrees [1]. This review began as an optimization project 6 months after completion of the post-launch optimization phase. During this period, traffic increased substantially and the network was expanded to satisfy capacity demand as well as to extend coverage.

A number of features were evaluated and fine-tuned. These features are listed below, followed by a short technical description of each and the philosophy of the performed changes, the exact settings selected, and a statistical evaluation of the results. The seven functions discussed below apply to Ericsson BSS R8 and R9 (Releases 8 and 9).

- Frequency hopping
- Mobile station dynamic power control
- Cell load sharing
- Locating penalty timers
- Flow control timers

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[1] Ericsson's GSM application

ABBREVIATIONS, ACRONYMS, AND TERMS

BCCH	broadcast control channel
BSC	base station controller
BSIC	base station identity code
BSS	base station subsystem
BTS	base transceiver station
C/I	carrier-to-interference (ratio)
CLS	cell load sharing
CP	central processor
CTR	cell traffic recording
DCR	dropped call rate
DPC	dynamic power control
FH	frequency hopping
GSM	global system for mobile communication
HSN	hopping sequence number
MAHO	mobile assisted handover
MS	mobile station
QoS	quality of service
SACCH	slow associated control channel
SDCCH	standalone dedicated control channel
TCH	traffic channel
UL	uplink

ERICSSON PARAMETERS

ACCMIN	minimum signal strength to access the cell
BSRXSUFF	received by the BTS sufficient signal strength level
CLSACC	CLS traffic accept
CLSLEVEL	CLS level
EVALTYPE	evaluation type
HIHYST	high-signal-strength hysteresis
HODWNQA	handovers due to downlink signal quality
HOTOKCL	handovers to K cells
HOTOLCL	handovers to L cells
HOUPLQA	handovers due to uplink signal quality
HYSTSEP	signal strength level between high and low strength cells
KHYST	K-criterion hysteresis
LCOMPUL	uplink signal strength compensation factor
LHYST	L-criterion hysteresis
LOHYST	low-signal-strength hysteresis
MSRXSUFF	received by the mobile sufficient signal strength level
PSSBQ	penalty value for bad quality
PSSHF	penalty value for failed handover
PTIMBQ	penalty timer for bad signal quality
PTIMHF	penalty timer for handover failure
QCOMPUL	uplink signal quality compensation factor
QDESUL	quality desired for uplink
RHYST	region hysteresis
RXLEV	measured signal strength level
RXQUAL	measured signal quality
SSDES	signal strength desired
TALLOC	time between TCH allocations
TCALLS	counter for TCH allocation attempts
TCONGAS	congestion timer for immediate TCH assignments
TCONGHO	congestion timer for handover TCH assignments
TURGEN	time for urgent handover

- Cell selection and access
- Signal strength measurement criteria in the locating algorithm

FREQUENCY HOPPING

Frequency hopping (FH) means that multiple frequencies are used to transmit speech or data in a single connection. The basic principle involves transmitting consecutive bursts at different frequencies. Each cell uses a predefined set of frequencies, among which the connection hops according to a specified pattern (i.e., cyclic or random) 217 times per second. The radio environment between a mobile station (MS) and a BTS is subject to variations due to multipath fading and cumulative interference. FH can improve the radio environment, providing frequency diversity against the multipath fading and averaging the overall interference. See [2].

Parameter Adjustment and Evaluation

Cyclically sequenced baseband FH was introduced at launch in traffic channels (TCHs) and standalone dedicated control channels (SDCCHs). With this pattern, all available frequencies of a cell are used with a consecutive order in a call or signaling connection. For instance, a connection in a three-frequency *(f1, f2, f3)* cell will show the following burst-to-burst pattern:

…f3, f2, f1, f3, f2, f1, f3, f2, f1, f3, f2, f1,…

With reuse-pattern frequency planning, cyclic hopping may result in connections in cells that are reusing the same frequencies to get in phase with one another, hopping "hand in hand" but losing the benefit of interference averaging.

Random FH was proposed, which introduces a pseudo random hopping sequence, according to parameter hopping sequence number (HSN). Up to 63 different FH patterns not correlated with one another can be defined. The burst-to-burst pattern would look as follows:

…f3, f1, f2, f2, f1, f3, f3, f2, f1, f1, f2, f1,…

Carefully choosing HSN values for cells using the same frequency groups was expected to increase the interference averaging gains of FH.

Random FH was introduced in all cells, with an HSN per cell based on the base station identity code (BSIC) plan (HSN = 63 – BSIC), which was also planned to differentiate between co-channel cells.

Old values: HOP = ON, HSN = 0 => Results in cyclic hopping (HOP is the Ericsson cell level parameter to enable hopping)

New values: HOP = ON, HSN = (63 – BSIC) => Results in random hopping

As can be seen from the results in **Figure 1,** a considerable improvement in QoS was achieved. The dropped call rate (DCR) decreased by approximately 20 percent.

MOBILE STATION DYNAMIC POWER CONTROL

MS dynamic power control (DPC) is a feature that controls the output power of an MS so that the BTS receives a desired uplink signal strength level. MS DPC helps reduce MS battery consumption, protects against possible BTS receiver saturation, and reduces overall uplink interference.

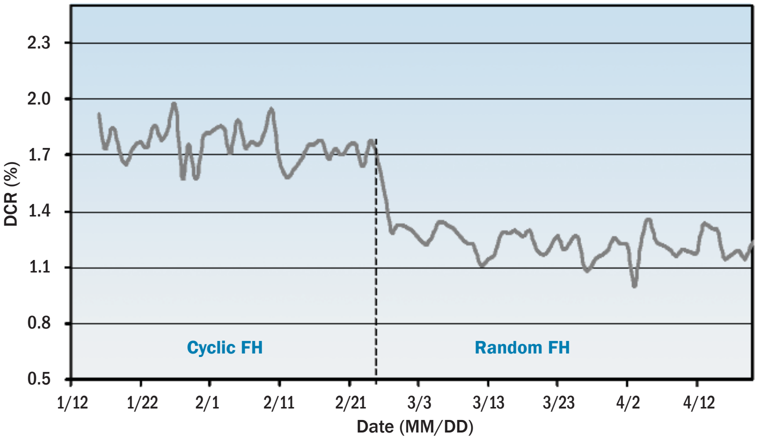

Figure 1. Network DCR After Implementation of Random Hopping Sequence

The MS DPC algorithm is implemented on the base station controller (BSC) and performed for both TCHs and SDCCHs. The algorithm calculates a power order according to BTS received signal strength and BTS measured quality. The first term introduces MS power reduction based on a desired value—signal strength desired (SSDES)[2]. The second term introduces compensation for bad quality, according to a desired value for signal quality—quality desired for uplink (QDESUL)[2]. The MS power capabilities are a limiting factor. The MS power cannot be reduced beyond the minimum output power of the MS (for phase 2 MSs, the dynamic power range is 8 dBm to 33 dBm).

Parameter Adjustment and Evaluation

MS DPC was initially introduced with the following settings for desired values and weighting factors:

- SSDES = –94 dBm
- QDESUL = 10
- Uplink signal strength compensation factor (LCOMPUL)[2] = 50
- Uplink signal quality compensation factor (QCOMPUL)[2] = 30

These initial values correspond to an aggressive power-down regulation aiming to minimize uplink interference. However, it was observed from analyzing drive test files and cell traffic recording (CTR) files that the settings could lead to performance deterioration. For instance, a connection with received signal strength (RXLEV)[2] = –80 dBm and received signal quality (RXQUAL)[2] = 5, given the previous settings, would be further down-regulated in steps of 2 dB, despite the obvious quality problem.

After studying the case, a more reasonable value of SSDES = –88 dBm was introduced, while QDESUL was set to zero. Also, compensation factor LCOMPUL, which introduces a slope in the

> *Considerable network performance gains can be made by fully utilizing the available functionality and fine-tuning the network parameters using statistics to evaluate the results.*

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[2] An Ericsson DPC parameter

power reduction, was set to 100. This setting corresponds to maximum uplink regulation (no slope) because the algorithm was expected to work rapidly on "good" signals. Quality compensation parameter QCOMPUL was set to 60 to enhance up-regulation in case of interference and to give the connection a chance to overcome the bad quality by increasing the output power. For a more detailed description of the algorithm, see [3].

Figure 2 shows the positive effect of the changes on the MS DPC settings in terms of dropped connections due to uplink quality and uplink signal strength. The indices "min-ERLANG/ UL_QUAL-DROP" (minutes of traffic carried before a call drop due to uplink signal quality occurs) and "min-ERLANG/UL_SS-DROP" (minutes of traffic carried before a call drop due to uplink signal strength occurs) were used.

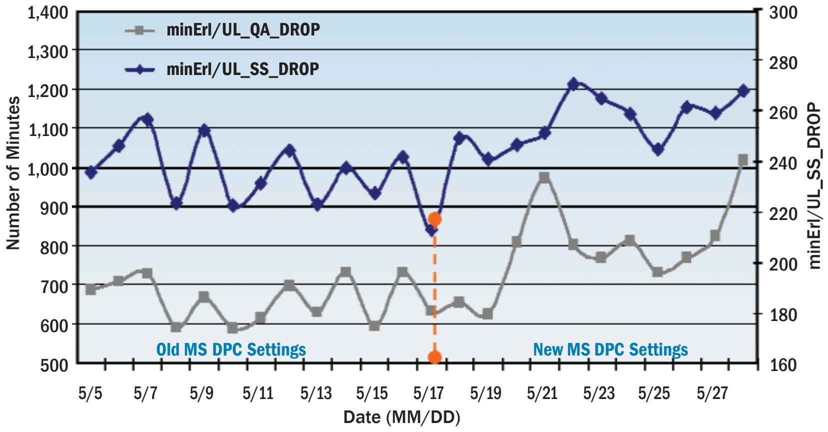

Figure 2. Effect of New MS Power Control Settings

The indices presented in Figure 2 are TCH drops due to bad uplink quality and low uplink signal strength related to the traffic carried by the system. The indices "minErl/UL_QA_DROP" and "minErl/UL_SS_DROP" express the minutes of traffic the system carries before a drop occurs due to bad uplink quality or low uplink signal strength. The minute-Erlang method was used because it is more sensitive to changes and thus more accurately evaluates the effectiveness of optimization activities. The minute-Erlang per drop index is inversely proportional to the DCR index.

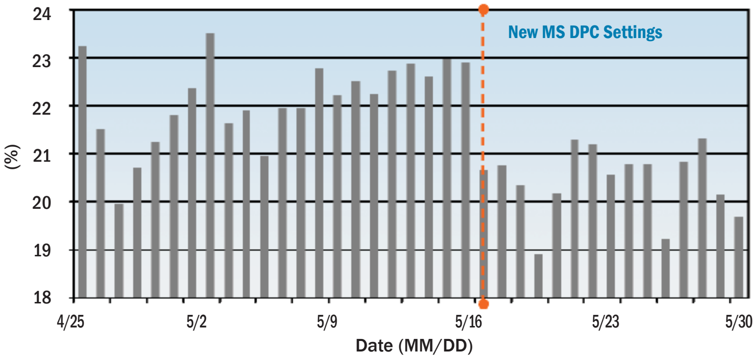

Figure 3. Effect on Handovers due to UL Quality of new MS Power Control Settings

Due to the new settings for SSDES, the average power received on the uplink is greater than before, so the risk of a connection dropping due to weak signal strength on the uplink should decrease. Since the main reason for uplink quality is also believed to be the strength of the MS transmitted signal power, bad quality drops on the uplink should also decrease with the new settings.

In **Figure 3**, the improvement trend can be verified by examining the handover reasons due to uplink (UL) quality.

CELL LOAD SHARING

Cell load sharing (CLS) is a feature that distributes traffic among neighboring cells at high traffic load to reduce congestion and better use the available resources.

The CLS algorithm works by monitoring traffic load for every cell in terms of idle TCHs. When the number of idle TCHs in a given cell, expressed as a percentage of the total, falls below the CLS level (CLSLEVEL)[3], traffic is shifted from this cell to prevent it from being congested. Connections close to the cell border, within an area determined by region hysteresis (RHYST)[3], are handed over to any neighboring cell considered suitable to accept traffic, i.e., whose percentage of idle TCHs is greater than the value CLS traffic accept (CLSACC)[3].

Drawbacks of the feature are the increased number of handovers and a considerable increase in BSC central processor (CP) load. For a detailed description of the functionality and algorithm, see [4].

Parameter Adjustment and Evaluation

The CLS feature was introduced networkwide to cope with unevenly distributed traffic among cells, to use the available resources efficiently, and to increase the total capacity. The original parameter set was CLSLEVEL = 23, CLSACC = 55, and RHYST = 75, meaning that CLS evaluations for a cell started when the idle number of TCHs fell below 23 percent, while a cell accepted CLS traffic only if 55 percent or more of its resources were idle.

Statistical analysis indicated that with these settings, the success rate of CLS handovers was poor, mainly because of the high values of

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[3] An Ericsson CLS parameter

CLSLEVEL and CLSACC. A more reasonable setting was introduced, where a cell would more easily accept CLS handovers (CLSACC = 25) and would not start CLS evaluations as soon (CLSLEVEL = 15). Also, RHYST was set to 100, maximizing the area around the nominal cell border where CLS could take place.

In **Figure 4**, the impact of the change can be seen. Cell load sharing became more effective, since CLS calculations were limited, practically maintaining the same number of successful CLS handovers. This development had a positive effect on the BSC CP load.

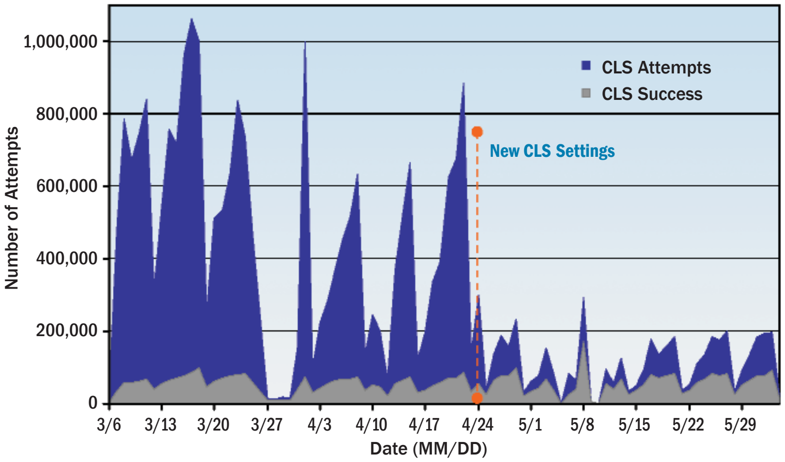

Figure 4. Effect of CLS Parameter Changes

LOCATING PENALTY TIMERS

Penalty timers for bad signal quality (PTIMBQ)[4] and for handover failure (PTIMHF)[4] specify the time in seconds for which the respective penalty values in decibels, namely penalty value for bad quality (PSSBQ)[4] and penalty value for failed handover (PSSHF)[4], are applied to a cell's neighbors.

When an urgent handover is successfully performed that resulted from bad quality due to downlink, uplink, or both, the originating cell is penalized with PSSBQ decibels to prevent immediate hand-back to this cell. The original cell is penalized because bad radio conditions might still be in effect there; also, the original bad quality cell is most likely the best cell from a strictly signal strength point of view. Under a similar philosophy, handover to a cell where a handover failure occurred is inhibited for a time determined by timer PTIMHF [5].

Parameter Adjustment and Evaluation

Penalty values PSSBQ and PSSHF were both set to 50 dB to remove the penalized cells from the locating algorithm evaluations. However, the lengths of the timers, PTIMBQ = 10 sec and PTIMHF = 5 sec (original settings), were thought to be insufficient to give radio conditions in the penalized cell a chance to improve. The lengths of the two timers must be carefully chosen, on the other hand, to predict handover performance of fast-moving subscribers. A very high value may lead to call drops due to handover being inhibited for a time not matching the user's mobility. The new time settings selected were PTIMBQ = 15 sec and PTIMHF = 12 sec.

Figure 5 shows the effect of this change in handover performance. The term "ping-pong" indicates the percentage of handovers back to the originating channel within 10 seconds. Handover success improved as a direct result of reducing the possibility of attempted connections to a cell suffering from poor quality.

The reduction of mobile connections lost during handover can be seen in **Figure 6**. In addition to the improvements in ping-pong effect and handover success rate, the timer change also had a positive effect on network dropout performance. In a typical GSM network, nearly

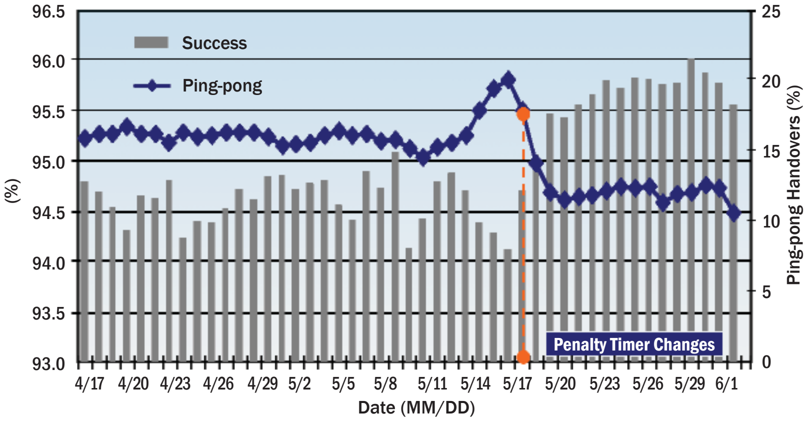

Figure 5. Effect of Penalty Timer Changes on Network Handover Performance

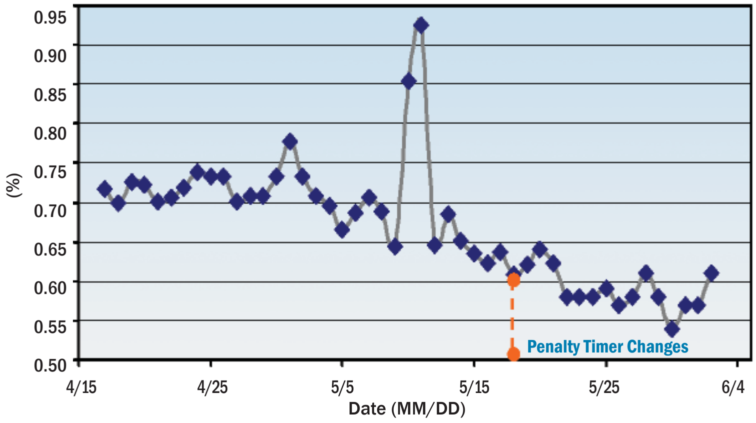

Figure 6. Effect of Penalty Timer Changes on Percent of Mobiles Lost During Handover

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[4] An Ericsson locating algorithm parameter

30 percent of the total dropped calls occur during handover, which is considered a sensitive task in the radio environment.

A more reliable way to assess the overall dropout performance is to determine the MSs lost during handover in relation to the total traffic. This data is shown in **Figure 7**, where a clear and steadily increasing trend is apparent for the index "minErl/MSLOST" (minute-Erlangs per MS lost during handover).

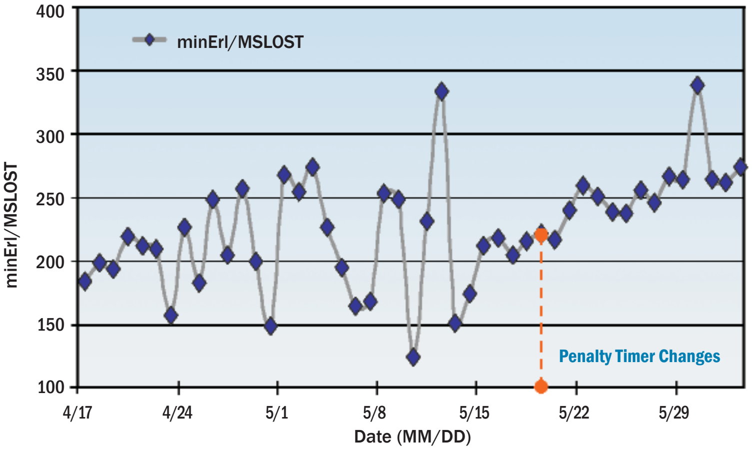

Figure 7. Effect of Penalty Timer Changes on Mobiles Lost During Handover in Relation to Traffic

FLOW CONTROL TIMERS

Flow control timer time between TCH allocations (TALLOC)[5] gives the time in slow associated control channel (SACCH) periods (480 msec) between consecutive TCH allocation attempts, from the channel allocation algorithm, if the first TCH allocation attempt fails. The timer is used during assignment when the BSC attempts to find an idle TCH for data or speech and also during handover. No candidate list is prepared from the locating algorithm before the timer expires unless an urgency is detected, in which case the new list for handover is sent within the time specified by the timer for urgent handover (TURGEN)[5].

Parameter Adjustment and Evaluation

Parameter TALLOC specifies the pace at which allocation attempts counted by the Ericsson BSC counter for TCH allocation attempts (TCALLS)[5] are repeated when congestion is counted by the Ericsson congestion timer for immediate TCH assignments (TCONGAS)[5] or by the Ericsson congestion timer for handover TCH assignments (TCONGHO)[5]. A decision was made to change the original setting from two SAACH periods to four to limit the number of allocation attempts per event (assignment or handover). Multiple allocation attempts increase the overall measured congestion because congestion timers TCONGAS and TCONGHO count every allocation attempt. By increasing TALLOC, the measured figures for congestion during handover and assignment will be closer to the true, customer-perceived congestion.

Figure 8 shows the measured congestion trend after the change was performed, indicating that the overall measured congestion rate during the busy hour is reduced. Reducing the number of channel allocation attempts can also have a positive effect on the BSC CP load.

CELL SELECTION AND ACCESS

Some of the parameters controlling MS idle mode behavior during cell selection and system access are critical for the system's performance. Minimum signal strength to access the cell (ACCMIN)[6] is a cell-level parameter that determines the minimum received signal strength at the MS required to access the system. When an MS first tries to camp to a cell, the MS decodes ACCMIN, which is transmitted on the system information messages of the broadcast control channel (BCCH), and compares it to the actual signal strength the MS measures. If ACCMIN is higher, the MS is not allowed to camp to the cell because the MS is considered to be at poor radio conditions.

Parameter Adjustment and Evaluation

Depending on the setting of ACCMIN, the cell radius (in idle mode) can be modified. ACCMIN was originally set to –107 dBm to improve the customer perception of the available coverage. However, such perceived improvement was achieved at the risk of an increased number of call set-up failures, since MSs at poor radio conditions were allowed to access the system. Additionally, the mobile equipment static sensitivity is limited to approximately –104 dBm for most of the handsets available, so lower signals are not practically measurable.

A lower ACCMIN value also meant that fewer subscribers were able to respond to paging messages and that poor paging performance could result [6].

To improve call set-up performance and minimize the risk of SDCCH dropped connections, ACCMIN was set to the quoted mobile static sensitivity of –104 dBm and the SDCCH drop rate was monitored. The expected improvements were verified by a 22 percent reduction in SDCCH drops, as shown in **Figure 9**.

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[5] An Ericsson flow control parameter

[6] An Ericsson access parameter

SIGNAL STRENGTH MEASUREMENT CRITERIA IN THE LOCATING ALGORITHM

The locating algorithm implemented in the BSC controls cell selection in dedicated (i.e., call) mode and determines handover decisions. The main objectives of handover are to maintain call continuity and quality and to control cell size and handover borders to minimize total network interference.

The inputs to the locating algorithm are signal strength and quality measurements from the MS (the so-called mobile assisted handover [MAHO]) and from the BTS. The output is a list of candidate cells for handover, ranked in descending order according to preferences and constraints introduced by other features and by the settings of the algorithm itself. The locating algorithm works continuously for all active MSs and completes a cycle every SAACH period (480 msec).

The signal strength measurements reported by the MS and the BTS are evaluated according to comparison criteria that can be selected with different settings in the locating algorithm. The first is the *signal strength* or *K* criterion and the second is the *path loss* or *L* criterion. They are used to compare reported values for serving and neighboring cells to determine the optimum cell ranking and the handover borders.

In the K-criterion mode, the comparisons are performed purely according to the received signal strength (i.e., cells measured with higher signal strength are ranked higher). Hence, an increase in the output power of a cell signifies expansion of its service area. This criterion seeks to maximize the carrier-to-interference (C/I) ratio by maximizing "C."

In the L-criterion mode, path loss is taken into account. Cells with lower path loss are ranked higher, and the output power of each cell does not affect the calculations. The criterion actually favors cells with low output power; thus, improvement in C/I ratio is attempted by decreasing the total interference. However, L ranking can sometimes lead to a locally lower C/I ratio than K ranking. Two cell ranking algorithms are available, set by BSC parameter evaluation type (EVALTYPE)[7] [5]:

- Ericsson-1-2, which uses both L and K ranking. The candidate cells are separated into high- and low-signal cells by comparing received signals to the following parameters for downlink and uplink, respectively: received by the mobile sufficient signal strength level (MSRXSUFF)[7] and received by the BTS sufficient signal strength level (BSRXSUFF)[7]. High-signal-strength cells are ranked according to the L criterion and the rest according to the K criterion.
- Ericsson-3, where ranking is performed only according to the K criterion, but two separate hysteresis values are used.

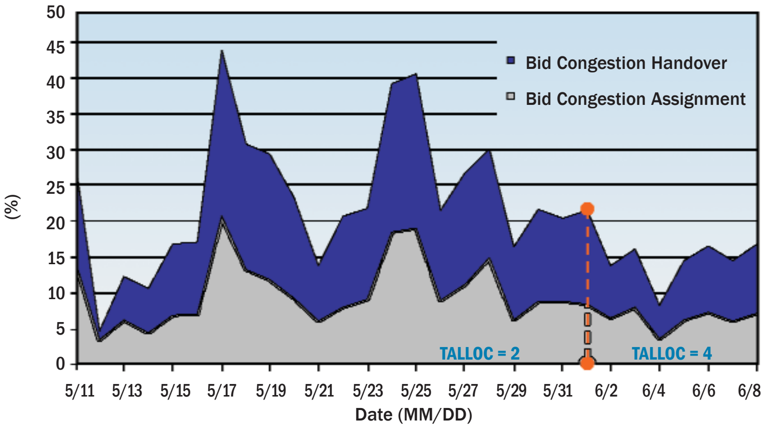

Figure 8. Difference of Measured Congestion After Flow Control Timer Change

Parameter Adjustment and Evaluation

Before this exercise, only the K criterion was used for handover calculations. The hysteresis was set to K-criterion hysteresis (KHYST)[7] = 4 dB. Hysteresis is a signal strength offset that is added to the actual reported value for the serving cell to prevent unnecessary ping-pong handovers at the border between two cells. The L criterion was introduced in an attempt to further improve network handover performance. Sufficient condition parameters MSRXSUFF = –86 dBm and BSRXSUFF = –92 dBm determine the breaking point between L and K ranking. Cells reporting with signal strength values greater than both levels are considered suitable for L ranking, where an increased hysteresis value, L-criterion hysteresis (LHYST)[7] = 7 dB, is used. The remaining cells are K ranked with a hysteresis KHYST = 4 dB.

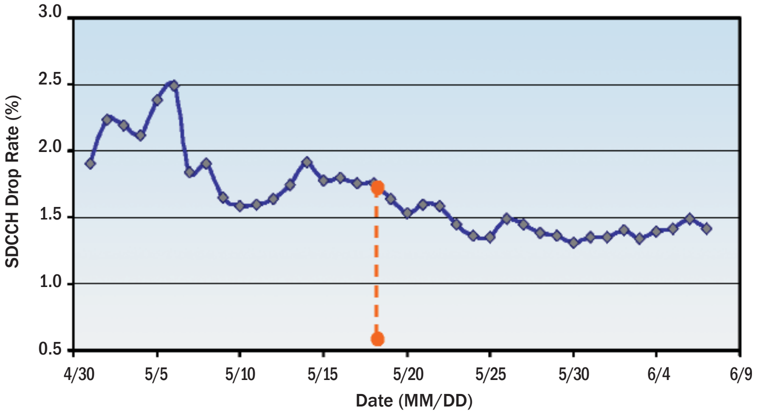

Figure 9. SDCCH Drop Rate Before and After ACCMIN Change

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[7] An Ericsson locating parameter

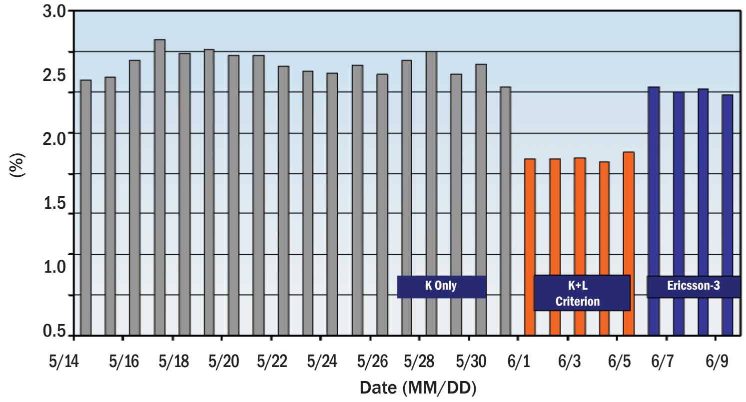

Figure 10. Handovers per Call per Evaluation Criterion

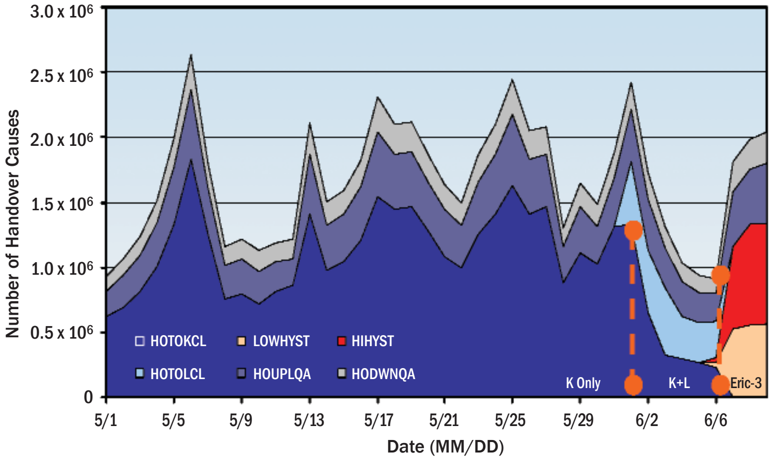

Figure 11. Handover Causes per Evaluation Criterion

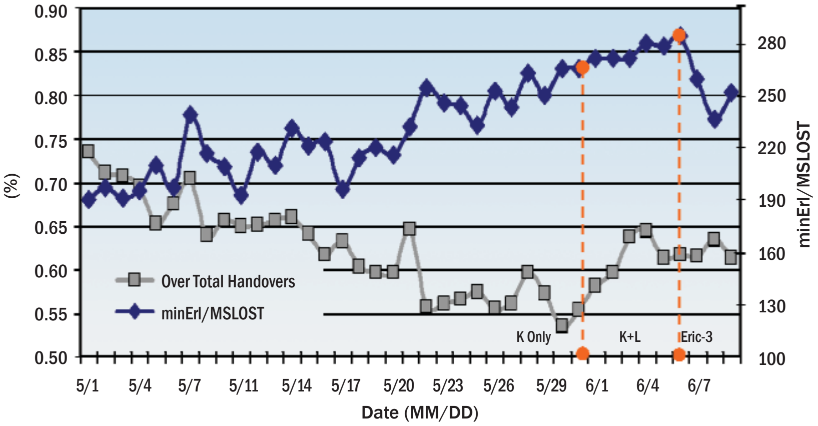

Figure 12. Mobiles Lost During Handover per Evaluation Criterion

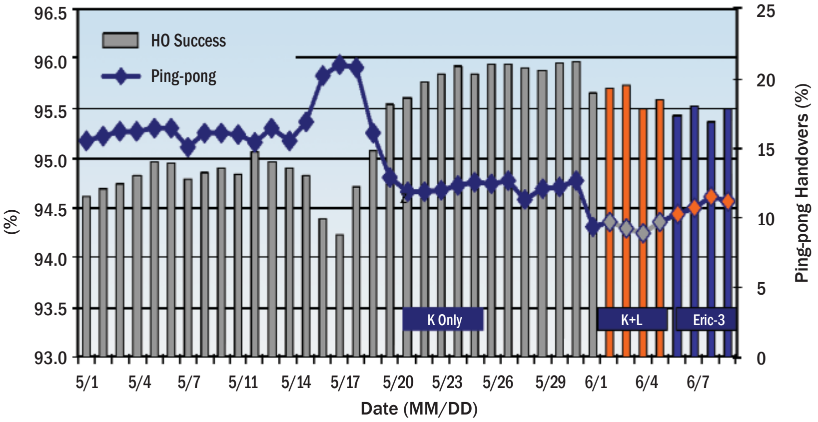

Figure 13. Handover Success Rate and Ping-pong Rate per Evaluation Criterion

The Ericsson-3 algorithm was also tested. The main difference from the previous K-ranked-only algorithm is that, depending on the received downlink signal strength, one of two hysteresis values is used. The signal strength level between high and low strength cells (HYSTSEP)^{7} = –86 dBm parameter specifies whether the serving cell is a high or low strength cell, allowing a larger high-signal-strength hysteresis (HIHYST)^{7} = 7 dB or a smaller low-signal-strength hysteresis (LOHYST)^{7} = 4 dB to be applied. The purpose of the high hysteresis values for both tested algorithms is to prevent unnecessary handovers in the cell borders when radio conditions permit.

In **Figure 10** the reduction in the total number of handovers in the system due to the increased hysteresis in both testing cases can be verified. It is noteworthy that the L-criterion algorithm seems to introduce the highest (25 percent) reduction in the handovers, as expressed by the handovers per call index.

Figure 11 shows the following handover areas: handovers to K cells (HOTOKCL)^{7}, handovers to L cells (HOTOLCL)^{7}, low hysteresis (LOWHYST), (HIHYST), handovers due to uplink signal quality (HOUPLQA)^{7}, and handovers due to downlink signal quality (HODWNQA)^{7}.

The portion of handovers performed with the L criterion in the first case and with the HIHYST value in the second can well justify the previous deviation. Up to 30 percent of total handovers in both cases take place with the use of the increased hysteresis values, which means that the handovers are actually delayed. The result is a total handover reduction, if averaged over the whole network.

As already mentioned, handover is considered a task with a high risk of call drop. **Figure 12** shows the effect of the tested settings in call drop performance of the handover algorithm.

Handover dropouts, expressed as a percentage of total handovers, may initially convey that the situation worsened with the new settings. Nevertheless, what matters is the absolute number of failures actually experienced by the subscriber; since the total number of handovers decreased, this difference is not substantial. To emphasize this point, the index "minErl/MSLOST," giving Erlang minutes of traffic carried out per handover dropout, is also depicted. Inspecting this index, it is clear that the L-criterion algorithm appears much improved, while the performance of the Ericsson-3 algorithm is rather ambiguous.

The superiority of the L-criterion algorithm over the Ericsson-3 algorithm is also apparent in **Figure 13**; the ping-pong handovers (i.e., handovers back to the originating cell within 10 seconds) are reduced in both cases. This reduction is a direct consequence of the hysteresis values of 7 dB introduced in both algorithms. However, the L-criterion algorithm shows the best performance in this field, meaning that more accurate and reliable handover decisions accompany this algorithm, exactly as predicted by theory.

The only disadvantage of the L-criterion algorithm appears to be the handover success percentage, half a decimal unit below the previous figures. The same applies for the Ericsson-3 algorithm, which can be attributed to the lower number of handover commands. It can be assumed that, due to various radio problems, a significant number of handover failures always exist in the network. This assumed value can be highlighted or hidden, in a statistical sense, depending on the volume of the total sample. It is believed that careful optimization and individual neighbor cell inspection of the network's handover performance can further improve this figure.

As a result, the K-L combination algorithm was eventually introduced. Further improvement can be achieved by fine-tuning sufficient level parameters BSRXSUFF and MSRXSUFF to identify a balanced breakpoint for cell ranking. Also, different LHYST values can be tried.

CONCLUSIONS

All of the optimization-related changes were made in a controlled manner so that their effectiveness could be measured and evaluated. At the end of the project, the average daily DCR was reduced by 30 percent, and the average minute-Erlang per drop was increased by almost 45 percent. At that point, a foundation was created for further fine-tuning as the network expands in response to increases in traffic and subscriber base.

As has been shown, considerable network performance gains can be made by fully utilizing the available functionality and fine-tuning the network parameters using statistics to evaluate the results. ■

TRADEMARK

Ericsson is a trademark or registered trademark of Telefonaktiebolaget LM Ericsson.

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[3] "User description, MS Dynamic Power Control" – Ericsson CME20 Documentation.

[4] "User description, Cell Load Sharing" – Ericsson CME20 Documentation.

[5] "User description, Locating" – Ericsson CME20 Documentation.

[6] "User description, Idle Mode Behaviour" – Ericsson CME20 Documentation.

BIOGRAPHY

Michael Pipikakis is a network planning and wireless technology manager for Bechtel's Europe, Africa, Middle East, and Southwest Asia Region. He supports ongoing and new projects and new business development; writes guidelines and procedures for mobile network design, planning, and optimization; and participates in technology forums.

Michael is a mobile networks specialist with 17 years of experience in the telecommunications industry, including more than 11 years in RF planning, design, optimization, and management of the end-to-end performance of cellular networks.

Before joining Bechtel, Michael held various management positions in the Vodafone Group's radio system design and optimization department and development department over a 10-year period; worked for Cellnet UK and GEC Marconi UK; and was a telecommunications operator in the Greek Navy. From 1999 to 2003, he was a member of the Vodafone Global Forum for UMTS design harmonization.

Michael has a BEng Honors in Electronics Engineering with Computing and Business from Kingston University in Surrey, England, and an HND in Radio Communications Systems Design from the Polytechnic School of Athens, Greece. He is a member of the Institution of Electrical Engineers.