SCHEMA

Optimizing the Wireless World

Planning Scrambling Codes the Right Way

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Introduction

Scrambling Codes (SCs) are the internal method used to identify and distinguish sectors from one another in 3GPP compliant WCDMA networks. Mobile handsets utilize Scrambling Codes to report to the network about which sectors they are able to access. This information is then used to: (a) determine which sector will broadcast to the handset, and (b) assign potential and actual handover pairings.

This document will provide an overview of common problematic Scrambling Code scenarios and their solutions, followed by an advanced methodology for optimal allocation of Scrambling Codes.

Scrambling Codes and Their Limitations

There are a total of 512 unique Scrambling Codes available, which must be reused throughout the network to accommodate the thousands of sectors that typically must be identified. When a handset reports a Scrambling Code number to the network, it must be unequivocally clear which sector is being referenced. As such, it is critical that the handsets and the network refer to the same sectors with identical Scrambling Codes.

The inherent problem and limitation in the Scrambling Code method is that, as mentioned above, there are only 512 unique SC sets available, versus the thousands of sectors that typically must be identified. Effective network planning is imperative to ensure that the SCs are distributed, dispersed, and reused correctly, efficiently, and in a manner that minimizes confusion among nearby sectors.

A lack of proper planning will ultimately lead to high-level errors in decoding signals and messages. In turn, these errors lead to dropped and blocked calls, despite the fact that sufficient network resources are readily available to support the session in question, as well as high-BLER (block-error rate) errors, despite the existence of good RF conditions.

Traditional Scrambling Code Planning

Scrambling Code assignments are usually carried out during initial network deployment with the help of a variety of prediction-based Planning Tools. Operators rely on these tools to define the initial network topology based on signal strength propagation predictions and simulated traffic conditions. Any changes that may come later to the network (for example: additional sites, change in topology) necessitate reassignment of Scrambling Codes, and this is usually executed with the help of either off-shelf Planning and Optimization Tools, or operator defined internal procedures.

The most common Planning and Optimization Tools available in the market today are based on a ***geographical methodology***, and utilize one of two techniques: a cluster-reuse pattern map that is applied across the network, or a graph-coloring technique to ensure that nearby sectors have unique SCs. This methodology, which is easy to administer, is considered less advanced than others, because it relies mainly on the distances between sites for their results. (More sophisticated tools based on this methodology will also occasionally figure in the azimuth setting of the sectors as well).

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An additional, more advanced methodology utilized by Planning and Optimization Tools takes into account ***signal-propagation predictions*** in addition to distance and azimuth. Tools that utilize this methodology factor-in the propagation of RF signals in actual topography as well as cluttering of the planned network in order to avoid CO-SC's for sites that may interact due to their signal behavior (despite appearing sufficiently distant). This method also takes into account propagation of signals that take place in the network for different locations of the subscriber traffic to minimize traffic overlap between sectors with the same scrambling codes.

The above methodologies are able to resolve SC collisions during user access, so that they are usually sufficient for Greenfield networks or for networks in the deployment phase. However, these commonly used methodologies do not factor in real-time measurements and activities. Neither Scrambling Code usage during the handover process or neighbor list sector definitions are taken into account at all. The result in real-time networks is that sectors with identical scrambling codes will be assigned to the same Neighbor List (also referred to as "overlapping SCs"). When a handset reports a SC as a result of an interaction with one of these sectors, the network will not be able to distinguish which of the two the handset is referring to. The end result for the end-user? Interference or even dropped calls.

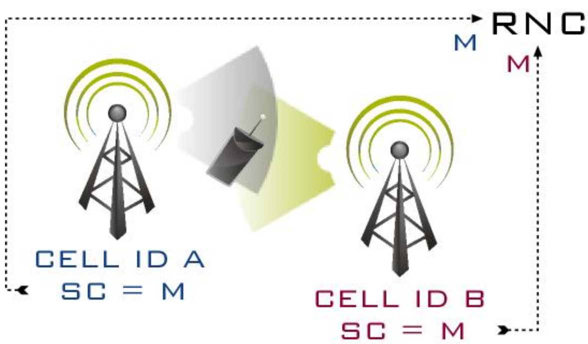
Common Scrambling Code Problems

As described above, WCDMA networks manage a database of neighbor lists per each sector. To prepare for possible handovers, the network sends the User Equipment (UE) a list of neighboring sector SCs to measure, based on the sector's reported Active Set. This list is comprised of a combination of all the neighbor lists for all the sectors in the Active Set. If either the Active Set, or any of its sectors' neighbor lists contain overlapping SCs, (even for sectors so distant that they have no RF interactions), the handover attempt to a non-uniquely identified sector may fail. As mentioned, prediction-based methodologies for assigning SCs, which do not take into account real-time measurements from the network, are unable to identify or resolve these issues, which result in a variety of errors in the network.

The following section describes these problematic scenarios in more detail.

Scenario 1: Two sectors (A&B) with overlapping RF conditions share the same Scrambling Code (Overlapping SC's)

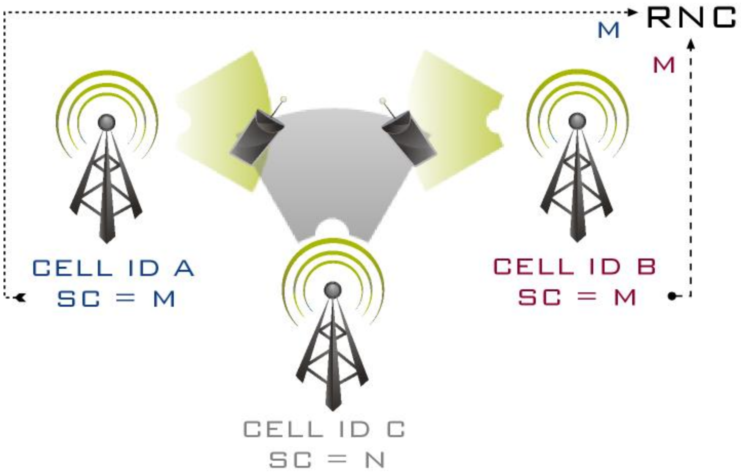
This scenario is the root of two problems: (a) The network will be unable to identify which sector the handset is reporting and (b) The two sectors will interfere with each other as a result of the handset's attempts to decode signals from the both of them (although in actuality only one sector is sending relevant data). As a result, BLER will increase, even if RF conditions (Ec/No values) are relatively good.



Prediction/Signal-propagation based methodologies are sufficient in avoiding and/or resolving these issues.

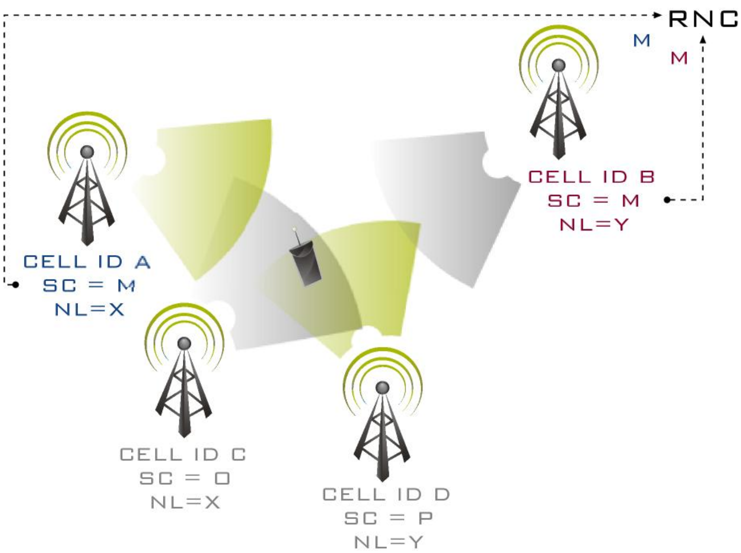
Scenario 2: Two sectors (A&B) with no RF overlap (estimated or measured) share the same SC, and share a common neighbor (C) that "detects" the both of them

In this scenario, handsets in varying locations covered by Sector C detect both Sectors A and B due to unexpected signal propagation. Both sectors are defined as C's neighbors.



When Sector C wants to attempt a handover, the Network is unable to identify which of the two sectors the Handset is referencing, and may attempt to handover to the wrong sector. This will result in a dropped call. Some Network vendors will even lock sector C and prevent it from handling calls at all (sleeping sector), further exasperating the problem.
This scenario is easily resolved by simple Database Queries that check for these types of occurrences. However, a more complicated situation can occur when only one of the two interacting sectors is defined as C's neighbor, despite the fact that the other sector has equal or even stronger RF interaction. In this scenario, a DB query will <u>not</u> uncover the problem, because the stronger interacting sector is not defined as C's neighbor. As a result, the call will be handed over to the wrong sector and dropped.

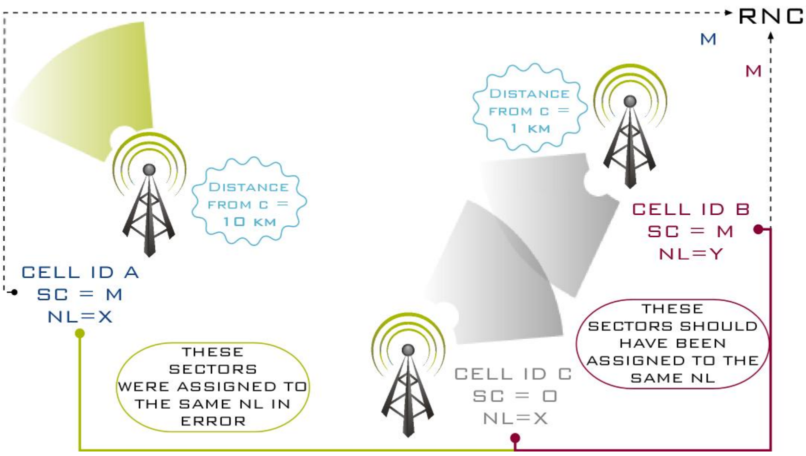
Scenario 3: A handset interacts with two sectors (C & D) with different neighbors (A&B) that were assigned the same scrambling code



This scenario highlights the interdependence between Scrambling Code and Neighbor List Planning. When a handset interacts with two sectors (C & D) with different neighbors that were assigned the same scrambling code (A&B), the network will create a ***combined neighbor list*** in accordance with the sectors in the handset's Active Set. (In the above diagram the combined list will include both C and D's neighbors). Similar to scenarios 1 and 2, once again the Network will be unable to distinguish between Neighbors A and B, and the handover has a higher probability of failure. In these cases, the only method to resolve these situations (which are further complicated when there are more than two sectors in the Active Set) is to switch the assigned SC for one of both of the sectors so that they are no longer identical.

Scenario 4: SCs are assigned and reused properly, but an additional (possibly distant) sector was incorrectly assigned to a Neighbor List which already contains a sector with the same Scrambling Code

Improper neighbor list definitions are the cause of this problematic scenario. As a result, in handover conditions, the handset will receive the distant sector's neighbors as part of the combined Neighbor List, and these remote sectors may very well have a great deal of SC overlap with the nearby neighbors. The probability of handover failure is very high in this scenario, despite good quality and well allocated SCs.



An Advanced Approach to Scrambling Code Planning

As is evidenced by the above scenarios, the primary deficiency of existing Scrambling Code allocation methodologies is that the Planning and Optimization Tools often used by operators lack crucial key capabilities, namely the ability to take into account actual RF conditions and network traffic distribution across all possible scenarios with the required accuracy, and the ability to verify proper Neighbor List allocations. In other words, these tools may cause network errors by recommending SC assignments that do not fit the actual network conditions. In these cases, the only solution is to reassign Scrambling Codes.

Based on a deep understanding of SC usage and 3GPP standard definitions in WCDMA networks, Schema suggests a novel approach for SC planning, which also takes into account SC usage during the handover process in order to prevent the abovementioned failures. Schema's advanced solution for SC planning takes into account the handset "experience", in any location, and ensures that Scrambling Codes are allocated in such a way that minimizes contradictions between SCs for the required NL plan.

"The result is a more efficient, error-free Scrambling Code and Neighbor List plan that fits the physical reality of the network as well as actual subscriber traffic"

How is this Accomplished? Via Mobile Measurements

Mobile Measurements refer to the 3GPP events and reports that are generated when subscribers move around the network using their mobile handsets. While powered on, the mobile handsets engage in complex interactions with the network, yielding specialized quality of service reports that reflect the subscribers' experience of network quality: signal strength, noise level, neighbor list candidates, and so on. Schema utilizes Mobile Measurements as the ultimate data for accurate neighbor list planning. For operating networks, mobile measurements are also the key to optimal tuning of Scrambling Code allocation, taking into consideration NL assignments.

Mobile Measurement reports can be sampled and used to generate an accurate model of the network, a representation of the up-to-date assignment of Scrambling Codes throughout the network, and a clear picture of where nearby identical assignments or remote Neighbor assignments have actually caused the types of problems described above. With the information contained in Mobile Measurements, a different approach to SC allocation becomes possible. True boundaries of RF interaction, both between sectors and between handsets and the network can be taken into account in addition to inter-sector distances, azimuth settings and theoretical signal propagation, and NL assignments can be verified for accuracy.

Schema's Mentor™ analysis and optimization tool implements this approach to deliver accurate and dependable SC and NL plans. Using this comprehensive tool can ensure that accidental interactions are prevented. The result is more efficient, error-free Scrambling Code and Neighbor List plans that fit the physical reality of the network as well as actual subscriber traffic.

About the Authors

Gennady Shenker, Chief Technology Officer for Schema
Mr. Shenker's twenty-plus years of experience in a variety of development and executive management roles led him to Schema, where he currently leads the company's strategic technological efforts as Chief Technology Officer. Prior to Schema, Mr. Shenker served as Deputy Vice President of Technology for eight years at Partner (Orange) Israel, where he was responsible for the company's GSM and UMTS networks, among other executive management positions. Mr. Shenker holds an M.Sc in Electrical Engineering (Communications Department) from Leningrad University, and an MBA from the College of Management in Rishon Letzion, Israel.

Ehud Riesenberg, Director of Wireless Technology
Mr. Riesenberg has served as Technology Manager for Schema since 2006, and brings comprehensive knowledge of wireless voice, data communications and over 11 years of engineering experience with CDMA,1x,1xEvDO, GSM,GPRS, UMTS, HSPA cellular technologies. Mr. Riesenberg started his professional career in 1999 as an optimization engineer in Motorola's Cellular Infrastructure Group (CIG) where he was involved in CDMA network optimization and tool development. In 2001 Mr. Riesenberg joined Orange Israel, a GSM/UMTS Operator, as a Senior Engineer in charge of regional planning and optimization. Later he was responsible for Radio Access Network optimization where he was responsible for meeting system KPIs goals, optimization strategies, purchases and trials and tool development.

Michael Livschitz, Chief Scientist for Schema
Dr. Livschitz currently services as Chief Scientist for Schema, specializing in simulation algorithms and optimization of 3G and 4G cellular networks. His previous optimization experience was in the fields of gas transportation, aircraft landing systems and cargo ship loading. Dr. Livschitz has published over 30 technical journals and conference papers in simulation, optimization and artificial intelligence, holds several patents, and co-authored the book "*Understanding UMTS Radio network Modeling, Planning, and Automated Optimization*". He obtained his MSc degree in Mathematics from Moscow Electronic Engineering Institute, MSc degree in Automation from Moscow Chemical Machine Building Institute and PhD study in Hybrid Expert Systems at the Moscow Chemical-Technology Institute.

About Schema

Schema is a leading global provider of advanced network optimization Software Solutions and Professional Services for wireless telecom operators. Schema's products and services provide innovative solutions across all 2G, 3G, and 4G technologies, optimizing network performance and increasing profitability while enhancing the end-user experience.

Founded in 1995, Schema has since enjoyed field-proven results as its solutions are benchmarked and deployed by major wireless operators worldwide. Schema products, which are fully compatible with most vendor equipment, can be integrated into different technology environments, assisting technology migrations and affording enhanced network-management capabilities. Schema's global presence enables it to provide local support to its customers.

Schema's Ultima™ and Maxima™ suites of products are suited for GSM/UMTS and CDMA/EVDO networks respectively.

About Mentor™

Schema's Mentor product is a tool that enables operators to maximize network quality, capacity and coverage automatically using only information collected from the network, known as mobile measurements. Mentor builds upon these mobile-measurement reports to deliver an accurate and comprehensive view of the network performance and service quality.

By using mobile measurements with Mentor, the process of tedious and expensive prediction-creation and calibration projects becomes obsolete. Mentor provides recommendations for network tuning on a weekly basis, based on up-to-date traffic and user-experience information, enabling engineers to maintain the network at top performance. With Mentor, for the first time 3G service providers can commit to aggressive KPIs and be confident that they will meet those goals. Mentor also enables carriers to sustain peak performance levels continuously over time.

The analysis and optimization capabilities offered by Mentor yield significant CaPex and OpEx savings from the start. Mentor makes it possible to meet target KPIs in an environment of fast growth and rapidly changing usage patterns typical of 3G networks. Through an advanced process of data retrieval, parsing and analysis, Mentor analyzes network data and builds an accurate and comprehensive view of the network performance and service quality.

Mentor takes the process one step further, streamlining complex and time-consuming maintenance, troubleshooting and optimization processes by automatically providing solutions to problems that are identified in the network.

By using Schema's renowned genetic-algorithm engine, RAN network engineers receive recommendations for RF configurations such as antenna tilts and power, as well as changes in the network's "soft" parameters like neighbor-list configuration. Network engineers can implement these changes automatically and assure long-lasting network quality.