

# Deployment Method for Real-Time Wireless Network Optimizer in CDMA Network

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**Abstract:** CDMA Network has developed from 2G to CDMA 2000 1X and 1xEV-DO, and made a rapid progress to WCDMA. In accordance with it, wireless network optimization method is also developing. Basic method for optimization is to measure field data manually using field tools. Better solution is to gather measured data and network data together and analyze them after combining them. But this solution also has limitation, since it gathers data off-line and the analyzing process is manual and repetitive, so we can think of more systematic optimization method by developing a real-time and on-line wireless network optimization system.

At first, the system interfaces with other operating tools automatically by on-line to store and manage wireless network data in a central database. Then, it analyzes the performance and efficiency of wireless network using this database. The analysis result is used to present base station's status and solutions to the network problems such as interference, high noise level, etc. This paper introduces a system for wireless network performance optimization, called "Optimizer", that does network data interface, KPI (Key Performance Indicator) monitoring, statistical analysis, wireless network analysis.

## 1. Introduction

After CDMA network has become in commercial use for mobile communication service, field engineers gather and analyze measured field data, network data, and RF data – Tx Power, Rx Power, waveform of Tx and Rx, etc. – independently. So, the engineers can figure out only partial solutions for wireless network optimization. Now, we can think of an operating tool to overcome the problems of repetitive process of existing optimization method. It is a wireless network optimizing system that analyzes field, network, and RF data simultaneously and builds a knowledge database

that stores optimization know-how. The system has 1) real-time automatic wireless network data gathering function, 2) wireless network performance and efficiency deterioration detecting function, 3) statistical analysis functions using time series, correlation, clustering, mining, etc., and 4) functions to give optimizing solutions to enhance the performance and efficiency of wireless network. In this paper, we introduce a framework of performance optimization and its application strategy, which can improve the performance of CDMA wireless network in a centralized and automated manner.

## 2. System Concept

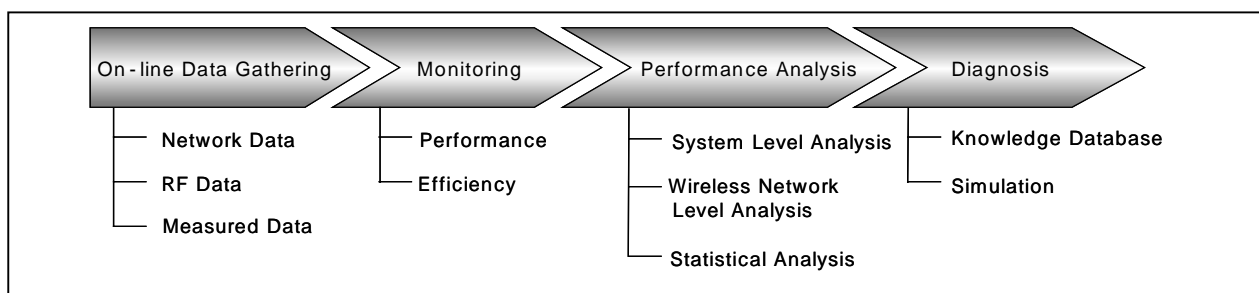
### 2.1. Optimization procedure

[Figure 1] shows wireless network optimization flow. First, it gathers raw data such as network data, measured field data, RF data periodically. Then, it monitors network performance and efficiency to detect base stations that deteriorate wireless network quality. And finally, it presents performance optimization solutions using 1) system level analysis, 2) wireless link level analysis, 3) statistical analysis, and 4) knowledge database.

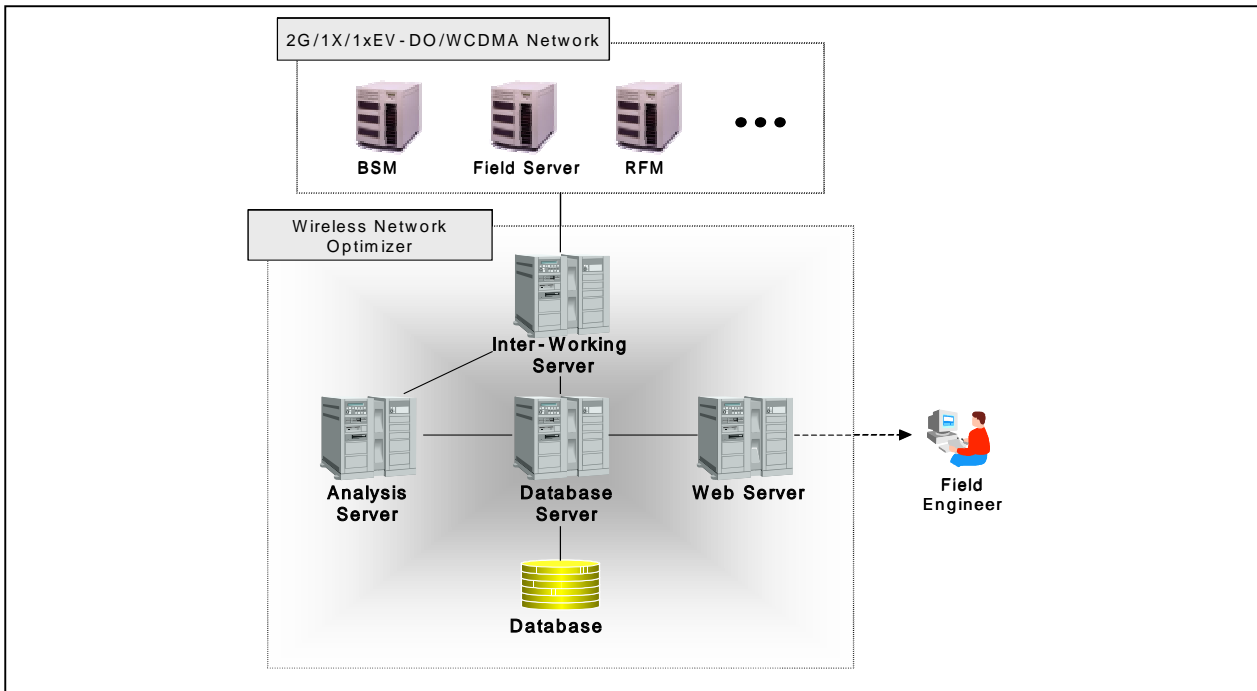
### 2.2. System Architecture

Wireless network optimization system, called "Optimizer", consists of Inter-working Server, Analysis Server, Database(DB) Server, and Web Server.[Figure 2]

Inter-working Server interfaces with external servers, which stores network data or RF data using special protocol for each server, gathers raw data periodically, and converts the data into appropriate format to store in the Database Server. Analysis Server uses gathered raw data from DB Server to generate wireless network analysis result. DB Server stores and manages all the data generated by Inter-working Server and Analysis Server. Web Server produces analysis result web pages for the field engineers.



[Figure 1] Optimization Process Flow



[Figure 2] System Architecture

### 3. On-line interface

To optimize the performance of wireless network, field engineers have been gathering data from various measuring tools or management systems separately, and analyzed the data manually. But, Optimizer interfaces with all the tools and systems by on-line interfacing process of Inter-working Server, and then builds a central database called “Optimizer DB”. It integrates diverse operational data, so the separate analysis process which was dependent upon the operating tools in the past, can be combined into one system, the Optimizer.

#### 3.1. Interfacing Types

Inter-working Server has to minimize the load of the other servers, so the way of on-line data gathering process depends on the performance of the interfacing counterpart. There are various types of interface in Optimizer.

- Text log file gathering
- Remote command interface
- Remote DB query

After gathering the raw data by one of these ways, Inter-working Server converts the data into appropriate format to store in the Optimizer DB.

#### 3.2. Data Types

Here are some of the data types used by the Optimizer.

- BSM(Base Station Management System) data

Optimizer uses BSM log files for performance, configuration, and system fault data. It periodically connects to BSM to get the log files, and parses the raw data into the database format.

- RF data

RF data, which is measured from base stations, contains Tx power, Rx power, and waveform of Tx and Rx power. These are mainly measured by automatic command interface. Optimizer usually takes statistical value of the RF data.

- Measured field data

It contains data that can be measured by field tools. And most of the measured data has its data storage server, so we can connect to the DB of the storage servers and do remote query to retrieve measured field data.

### 4. KPI Monitoring

After gathering wireless network data, analysis process of each base station starts. KPI (Key Performance Indicator) monitoring, which is the first part of the process, detects performance and efficiency deterioration of each base station. This monitoring process filters low-performance base stations, which should be optimized in the first place. We can get standard values of each performance indicator that are offered by statistical analysis of wireless network, and use them to select base stations that does not satisfy the performance threshold. For performance monitoring, we use current status and trend of origination/termination call success rate, call completion rate, call drop rate, and other statistical traffic data. For efficiency monitoring, we analyze handoff overhead, Q-Factor (traffic balance rate between sectors), channel element usage, FA (Frequency Assignment) usage, cell loading, etc. Also, average value of performance indicator of MSC or BSC can be used in non-parametric analysis. Using these data, Optimizer filters and triggers base stations that deteriorate wireless network’s quality.

## 5. Wireless Network Analysis

Optimizer analyzes and diagnoses base stations that are filtered by KPI monitoring. [Figure 3] shows the wireless network analysis process.

### 5.1. System Level Analysis

The most critical problems can be found at system level first.

- **Fault Message Analysis**

Optimizer integrates frequent critical fault messages caused by the network system's software, and determines the main cause by fault reasons.

- **Alarm Analysis**

Optimizer reports alarm messages caused by the network system's hardware. This includes system alarm, LPA/LNA alarm, repeater alarm, etc.

- **Parameter Analysis**

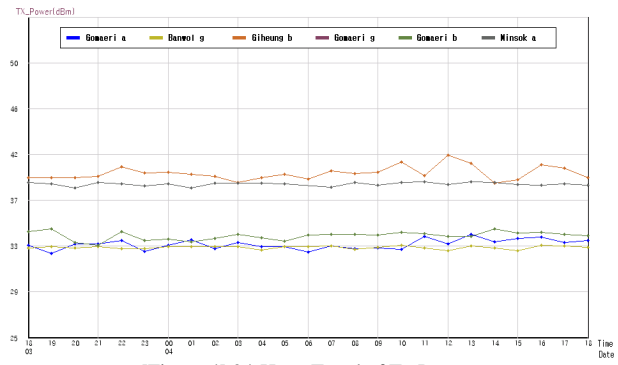
Optimizer detects abnormal parameter setting, and reports it to the field engineers.

### 5.2. Wireless Link Level Analysis – Forward Link

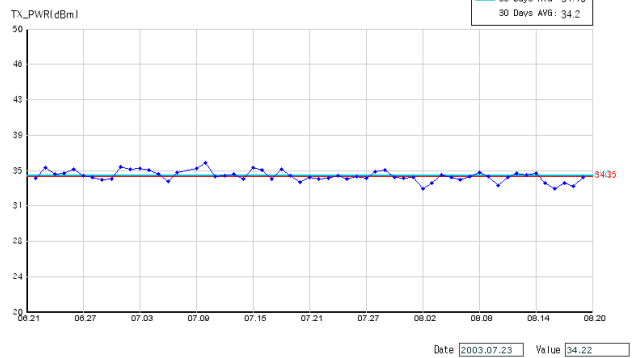
Forward link analysis handles overhead power – for pilot, sync, and paging – and Tx power – for total transmitting power including traffic. Here are sample functions that are analyzed on forward link.

- Traffic, handoff, and overhead power's ratio of Tx power
- Tx power trend of 24 hours[Figure 4], 20 days, and 60 days[Figure 5]
- Power usage per Erlang

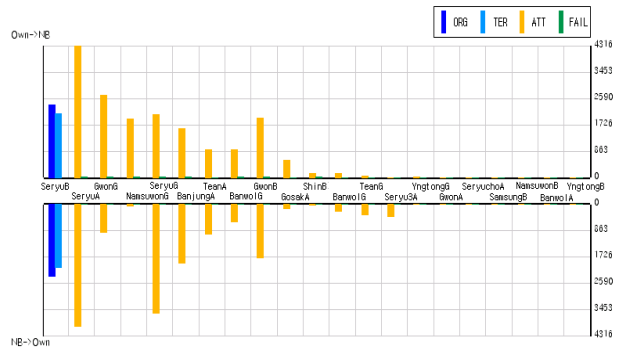
Average FPG (Forward Power Gain) and Over FPC (Forward Power Control) values are also used to detect abnormal power status. To detect abnormal handoff status and coverage efficiency, we analyze handoff attempt from/to the low-performance base station[Figure 6], active PN count, Ec/Io, C/I, RSSI, etc.



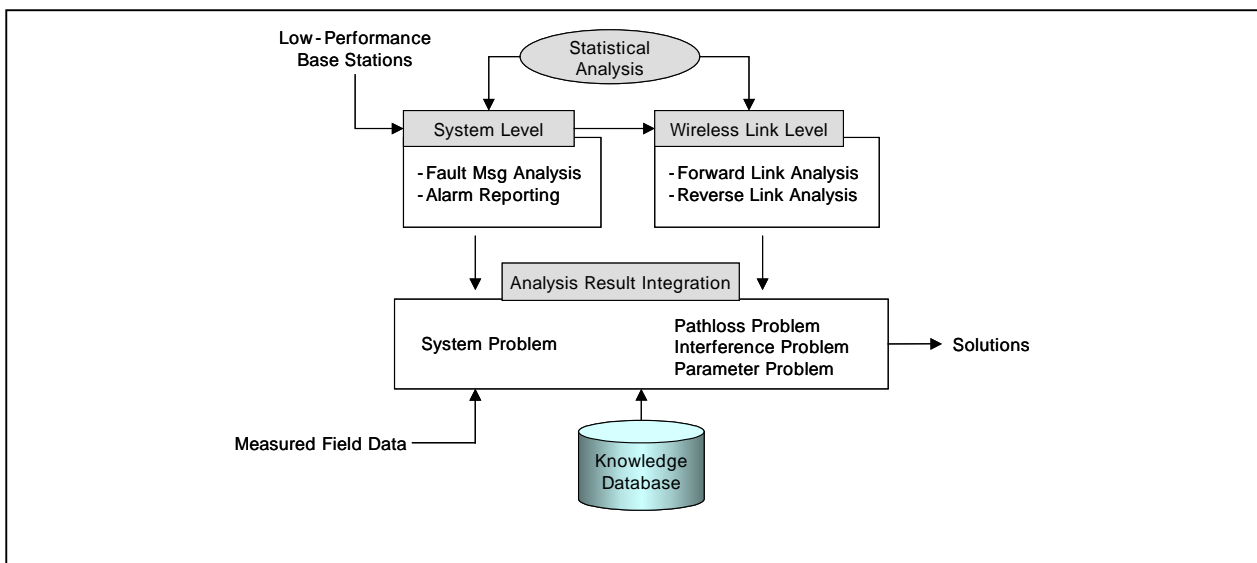
[Figure 4] 24-Hour-Trend of Tx Power



[Figure 5] 60-Day-Trend of Tx Power



[Figure 6] Handoff Analysis



[Figure 3] Wireless Network Analysis Process

### 5.3. Wireless Link Level Analysis – Reverse Link

Based on Rx level measured from base stations,  $N_oW$ (thermal noise),  $I_o$ (own cell interference),  $I_{oc}$ (other cell interference), and cell loading are obtained and used in reverse link analysis.[Figure 7]

Here is a sample process to derive own cell interference,  $I_o$ .

First, we calculate  $E_b/N_t$  by these equations.

$$E_b = \frac{S}{R} \quad N_t = \frac{R_t - S}{W} \quad (1)$$

$$\frac{E_b}{N_t} = \frac{\frac{S}{R}}{\frac{R_t - S}{W}} = G_p \frac{S}{R_t - S} \quad (2)$$

$E_b / N_t$  = Signal Energy per Bit divided by  
Noise Spectral Density  
 $S$  = Average Rx Level of one mobile station  
 $R$  = Bit Rate  
 $R_t$  = Total Rx Level of a base station  
 $W$  = CDMA Chip Rate  
 $G_p$  = Processing Gain

If required  $E_b/N_t$  of the cell is  $K$ ,

$$\left. \frac{E_b}{N_t} \right|_{Req} = K$$

by (2), we get equation for  $S$  like this.

$$K(R_t - S) = G_p S$$

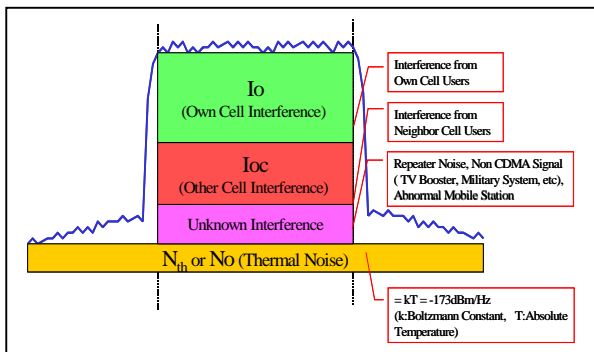
$$S(G_p + K) = KR_t$$

So, we can get total Rx level of the cell ( $I_o$ ) using  $S$ .

$$\therefore S = \frac{KR_t}{G_p + K}$$

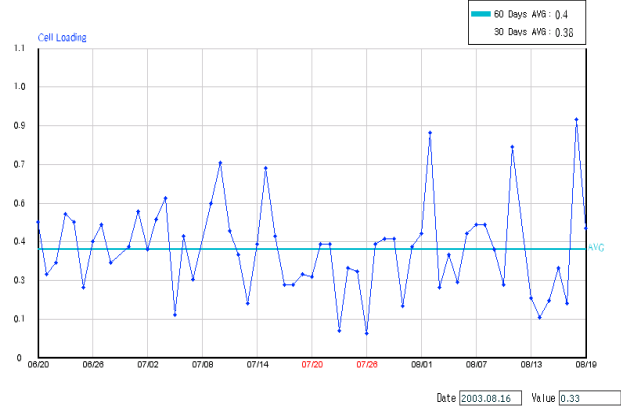
$$\therefore I_o = N_u S$$

$N_u$  = Number of users per cell



[Figure 7] Base station's Rx Signal

From measured RF value, we can get total Rx level  $R_t$ . And by monitoring RF value of idle hour (minimum call attempt hour),  $N_oW$  can be derived, so we can get  $I_o$  and  $I_{oc}$ . As we calculate  $I_o$  and  $I_{oc}$ , engineering parameter of reverse link such as frequency reuse factor and cell loading can be derived to use in the reverse link analysis process of Optimizer. [Figure 8] shows 60-day-trend of cell loading.



[Figure 8] 60-Day-Trend of Cell Loading

### 5.4. Statistical Analysis

To support system level analysis and wireless network analysis, statistical analysis process is also important in Optimizer.

#### ● Correlation

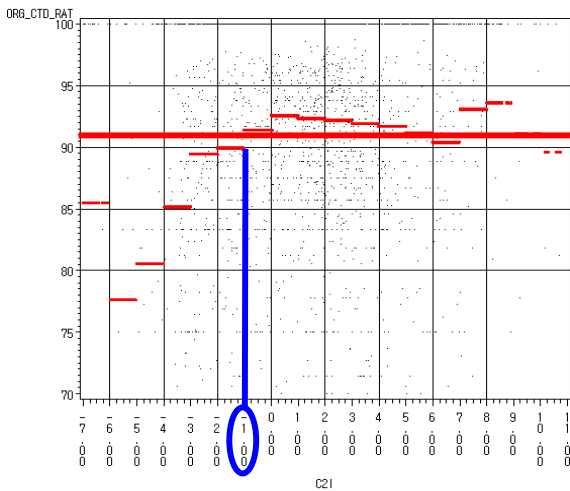
To figure out the main factor of performance deterioration, we use multivariate analysis, such as logistic regression. This analysis process takes all factors – wireless network performance indicator, statistical data, network system status or fault, parameter, etc. Then, it calculates the relationship between wireless network performance and the factors to figure out which factor effects the most. Also, data mining technique, such as decision tree, is used to determine factors that can classify high-performance or low-performance base stations.

#### ● Scatter Plot

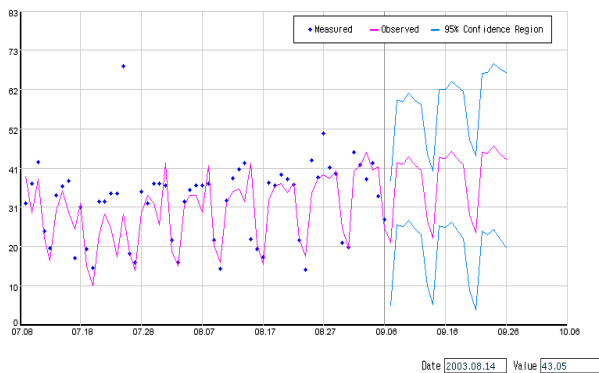
After detecting main factors of performance deterioration by correlation analysis, we use scatter plot to determine the point where the performance declination starts. [Figure 9] is a sample scatter plot of C/I and call connection rate in 1xEV-DO network. In this case, call connection rate keeps declining at the point of -1, so C/I = -1 is the deterioration point of call connection rate.

#### ● Trend

To forecast wireless network performance, statistical trend is used. So, the trend graph of wireless network performance indicator and correlated factor is a part of statistical analysis. [Figure 10] is a sample trend graph of origination Erlang with actual value and its forecast result. We use Winter's Additive Smoothing Model, which is one of the most practical method for trend analysis.



[Figure 9] Scatter Plot of C/I and Call Connection Rate



[Figure 10] Erlang Trend

## 6. Diagnosis and Solutions

Low-performance base stations, which are filtered by KPI monitoring process, go through system level analysis, wireless link level analysis, and statistical analysis. And finally, they go into the diagnosis process for solutions to improve the performance. Optimizer has knowledge database of CDMA theory and

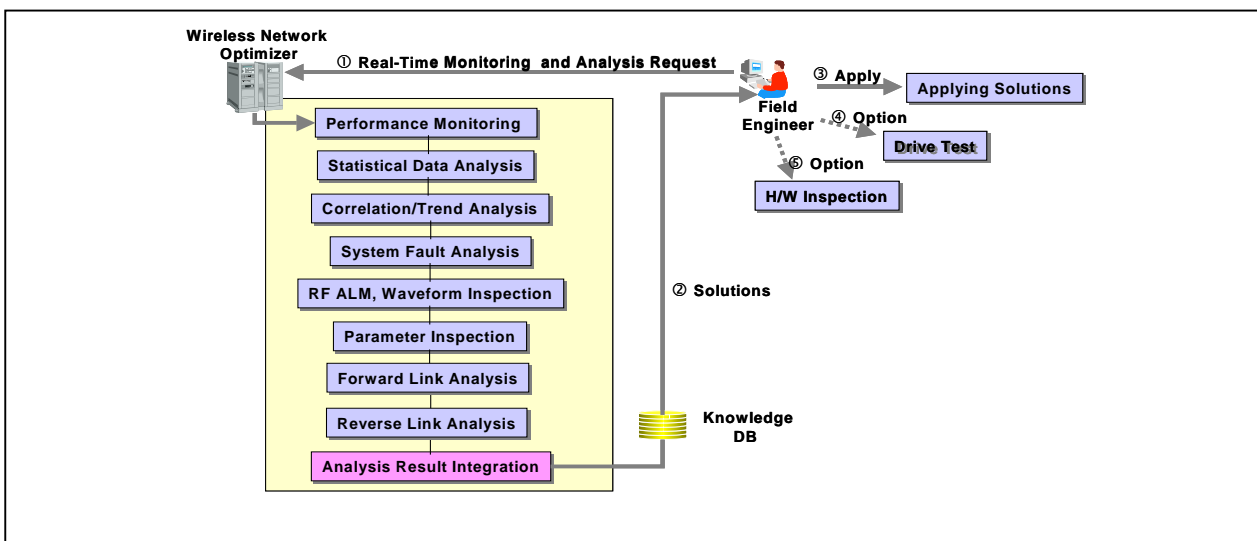
operational know-how, which describes the case-by-case solutions for the wireless network problems, that has been collected since the network construction. So, diagnosis process uses this knowledge database for each case of performance deterioration cause, to get the solutions that the field engineers can apply. Optionally, field engineers can do drive test or hardware inspection, before or after they apply the solution, if they think it's necessary. [Figure 11] shows the whole process.

## 7. Conclusion

Network field engineers had to gather data and analyze it separately from network management system, repeater management system, field measuring tools, etc. for wireless network performance optimization. This was manual, repetitive, and time-consuming job. Also, the analysis result was dependent upon the analyzer's skill. This paper introduced wireless network performance optimization system to overcome these problems of the past. Optimizer 1) collects and integrates operational data from all the other tools by on-line, 2) monitors performance of each base station based on the gathered data, 3) analyzes the wireless network performance indicator to determine the cause of performance deterioration, and 4) gives case-by-case solutions by the analysis result and knowledge database which stores CDMA theory and operational know-how. SK Telecom has been using this system, and there has been a dramatic change in performance optimization process. As it became more systematic, non-skillful field engineers could detect and analyze the network promptly as expert engineers do, so we could maximize the efficiency of operation and optimization process of wireless network. Future work is to enhance the diagnosis process as we itemize more solutions for each performance deterioration case, and evolve it into an expert system.

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[Figure 11] Analysis and Diagnosis Flow

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