Radio Access Networks Design and Optimization Technology

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Abstract

The rapid advances in recent years of the broadband implementation of wireless networks, has raised the issue of service quality requirements for wireless systems to a similar level to that of wired systems. As equipment investments have increased, it is now strongly required that the system operation makes maximum use of the equipment performance and improves the user experience quality. NEC has developed the radio access network (RAN) quality improvement technique "RAN-SAITEKIKA", which makes full use of its radio access network design and optimization technology, and provides professional services in support of activities for improving user experience quality. This paper introduces the technology and achievement of RAN-SAITEKIKA together with details of its future perspectives.

Keywords

Radio Access Networks (RAN), design, optimization, user experience quality, RAN-SAITEKIKA, W-CDMA job efficiency improvement tool, professional service

1. Introduction

Following the recent trends in broadband use of wired networks, broadband use for wireless networks has also advanced rapidly, raising the service quality requirement for wireless systems to a similar level to that for wired systems. As a result of announcements of various wireless broadband communication technologies, equipment investments have increased and it is now urgently required to improve user experience quality. NEC provides professional services that make full use of its W-CDMA RAN design/optimization technology, as one of the activities for improving user experience quality.

In this paper, we will provide an outline of the RAN quality improvement technique "RAN-SAITEKIKA" based on the RAN design/optimization technology accumulated by NEC in following up the process of RAN construction. Additionally, we will also introduce the element technologies of RAN-SAITEKIKA, a software tool developed to advance work efficiency and the actual results achieved in W-CDMA networks. Finally, we will also introduce the latest technologies and the technologies that are under development in preparation for future services deployments, as well as providing details of future perspectives.

2. Outline of RAN-SAITEKIKA

2.1 The Process of RAN Construction and the Concept of RAN-SAITEKIKA

The second-generation communication systems such as PDC and GSM used to meet quality requirements by allocating the frequencies optimally, the third-generation communication systems such as W-CDMA employ the same frequency band, so they have to meet the coverage, capacity and quality requirements by means of an unprecedented method of interference management according to the subscriber capacity. This strategy necessitates a dynamic adaptation of these various parameters according to the environmental change that depends on traffic variability. The tuning and activities for improving the user experience quality will thus become much more complicated than was the case for the second-generation systems.

At NEC, we provide professional services for improving the user experience quality through RAN design and RAN optimization with the use of consistent processes (RAN-SAITEKIKA) as shown in **Fig. 1**. The following paragraphs will describe each step of the RAN construction process and the concept of RAN-SAITEKIKA.

(1) Coverage Design

The RAN design is performed based on a commercial strat-

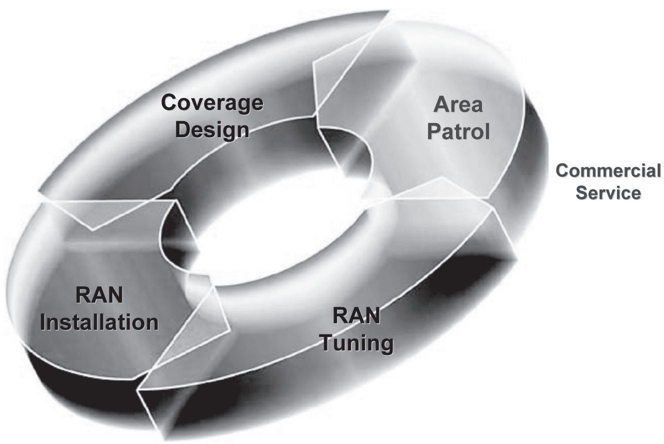

Fig. 1 Process of RAN construction and RAN-SAITEKIKA.

egy aimed at meeting quality requirements. This is composed of a capacity design based on the traffic information in the commercial plan, a coverage design based on a linked budget study, and a study into the equipment volume requirements, base station specifications and initial network parameters of the service target area.

(2) RAN Installation

The RAN equipment is installed according to the results of Coverage Design.

(3) RAN Tuning

This refers to the adjustment operations performed after installation to meet the coverage and quality requirements. The work is conducted to approach the design targets by adjusting the base station transmitting power and antenna tilting angle, etc.

(4) Area Patrol

While the RAN Tuning is adjusted in the absence of an operational traffic load, the Area Patrol is the interference management work to ensure the coverage capacity and network performance even when the actual traffic load deviates from the design value during commercial services. This is performed by monitoring the network quality and traffic load periodically and obtaining the protocol information and the various quality parameters of the W-CDMA network. The results are subjected to quantitative analysis and the parameters are adjusted accordingly.

Previously, quality improvement processing has been inconsistent and inefficient and it has been difficult to achieve the expected quality improvement because individual steps have been under the control of different departments. The NEC's RAN-SAITEKIKA concept aims to perform the construction process cyclically based on the unified objective of efficient area management.

2.2 Element Technologies and Tools Supporting Execution of RAN-SAITEKIKA

Wide ranging skills and experience are required to execute RAN-SAITEKIKA. To significantly improve the job efficiency, we offer tools that package the expertise of our skilled engineers converted into algorithms. In this section, we will introduce the main element technologies of the Coverage Design, RAN Tuning and Area Patrol as well as the tools provided by NEC.

(1) Coverage Design

The most important technologies for the Coverage Design are radio wave propagation estimation and traffic analysis. Since it is important for the interference management to correctly estimate the situation of the propagation from the base station transmitting the desired radio wave as well as that of the propagations from base stations that become the sources of interference, we will explain the radio wave propagation estimation technology in the following.

The radio wave propagation loss varies greatly depending on the incidence of buildings and the population density in the area. The propagation loss can be estimated either by statistical or deterministic techniques. The statistical techniques obtain the propagation loss of each location by using the propagation loss formulae that are established by turning the accumulated experiment results into functions. They feature a short computation time but, due to the statistical errors in conversion into functions, it is hard to ensure high accuracy in areas with a high building density. On the other hand, the deterministic techniques obtain the propagation loss of each location by closely tracing the physical phenomena (reflections, refractions, transmissions and diffractions) from the transmitting point to the receiving point. Their computation time is longer than for the statistical technique due to the sequential tracing of the radio waves radiated from the transmitting point. In the actual propagation estimation, we use both kinds of techniques above by considering a good balance between the computation time and accuracy. Namely, in areas with a low building density rate, as in urban and suburban locations, we use statistical techniques to analyze a wider area. In dense urban areas that feature building congestion or inside a building containing many obstacles, we use deterministic techniques for the analyses.

NEC has a simulator called the W-CARD, which is capable of correcting the propagation loss formulae based on the field data measured using the statistical technique. In addition, it also has a simulator called the RS3000 that incorporates 3D ray tracing, which is a ray launching technique belonging to the deterministic techniques and features the possibility of

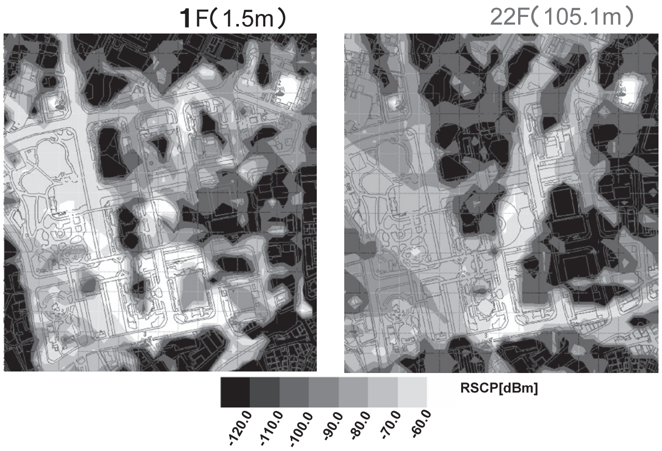

Fig. 2 Examples of received power (CPICH RSCP) analyses using RS3000.

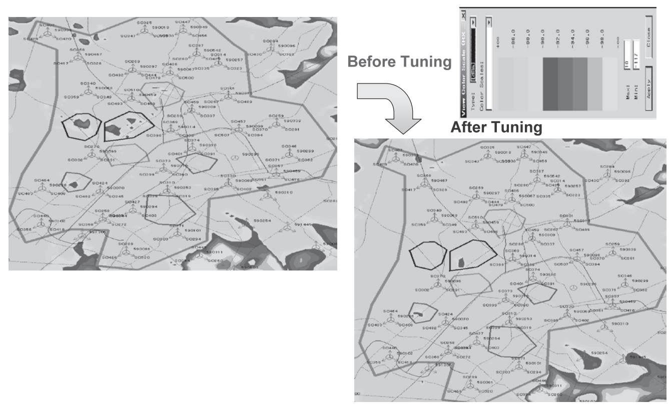

Fig. 3 Example of tuning using W-CARD.

increasing the computation speed. **Fig. 2** shows an example of received power distribution analysis using the RS3000, where the 3D analysis makes it easy to visually understand the differences in the received power distributions. This tool is capable of estimating the situation of radio wave permeations in a building as well as of radio wave leakage from indoors to outdoors by taking the effects of obstacles and indoor partitions into consideration. The computation results of the RS3000 can be exported to the W-CARD.

(2) RAN Tuning

The RAN Tuning operation includes measurement of the RF/network performance and the field quality using measuring instruments and user terminals (UEs). Also included are adjustment to the base station transmitting power, which is one of the RF parameters, adjustment of the antenna tilting angle and direction, optimum placement of scrambling codes and adjustment of the related parameters in the RRC protocol. The adjustment of the parameters has previously been the job of skilled engineers with a thorough knowledge of RAN construction, but NEC has developed an automated collection tool "UESOLTA" that collects data from the measuring instruments and UEs and controls them in order to improve the job efficiency. In addition, we also converted the expertise of our engineers into algorithms in order to automate the functions that included the "tilt adjustment function," "scrambling code allocation function" and "adjacent cell list creation function" in order to significantly improve the analysis frequency. **Fig. 3** shows an example of tuning by means of tilt modification using the W-CARD. It indicates that the weak receiving power values inside the black frames are increased to stronger power values.

(3) Area Patrol

The Area Patrol operations include measurements using measuring instruments and UEs including those of the RF/network performance quality of the field and those of the protocol information and traffic count, statistical processing by extracting the quality parameters required for the analysis, quantitative identification of the quality during operations and adjustments according to the variability of the actual traffic. These operations previously necessitated a huge amount of time because engineers highly skilled in measurement and protocol technology had to extract many parameters before analyzing the detailed causes. To solve this problem, NEC is at present developing a proactive measurement/analysis technology. This method can improve the network KPI (Key Performance Indicator) that indicates the quality of the wireless infrastructures and the field KPI thus indicating the degree of user experience quality.

Fig. 4 shows an example in which the improvement of characteristics by the Area Patrol has been confirmed. It shows that the rate of the area (location rate) satisfying the high quality level standard has increased by 4.6 percentage points.

Fig. 5 shows the tools used by NEC. Here, the Coverage Design falls on "Planning," the RAN Tuning and Area Patrol fall on "Analysis" and the measurements fall on "Measurement." Though not explained in this paper, there are also tools for "Benchmarking" the network quality of multiple communication carriers and a strategy building service is also provided as one of our professional services.

Comparative Table

Item			Before	After
HIGH	RSCP≧-87dBm	Ec/N0≧-8.8dB	93.1%	97.7%
MEDIUM & LOW	-87dBm>RSCP	-8.8dB>Ec/N0	6.9%	2.3%

Comparative Graph

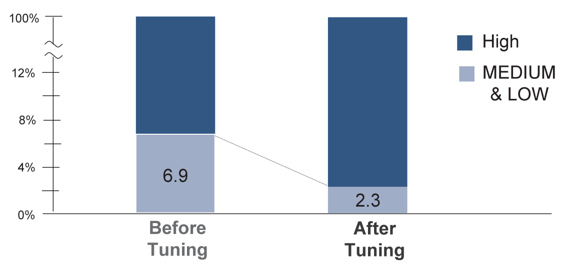

Fig. 4 Example of the analysis results of the tuning improvements.

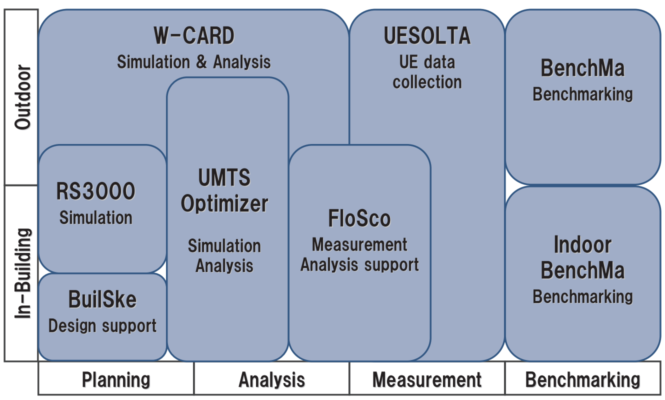

Fig. 5 RAN-SAITEKIKA tools of NEC.

2.3 Actual Results of RAN-SAITEKIKA

RAN-SAITEKIKA has already achieved impressive results in the field of W-CDMA in many European and Asian countries including the UK, France, Spain and Hong Kong. In Japan, too, RAN-SAITEKIKA has been adopted at the national scale.

3. Future Perspectives of RAN Optimization Technology

3.1 Improvement in Accuracy and Speed

We are developing highly accurate network construction simulations specifically aiming at improving the evaluation accuracy of the effects of obstacles and of traffic variability. The evaluation accuracy of the effects of obstacles is improved by developing a map data creation technology, and that of the interference power is improved by modeling traffic variability over time. It is also expected that a large-scale computer resource will be required to perform traffic analysis and radio wave propagation estimations of the map data that contains the obstacle information. The RS3000 already applies a parallel computation system for using multiple servers, but we are planning to provide this system with an increased speed capability.

3.2 Adaptation to New Technologies and Expansion into Administration Services

RAN-SAITEKIKA is confidently considered to be compatible with the new wireless communication systems (HSUPA, Beyond 3G and 4G), and the system is expected to adopt hierarchical configuration and become more complicated as new technologies are released in the future. We will deal with contingencies by providing professional services for the construction of diversified and elaborate networks based on a full consideration of equipment properties by fully exploiting our advantage as an equipment vendor. In addition to network construction, we will also adapt ourselves to the new technologies in the field of network operations by systematizing the knowledge and expertise of our engineers that has been obtained through experience in the provision of professional services.

4. Conclusion

In this paper, we described the methodology of wireless network optimization that we have accumulated independently (RAN-SAITEKIKA) and its element technologies. We also introduced the tools and software developed for improving job efficiency by converting the knowledge and expertise of our skilled engineers into algorithms. Additionally, we introduced our achievements and new technologies in the field of W-CDMA systems, together with particulars of the technical developments that are currently underway for promoting future opportunities and details of our future perspectives.

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