Mobile Service Level Management System

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Abstract

In recent years, mobile phones are being used as important communication tools in the business setting. In response to this scenario and to help guarantee a stable communication quality for business based users, it is expected that mobile carriers will introduce the SLA (Service Level Agreement) for business user mobile communication services in a similar manner to that which has been done for land-lined communications services.

This paper explains a mobile service level management system that supports mobile carriers in providing SLA compliance management services for business users. When introducing the SLA, the radio wave quality inside an enterprise building may be accurately predicted by using a 3-D radio wave propagation simulator.

After the introduction of the SLA, quality information is acquired from both the enterprise terminal and the mobile network. By analyzing this information statistically, radio cell anomalies and other adverse symptoms are detected, thus enabling the radio wave quality to be improved and the SLA guaranteed quality level to be maintained.

Keywords

mobile phone, management system, SLA, radio wave propagation, data mining

1. Introduction

Various changes are occurring in the mobile business environment, such as the saturation use of private mobile phone user contracts, the enforcement of mobile number portability and the assignment of frequency bands to entrant carriers. In response to these trends mobile network carriers are reinforcing their services such as mobile Centrex and data communications in order to target businesses. Currently, a quality guarantee agreement for land-line communications is contracted between the carriers and the businesses according to the SLA (Service Level Agreement). However, this agreement has not been applied to mobile services due to the difficulty of guaranteeing the radio interface quality. Also, owing to the lack of an appropriate management system to monitor and maintain the service, the SLA agreement cannot be effective as it stands. It is certainly difficult, in the domains both of technology and cost to guarantee the radio interface quality of an entire service area which is often very large. However, by limiting the area to that for which a high quality radio interface is required by the enterprise contractors, the possibility of being able to provide the SLA will be more realistic.

This paper introduces the technologies of service level management that are required to provide SLA for the mobile service environment.

2. Framework of the Mobile Service Level Management System

The provisions that are listed in the SLA for fixed phone networks are availability, fault recovery time, transmission capability and call completion success rate etc. In a mobile network environment the following additions to the above should be considered as provisions of the SLA; the SLA target area and the ratio of service unavailable area in the SLA target area. By limiting the target area of the SLA, mobile network carriers can clearly specify the units to be installed and be controlled to guarantee the radio interface quality for business use, so that appropriate radio network design and management can be planned and the service level can be provided.

The mobile service level management system developed by NEC is a service platform that supports mobile network carriers in carrying out the radio network design and business operation planning that is essential for providing services to enterprises under the SLA guarantees.

Fig. 1 shows the framework of the system. The system provides the following technologies.

1) In-building radio quality assessment technology, which evaluates the condition of radio waves over a wide urban area and also on each floor of the business premises by using

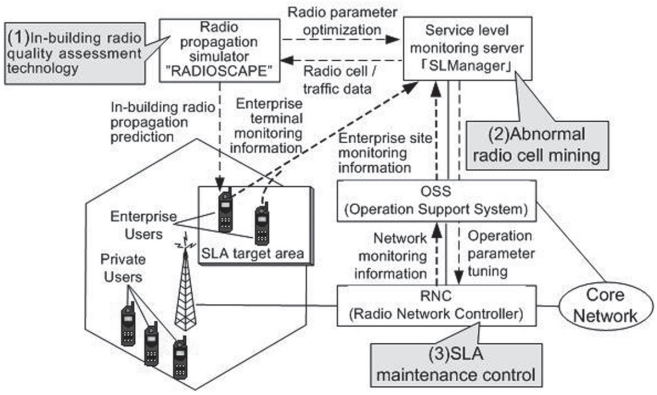

Fig. 1 Mobile service level management system.

NEC's 3-D radio propagation simulator "RADIOSCAPE". This technology enables quality improvement planning and the rapid establishment of SLA contract directions without carrying out manual measurements.

2) An abnormal cell mining technology, that effectively detects and predicts faulty radio cell sites (service areas), which might have the potential to violate the SLA. This technology statistically analyzes performance data monitored from enterprise mobile terminals and the radio access network via anomaly detection and time series data mining.

3) An SLA maintenance control technology that restores the radio quality of the SLA target users by controlling the appropriate resource assignment in case of a sudden increase in traffic is demanded. This technology maintains the transmission quality of the SLA target users at a level equivalent to the guaranteed quality level.

Technologies developed for the mobile service level management are shown in the diagram below.

3. In-Building Radio Quality Assessment

In drawing up an SLA contract between a mobile network carrier and an enterprise user, a mobile network carrier has to acquire accurate radio wave environment data for the SLA target business premises in order to decide whether to contract the agreement or if any quality improvement guidance should be introduced.

To understand the radio wave environment of a particular building, an experiment using exclusive measuring equipment is one of the methods, however, it tends to take a long time before such an experiment can be performed because of the frequently cumbersome negotiations involving the owners of the buildings that house the business users. To solve such problems, NEC has developed an in-building radio wave quality evaluation technology that simulates a radio wave environment by using a radio propagation simulator "RADIOSCAPE."

A ray launching method that analyses radio wave propagation characteristics by irradiating omni-directional rays from an antenna is employed via a RADIOSCOPE in order to evaluate radio wave quality. By precisely examining the building data acquired from 3-D maps and in-building floor layouts, it predicts the conditions of the radio wave propagation sent from an outside base station to a terminal inside the building. An experimental simulation has been carried out at Shinjuku Nishiguchi Station. **Fig. 2** shows the results. When carrying out a seamless analysis between outdoors and inside a building, it is important to know whether the resolution level of the rays should be adjusted to outdoor or inside building use. When the resolution level is adjusted to the outside of a large-scale building, detailed information of the inside of the building cannot be acquired precisely. This will cause deterioration in the accuracy. However, when the resolution level is adjusted for inside building use, a large amount of data extra to that which is necessary will be acquired. This state of affairs causes a significant increase in the calculation time. To solve this problem, NEC has developed a technology called the "Ray division and re-launching method." Rays expand during propagation. This technology enables the fractionation of a ray into several rays when a ray has reached a defined volume. With this technology, the ray volume can be maintained to an appropriate value that corresponds to the propagation environment, so that a high speed evaluation is available without deterioration of the evaluation accuracy. As a detailed example, increases in calculation speeds of approximately 5 to 10 times have been achieved for urban environments. A calculation time of 2km^2 per hour has been achieved, which can be adopted for practical use. With this technology, a precise in-building assessment for radio wave quality becomes available without carrying out actual measurements.

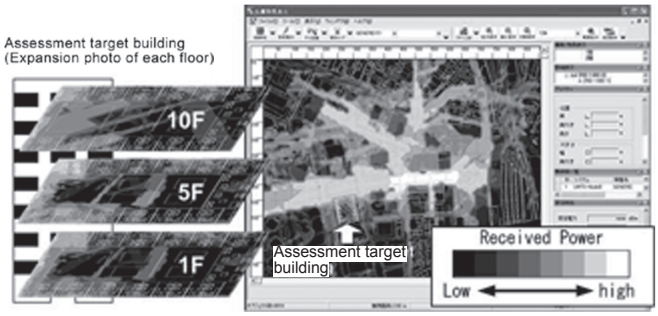

Fig. 2 In-building radio wave quality assessment using a RADIOSCAPE.

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4. Abnormal Cell Mining

After an SLA is concluded between a mobile carrier and an enterprise, monitoring is carried out to maintain the transmission quality at a level equivalent to the transmission quality guaranteed to the enterprise (SLA target user). This section explains a method for carrying out the efficient anomaly detection/prediction of radio cell quality, and data analysis to evaluate the causes via the quality monitoring information acquired from the business terminal and the radio access network.

In the mobile network environment, services are provided via radio waves, so that it is impossible to acquire full information of the transmission quality of a business terminal just by monitoring a mobile network system. In order to evaluate such conditions NEC has developed a quality monitoring agent that monitors radio wave quality on the enterprise mobile terminal. This measures the percentage value of service outage in the SLA target area and the transmission call completion success rate. It accumulates and calculates this data once a day and sends it to the remote service level monitoring servers. By introducing this monitoring system, an item regarding the outside-the-service area ratio, which has been so far difficult to acquire from the network side, can now be added to the SLA contract. It also enables an efficient determining the quality deterioration problem either network or business terminal sides.

The framework of the SLManager which is a server for monitoring service levels is shown in the **Fig. 3**. The monitoring server acquires quality monitoring results from the area surrounding SLA target area via the network operation support system (OSS) and an enterprise terminal, and then stores the analyzed results in its database. At the same time, it sends the monitoring results to the management department of the enterprise, and also sends directions to improve the radio wave quality such as operation parameter tuning directions, etc. to a mobile carrier.

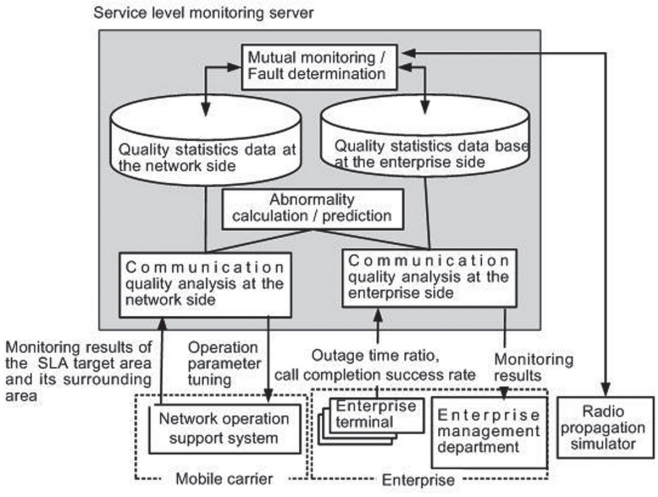

Fig. 3 Service level monitoring server, SLManager.

To minimize the SLA violation hours, it is generally required to detect anomalies at an early stage and to carry out cause analysis and to be able thus to quickly provide countermeasures. However, when providing an SLA anomaly judgment by analyzing a small amount of data accumulated over a short period, it is necessary consider the statistical reliability otherwise an erroneous judgment may be provided. To solve such a problem in the context of statistical reliance NEC has developed an abnormal cell mining technology that predicts faulty radio cell sites via anomaly detection and trend analysis of the time series data.

Firstly, in the context of anomaly detection it calculates statistical abnormality (anomaly ratio which can be assumed as an SLA violation) based on the percentage violation of the SLA contract while comparing the measurement value of fault occurrences against the number of times of dialing and receiving. By assuming that this statistical abnormality is a violation ratio, anomaly detection of data is statistically reliable because the anomaly detection ratio will increase according to the number of times of dialing and receiving within the same percentage of fault occurrences. A small transmission data rate of less than 50 calls per hour is important for surveying the symptoms of SLA violation. By employing our proposed method, 70% of the erroneous detection ratios of such small data rates have been reduced compared to those measured by the conventional anomaly judgment method based on fault occurrence percentages.

Also, by investigating anomaly levels of transmission quality acquired by this method and the trends in traffic demand, radio cell sites which have the potential to violate the SLA in the near future can be found efficiently. The quality and demands of mobile networks vary dynamically depending on their usage environment. Also, several cycles of variation per day or per week will occur depending on the user's life style. When considering these variations, future predictions including dynamic variations and cycles are necessary. A time series analysis using a state space model is widely accepted as a suitable prediction method for such purposes. However, the conventional state space model requires a calculation volume that is proportional to a power of three of the number of records involved in a cycle, which results in difficulty with the actual hours analysis of long cycle data and also causes inaccuracies in predictions. A time series data mining engine, TrendLiner developed by NEC employs a hierarchical state space model

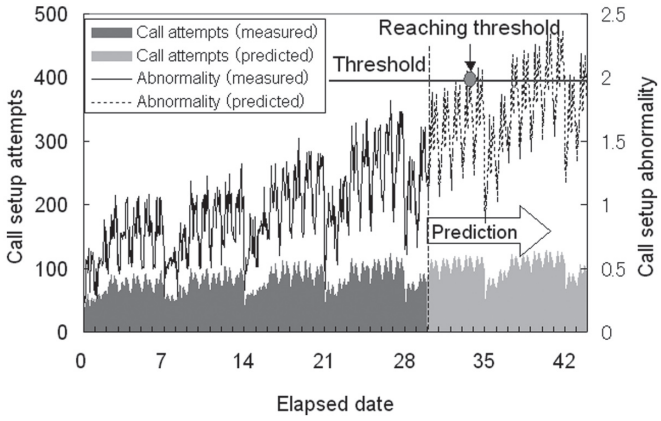

Fig. 4 Abnormal cell mining using a TrendLiner.

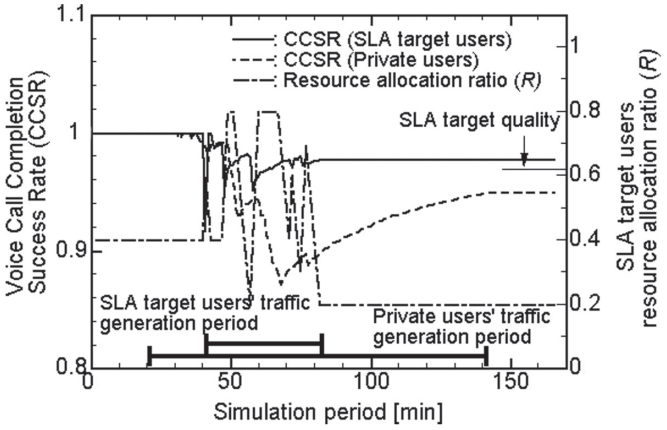

Fig. 5 SLA maintenance control.

that enables the handling of long cycle record data by accumulating it per appropriate time interval according to the information volume standard. With such technology, high processing speeds of approx. 100 times and prediction error of 10 to 30% less compared to those of conventional method have been achieved. **Fig. 4** shows an example of TrendLiner data employed for the service level monitoring server, SLManager. By showing, in consideration of cycle variation, the number of dialing/receiving demands and anomaly levels in a time series, the example indicates the prediction of the times when the anomaly level might reach a caution level in the future.

5. SLA Maintenance Control

When quality deterioration or a similar symptom is detected, a countermeasure to deal with its cause is required in order to maintain guaranteed quality of the SLA. When the quality deterioration occurs due to a long-term traffic demand increase or to a poor radio wave propagation environment, tuning of the radio wave parameters with a radio wave propagation analysis tool or constructing more base stations is recommended. In the case of short-term traffic variables that occur more often, an appropriate resource control should be provided to the SLA target users through the radio wave access network. A connection priority control system provided to a line with priority when disaster occurs is one of the resource assignment controls in the conventional mobile network that depends on user type. However, this connection control system is designed for public institutions for which absolute priority is expected. The system is not efficient enough to be adopted as the SLA maintenance control technology for businesse users. To solve this problem, NEC has developed a control system with a call admission control function. The efficiency of the SLA maintenance control using such a control system with a call admission control function has been proved in simulation experiments.

Fig. 5 shows the results. The voice call completion success rate (CCSR) decreases temporarily due to convergence, however, the transmission quality of the SLA target users recovers to the level aimed for, by increasing the resource assignment ratio (R). Also the transmission quality of private users recovers when some space is generated in the capacity while decreasing the SLA target user traffic. With the appropriate resource assignment control depending on user type, the SLA guarantee can be maintained even when different service levels are demanded for each enterprise.

6. Conclusion

In this paper, we suggest the possibility of providing the SLA by limiting the area to which a business user demands high quality mobile services, and also by carrying out appropriate network planning and installation. As a key technology to provide the SLA to a mobile service environment, we explained an in-built radio wave quality assessment technology, an abnormal cell mining technology and an SLA maintenance control technology. We expect that high quality and sufficient mobile services which meet user demands will become available in the future, by introducing a mobile service level management system and by integrating these technologies.

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