Development of “ASSISTA Management,” a Management-Assistance Service for Radiology Departments

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Abstract

We developed a new management-assistance service called “ASSISTA Management” for radiology departments to analyze X-ray exposure results using a chart view and a list view. ASSISTA Management provides “Dashboard” and “Drilling-down” functions for intuitive analyses. We built a highly scalable system in the cloud using a scale-out design for system extension based on user growth. In this paper, we introduce ASSISTA Management’s features, intuitive user interface, and cloud architecture.

1. Introduction

As medical practice is rapidly going digital in recent years, the use of computed radiography (CR) and digital radiography (DR) is spreading in the field of radiology and the workflow is being drastically improved. In CR or DR, unlike analog radiography using film, it is difficult to keep a record of doses used, the number of retakes and other information.

In developed countries, improvement in hospital profitability and that in patient service are key issues. In radiology departments, enhancement of productivity is getting in great demand.

We have developed ASSISTA Management, a management-assistance service for analysis of X-ray exposure results. ASSISTA Management collects exposure results, such as examination records, miss shots and exposure conditions, stored in image processing units (consoles) of our CR and DR systems. Those exposure results are visualized in the form of charts and lists for analysis.

2. Overview and features of the service

Fig. 1 shows the system configuration of ASSISTA Management. The exposure results of all the X-ray rooms in a hospital are sent from the console in each room to be collected into the management PC for ASSISTA Management in the hospital. Those collected exposure results are anonymized by deleting personal information and uploaded to the server in the cloud via a secure line for remote maintenance. The uploaded exposure results are visualized on a web browser on the maintenance PC. They are shown as a chart or a list to enable analysis from various angles.

2.1 Analysis functions

ASSISTA Management has four analysis functions: Examination record analysis, exposure condition analysis, retake analysis and equipment operating rate analysis. Those analysis functions are explained below.

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2.1.1 Examination record analysis

The number of examinations and the number of shots are analyzed from various parameters, such as day of week, hour of day, gender, requesting department and X-ray room. Those analyses visualize peak hours and off-peak hours of radiology operations. That is expected to help optimize staff assignment and shift schedules and reduce patients’ waiting time.

2.1.2 Exposure condition analysis

Statistics on exposure conditions per body part and exposure menu are viewed together with the images taken and that helps users to determine the optimum exposure conditions and helps reduce patients’ exposure dose.

2.1.3 Retake analysis

The number and the rate of miss shots are analyzed by body part, exposure menu, X-ray technician or any other parameter. That helps identify types of exposure with a high rate of retakes. An miss image is displayed together with a retaken image to help users to explore ways of reducing the number of retakes.

2.1.4 Equipment operating rate analysis

The analysis is performed on the frequency of use of X-ray equipment and the occupancy rate of X-ray rooms by year, month, week and day of week. It helps even out the operating rates by increasing the rates of the time when they are lower than those in other time.

2.2 Intuitive user interface

We have employed the Dashboard and Drilling-down functions for the user interface of ASSISTA Management to help users to operate intuitively without specialist knowledge of statistics and analysis.

2.2.1 Dashboard

After you log in ASSISTA Management, the Dashboard appears. It displays the retakes and examination records of the day (Fig. 2). It shows the number of retakes and the number of examinations by X-ray room, X-ray technician or other parameters. It also shows changes by hour. The busy chief technician of a radiology department can grasp what is going on at a glance in the actual field of radiology without any key operation on the screen. When detailed information is needed, the user can just click the relevant chart and change the refinement criterion and the target period for more detailed analysis.

2.2.2 Drilling-down

ASSISTA Management provides the Drilling-down function. A specific area in a chart can be further analyzed by another parameter. Fig. 3 shows the flow of drilling down of an analysis of the number of examinations. The chart (1) shows the number of examinations by day of week. The chart (2) shows the number of examinations by requesting department for Thursday when the number of examinations is the highest on the chart (1). The chart (3) shows the number of examinations by hour of day for surgical ER which has the highest number of examinations in the chart (2). The chart (3) indicates that, for Thursday when the number of examinations is the highest, X-ray examinations are requested most by surgical ER and that the busiest hour is between 7 and 8 o’clock in the morning.

The Drilling-down function of ASSISTA Management allows the user to drill down into his or her concern intuitively and dig deep into data or analyze from another viewpoint with simple operations.

3. System configuration in the cloud

In the development of ASSISTA Management, we have decided to use the cloud as we wanted to configure a small system fast and extend flexibly in accordance with an increase in the number of users.
In the case of conventional on-premises architecture, with a physical server installed in the in-house data center, it is not easy to add servers. In that case, a scale-up design is used: The CPU and memory of the existing server are expanded to improve the system’s processing capacity.

In the cloud, configured on a virtualized infrastructure, there are few restrictions on the number of servers to increase or decrease. It is easy to establish a scale-out design, which allows the number of servers to be increased in accordance with the number of users or the frequency of access (Fig. 4).

Also, because of economies of scale due to virtualization in the cloud, the cost per server is less than that in an on-premises architecture.

### 3.1 Scaling out of application server

Fig. 5 shows the application server used to provide an analysis result in response to a request of the user. A scale-out design is achieved by installing a load balancer and dividing requests among several application servers.

Even if a series of requests of a particular user are sent to a number of different application servers, the requests must be answered properly. To that end, the application servers have to be stateless servers and not to keep state information. ASSISTA Management has the database containing exposure results, the session server retaining log-in information and the storage storing files independent of the application servers. That allows the application servers to be stateless and freely increased and decreased based on the load status.

### 3.2 Scaling out of database

In ASSISTA Management, the number of records in the exposure-results table to be stored in the database is increased as the number of hospitals used or data storage period increases.

Fig. 6 shows how the response time changes in accordance with the total number of exposure records when 50,000 records out of the total number are tallied by body part. Although the number of records to tally is constant, the re-
Response time increases if the population, the total number of records, increases. In order to minimize the response time, the database must be scaled out so that the number of records per table does not exceed a specified limit when the number of hospitals or the data storage period increases.

3.2.1 Table split for each hospital

To suppress an increase in the number of records per table due to an increase in the number of hospitals, a schema is created for each hospital in the database and a table, like one for exposure results, is placed in each schema (Fig. 7). A table contains only the exposure results of a single hospital. Therefore, if the number of hospitals increases, the number of records in a table is not increased.

We have also fixed the number of hospitals in a database server to achieve a design in which the database servers are increased and scaled out with an increase in the number of hospitals.

3.2.2 Partitioning of table

To suppress an increase in the number of records per table due to an increase in the data storage period, we have employed partitioning to split a huge table into several sub-tables in the database.

Fig. 8 shows partitioning of the exposure-results table of a hospital. The table is divided by the year of exposure. Exposure data of 2016 are to be stored in the sub-table of 2016. When data of a target period is to be tallied in the database, sub-tables of period other than the target period do not have to be referenced. The response time will not be affected by an increase in the data storage period.

When data are to be deleted from the database after a certain period of time has passed, only the relevant sub-table needs to be deleted and thus it is quick. That is an advantage in long-term use.

4. Conclusion

As introduced above, ASSISTA Management provides "examination record analysis," "exposure condition analysis," "retake analysis" and "equipment operating rate analysis" with intuitive operation using the "Dashboard" and "Drilling-down" functions. To provide the service, a system flexibly extendable with an increase in the number of users is configured in the cloud using a scale-out design.

We will continue our efforts to add content that directly improves hospital profitability and patient service and will provide services that further improve productivity in radiology departments.

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