Building of System to Monitor Environmental Radioactivity Level

● Satoshi Kitadate ● Junichi Hasunuma ● Tomoaki Sato ● Mitsuteru Ishida

The Japanese government required a system to monitor the environmental radioactivity level and protect the children living in Fukushima from radiation, and requested it in the second supplementary budget for 2012. Fujitsu accepted an order for this system from the Ministry of Education, Culture, Sports, Science and Technology (MEXT) in December 2011. This system was transferred to the Nuclear Regulation Authority (NRA) in April 2013. We finished building this system in 75 days, and started running it partially in mid-February 2012, and completely in April 2012. Now, we are keeping the system running stably. We received the Good Design Award for it. In this paper, we describe the problems (short development period, suitable Web design, maintaining system response) we faced in developing this system. We also describe how we solved them by using cloud services, dividing up parts of the system for data processing, using Web designer and open source software (OSS), and using the Ajax (asynchronous JavaScript + XML) method.

1. Introduction

In July 2011, the Cabinet Office and relevant government ministries and agencies launched the Monitoring Coordination Meeting to monitor radiation caused by the accident at the Fukushima Daiichi Nuclear Power Plant of Tokyo Electric Power Company.[1),2)]

Subsequently, the building of the Radiation Monitoring Data Integration System as a specific monitoring system was planned[3)] in order to meet public demand for safety and security and, in December 2011, Fujitsu accepted an order for this system from the Ministry of Education, Culture, Sports, Science and Technology (MEXT) through a tender.

The Radiation Monitoring Data Integration System aggregates the radiation dose data from monitoring posts installed mainly in Fukushima Prefecture into a database to make such data available for real-time disclosure via the Web.

This system started partial operation in February 2012 and full-scale operation on April 1 of that year. Then, operation was transferred to the Nuclear Regulation Authority (NRA) in April 2013, and it has been in control of it since then.

Figure 1 shows the site for disclosing the monitoring information of environmental radioactivity level.

This paper outlines the system and describes problems encountered in its development and their solutions.

2. System overview

As shown in **Figure 2**, the Radiation Monitoring Data Integration System is composed of five subsystems. The system is operated by cloud services offered by a cutting-edge Internet data center (IDC) of Fujitsu FIP Corporation.

The following outlines the respective subsystems.

1) Monitoring data automated acquisition system

The acquisition server installed in the IDC automatically acquires the following six types of data sent from the monitoring devices installed nationwide at intervals of 10 minutes and stores them in a database.

- Real-time dosimeter: 2700 units
- Portable monitoring post: 595 units
- Nuclear Safety Technology Center (local government monitoring post): 218 units
- Japan Chemical Analysis Center (monitoring post

http://radioactivity.nsr.go.jp/map/ja/

Figure 1
Monitoring information of environmental radioactivity level.

for environmental radioactivity level survey)[note)] : 297 units
- Japan Chemical Analysis Center (portable monitoring post): 80 units
- Japan Chemical Analysis Center (nuclear-powered warship radioactivity level monitoring post): 21 units

The numbers of units are current as of April 2012.

2) Integrated database system

A database is built to store the following two types of information.
- Monitoring data
- Management information required for system operation including the observation point master

3) Information disclosure site

Discloses the following two types of information via the Web.
- Static content

Content including reports compiled by MEXT based on the information acquired from local governments and relevant organizations
- Real-time monitoring information

Data acquired by the monitoring data automated acquisition system that are disclosed using maps and graphs

4) Content management system (CMS)

Fujitsu Systems West's package product GWebLink-Neo is introduced to provide content management functions. The CMS allows standardization of site design without having to depend on the person in charge of site updates.

5) Information management system

By introducing Fujitsu's cloud service RapidWeb+,[4] database search and data editing functions are provided to manage the information in the integrated database system.

note) Stationary monitoring posts installed in 47 prefectures to grasp the environmental radioactivity levels.

3. Problems in system development

The following describes the problems encountered in system development.

3.1 Short development period

When the development was launched, MEXT had already been working on the installation of real-time dosimeters mainly in Fukushima Prefecture and their operation was scheduled to start in mid-February 2012. In order to start disclosing monitoring information in time with this schedule, we had to complete all of the work below in 75 days, which made the project difficult in terms of time constraints.
- Provision of the information infrastructure
- Development of the monitoring data automated acquisition system
- Development of the integrated database system
- Development of the information disclosure site
- Introduction of the CMS
- Development of the information management system
- Content migration

In particular, an urgent task was to provide the information infrastructure and carry out the wide-ranging work as shown below needed to be carried out systematically and promptly.
- Ensuring of the servers and network devices
- Ensuring of the lines for data acquisition
- Installation of the servers
- Provision of the NTP service for dosimeters
- Network configuration setting
- Installation of the middleware
- Ensuring of security

3.2 Development of aggregation functions for various data

The real-time dosimeter data are received in YAML

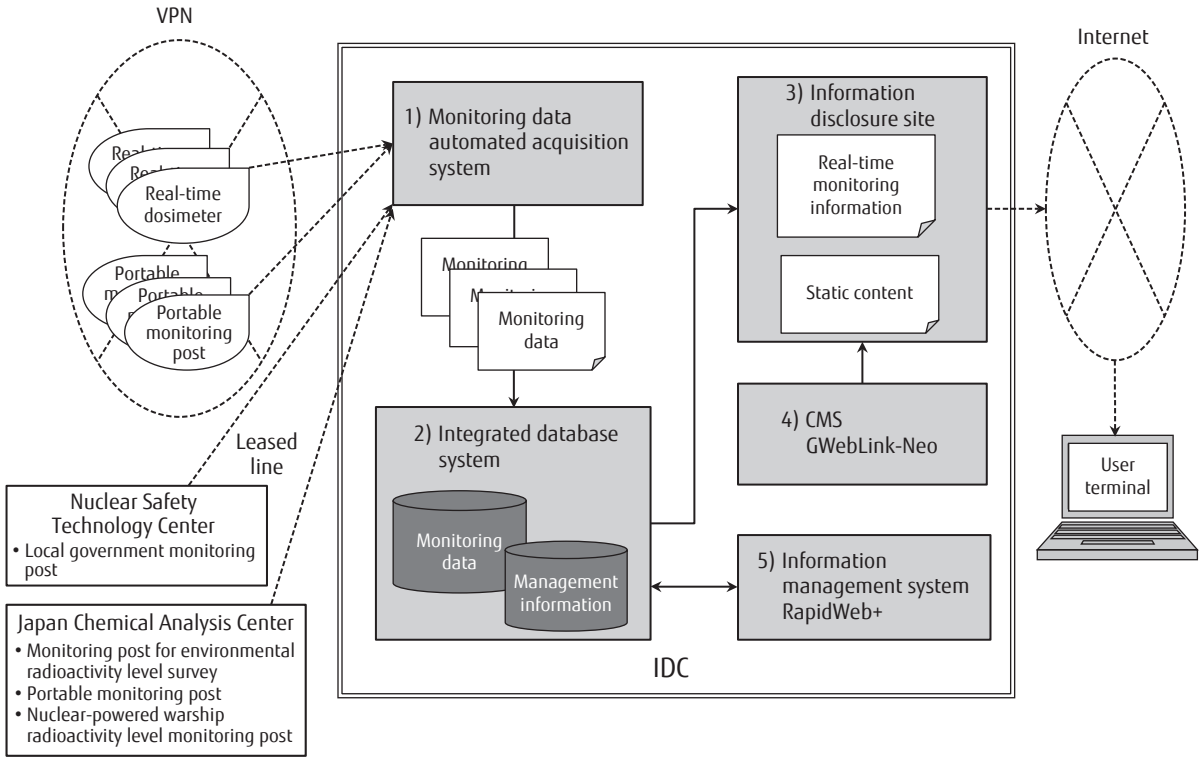


Figure 2
Overview of Radiation Monitoring Data Integration System.

Ain't Markup Language (YAML) format by using http. Data from portable monitoring posts are received in binary format by using socket communication. Data from relevant organizations such as the Nuclear Safety Technology Center and the Japan Chemical Analysis Center are received as text files in CSV format by using ftp.

Even if the protocol is the same, there is no standard format for received data. Some dosimeters may offer data on the amount of rainfall or precipitation detection in addition to radiation dose values. This variety of monitoring data hindered speedy development of the data aggregation functions.

3.3 Site design

To communicate monitoring information to more people in an easy-to-understand manner, a site design with high visibility and an intuitive and user-friendly user interface was required. For buttons and icons, designs that accurately communicate the intention of the information provider were desired.

Along with the dissemination of smartphones, we were expected to provide monitoring information which is based on the user's location data and which can be viewed on handheld terminals.

3.4 Ensuring of information disclosure system response

Response of the information disclosure system must be ensured from two perspectives:

1) Response of terminal

The number of monitoring points is over 3000 in Fukushima Prefecture alone. Load may increase on users' terminals depending on how information is processed, and this can degrade the response.

2) Response of server

The information disclosure server is said to need to assume 24/7 operation and must meet the following performance requirements.

- 10 million accesses/month
- 300 000 accesses/day
- Response within 3 seconds for 1000 simultaneous connections

4. Solutions to problems

To solve the problems described above, the following measures have been taken respectively.

4.1 Utilization of existing services and products

The development period can be reduced by making use of existing services and products offered by Fujitsu.

1) Use of cloud services

The IDC has a menu of cloud service descriptions, which allows prompt provision of information infrastructure by filling in standardized design sheets with the server specs and service descriptions required.

This system uses 18 servers and many services including operation monitoring and a firewall. Providing information infrastructure of this scale usually requires a period of three months or longer, but making use of cloud services has realized a significant reduction in design and verification work and made it possible to complete providing the information infrastructure in about two weeks.

2) Introduction of RapidWeb+

Radiation monitoring implemented by MEXT requires functions of searching for measurements at arbitrary points and editing management information. In order to achieve speedy development of an information management system that offers these functions, we have introduced RapidWeb+. This is a service for sharing and managing data generated from a customer's office operations on the cloud. As shown in **Figure 3**, functions are provided that configure workflow definitions and work tables based on the workflow and file layout and automatically create screens without the need for programming.

We have introduced this service into the IDC and successfully provided three functions of "search," "data listing" and "editing," which are required of information management systems, in one week. The introduction of RapidWeb+ has eliminated the need for developing more than ten screens in addition to basic functions including authentication and user management, which led to a reduction of development labor equivalent to 10 person-months.

4.2 Processing of various pieces of data

We have dealt with the variety of data by unifying the syntax (format of information) and external representation of semantics (meaning of information). Data processing is divided into two steps: a unification process for syntax unification and a mapping process for handling of semantics.

1) Unification process

Input data that is in YAML text and binary formats are converted into CSV files to unify the syntax of monitoring data.

While real-time dosimeters and portable monitoring posts send measurement data at intervals of

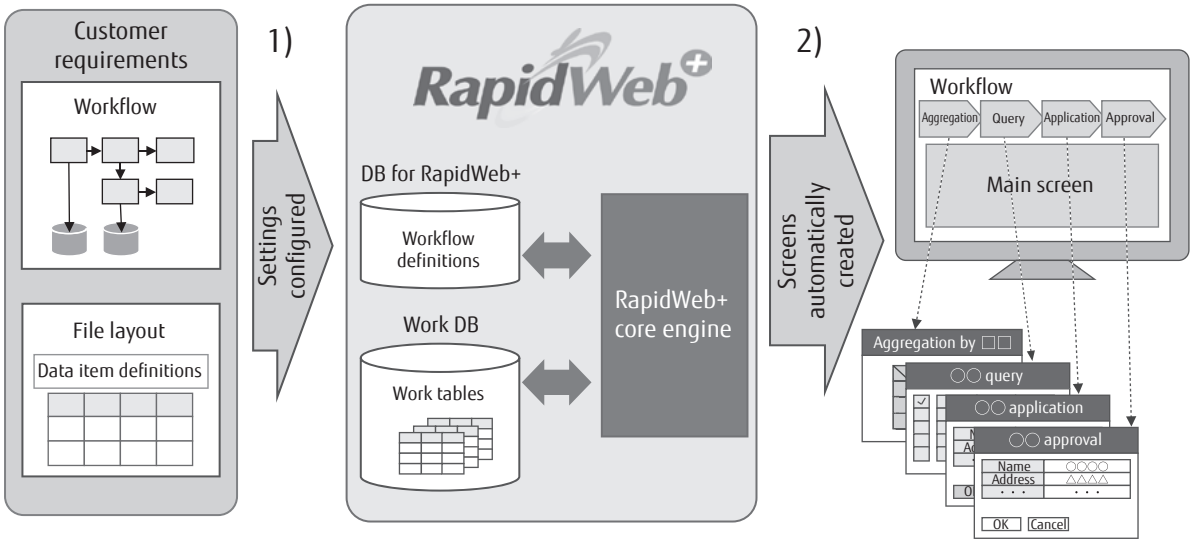


Figure 3
RapidWeb+ features.

10 minutes, time lags are provided in the transmission timing for distributing the data line load and server load at the receiving end. In this way, data that continually arrive at the IDC intermittently are accepted regularly and converted into CSV files.

2) Mapping process

Information representation in CSV format includes unique semantics for individual columns and a description of them in the Extensible Markup Language (XML) format is defined as a mapping file.

Major description items of a mapping file include:

- Association between input items and items stored in the database
- Check method for input values
- Conversion method for input values

In the mapping process, the CSV and mapping files are used as two inputs and the data are stored in the database. By loosely coupling the two processes, early development has been realized and maintainability improved.

4.3 Appointment of Web designers and use of OSS

To improve the visibility of Websites, visual elements such as colors, a color scheme and balance must be effectively incorporated. For that purpose, we had Web designers of Fujitsu Design Limited participate from the design phase for the information disclosure site.

Map icons indicating measurement points are important elements for communicating monitoring information and the shapes and colors of icons represent monitoring post types and radiation dose levels.

A monitoring data information display has been implemented by using the following open-source software (OSS) libraries to realize an intuitive user interface.

- Google Maps: map display
- Highcharts: time series graph display for radiation doses
- Ext JS: data list display

The libraries above have been selected with the expressiveness and operability taken into consideration based on benchmarking with multiple browsers.

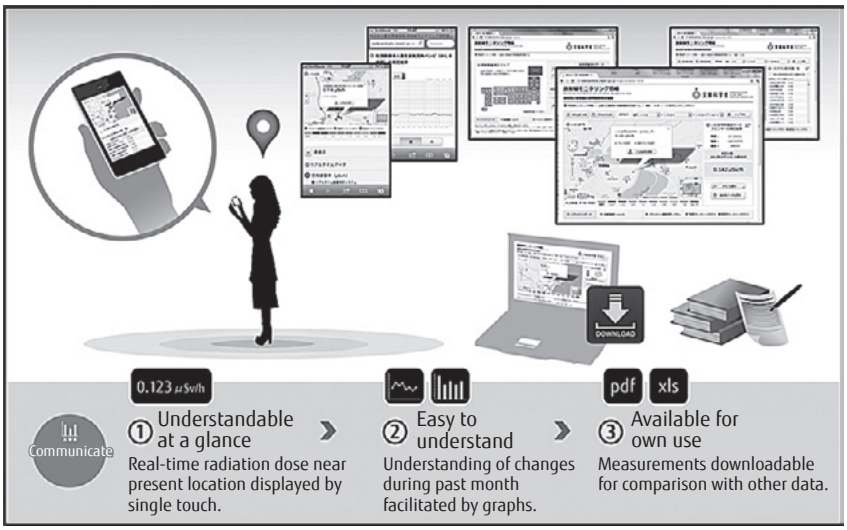
We have used style sheets for application to smartphones and attempted to standardize the system with PCs whenever possible.

For terminals that support Geolocation API of HTML5, we have made it possible to display information from neighboring monitoring posts based on the user's location information for improved convenience.

Figure 4 shows an example of displaying monitoring data by using maps and graphs.

4.4 Ensuring of response by using Ajax

A system in which information is processed on the server every time a device operation takes place



Source: GOOD DESIGN AWARD

Figure 4
Examples of display of measurements by maps and graphs.

causes a load on the server and raises the possibility of response degradation due to communication. To address this issue, we have applied the mechanism of Asynchronous JavaScript + XML (Ajax) that processes information on the browser to reduce the server load. In order to prevent excessive load being placed on the browser, the minimum required information is acquired from the server in JavaScript Object Notation (JSON) format for the information to be displayed and controlled on the terminal.

JSON, which is used as a data exchange format on the Internet, has the following features.

1) Structured data can be handled more compactly than XML.
2) APIs are prepared in many languages including JavaScript

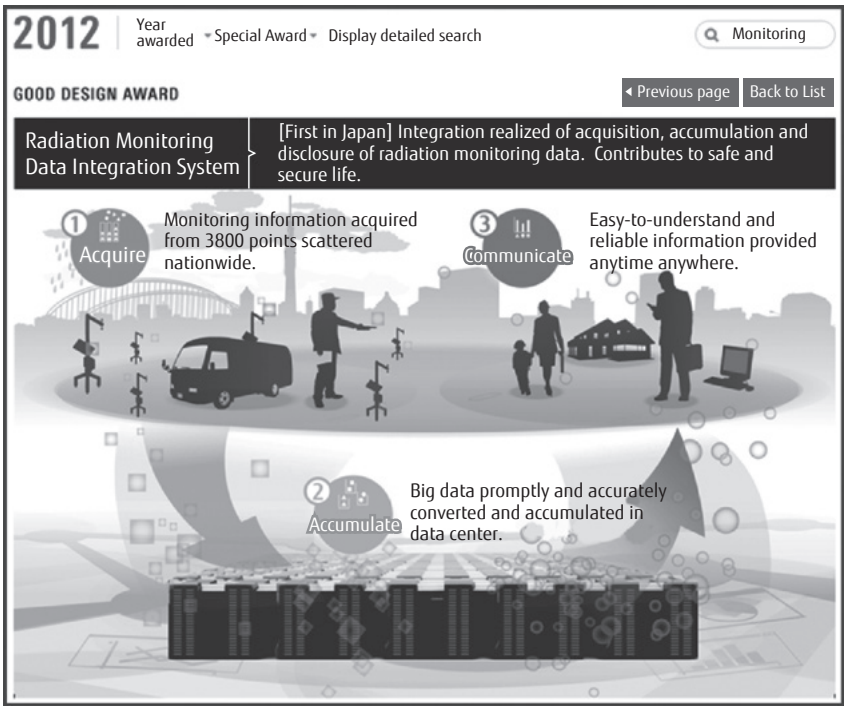
The information disclosure server divides the data required for displaying monitoring data into parts, which are generated as JSON files every 10 minutes. The total number of JSON files generated at one time is 4000 or more, of which only those that are necessary are read by the browser control script for display.

Design changes to JSON data must be carried out carefully because they have an influence on both the server and the terminal. We ensured engineers of both fields were involved from the design phase to coordinate the interface specification and achieved the expected level of response.

The system of information disclosure by JSON is making contributions to effective use of monitoring data not only by realizing a highly convenient information disclosure site but also by providing a means of data acquisition in research and monitoring operations.

5. Results and future outlook

We have quickly built an infrastructure for managing radiation data in an integrated manner by making use of data center cloud services and existing products. The function for acquiring highly diverse monitoring data has been divided into two processes for development in a short period and the scalability has also been maintained. In the information disclosure site, the monitoring information is displayed quantitatively in real time, which has helped to eradicate people's vague fear of radioactivity. The information disclosure site received high evaluation for the site design by Web designers and was awarded the Good Design Award for FY 2012 (in Japanese) (**Figure 5**).[5] The dose



Source: GOOD DESIGN AWARD

Figure 5
Winning of Good Design Award.

display function based on location information using smartphones has met with a favorable reception also in terms of safety and security.

More than two years have passed since the start of system operation and monitoring posts have been added during that time. The system has been running stably without any major failure and still continues to accumulate and disclose monitoring data.

In the future, we intend to use the accumulated radiation information and other types of information (such as weather and satellite information) for simulation on a supercomputer so as to create activities that generate new information values useful for the environment.

6. Conclusion

This paper has described how problems in the building of the radiation monitoring data integration system were solved and achievements were made. At present, this technology is applied to environment monitoring systems in Thailand and Saudi Arabia. We are committed to having continued development of environment-oriented solutions by making use of this technology.

Lastly, we would like to extend our heartfelt gratitude to the many people including dosimeter manufacturers who gave us cooperation in the building of this system.

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Satoshi Kitadate
Fujitsu Ltd.
Mr. Kitadate is currently engaged in business related to nuclear energy and weather.

Tomoaki Sato
Fujitsu Ltd.
Mr. Sato is currently engaged in development of applications for radiation monitoring operations.

Junichi Hasunuma
Fujitsu Ltd.
Mr. Hasunuma is currently engaged in business related to nuclear energy.

Mitsuteru Ishida
Fujitsu Ltd.
Mr. Ishida is currently engaged in development of applications for operations related to nuclear energy.