Jurnal Teknologi

Full Paper

A PROPOSED MONITORING DASHBOARD OF SMART CABLE GUARD (SCG)

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Article history
Received
8 June 2015
Received in revised form
9 September 2015
Accepted
10 December 2015

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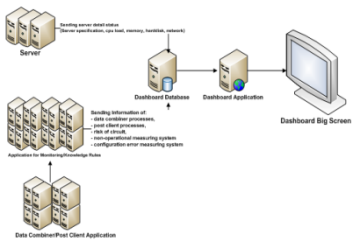
Graphical abstract



Abstract

One of services that DNVGL provides to its customers is to continuously monitor distribution cable circuits for upcoming defects. This monitoring system called Smart Cable Guard (SCG), which monitors over 100 circuits with an average of 5 discharges circuit per minute. Regardless of the amount of circuits and pulse discharges per minute, the system should be able to complete all processes within one hour or less. While in order to offers best services to the clients, DNVGL do analysis to the incoming smart cable data, applied defined knowledge rules, communicate to the customers for certain state of their cable circuit. To help the analyst monitoring the ongoing process and enable them to take a decisive action at the right time, proposed a monitoring dashboard. Dashboard is the solution when the nature of the works is to monitor day-to-day operational such as monitoring strategic information, operational information that changes daily.

Keywords: Dashboard; smart cable guard; monitoring; DNVGL

1.0 INTRODUCTION

Smart Cable Guard (SCG) measuring system is used for the online monitoring and locating partial discharges (PDs) in medium-voltages power cables. It comprises of two separate measurements units installed at both ends of the cable circuit to be monitored. Each measuring unit consists of a sensor/injector unit to measure and generate the time synchronization pulses and a controller unit to control the measurement sequence, the data collection and signal processing. Partial discharge data is sent via internet to DNVGL data acquisition and control center for interpretation and visualization of the data [1].

Data interpretation is done against knowledge rules defined by DNVGL based on fifteen years of offline testing. Analytical data and knowledge rules are combined to determine the level of risk posed by any partial discharge activity detected and the possible cause. DNVGL also offers clients the opportunity to directly monitor their cable circuits [1].

Many applications that applied the knowledge rules are built to support these objectives, these applications are run from host or server, and also database that stored the incoming analytical data. It is anticipated that besides providing online monitoring of power cables, monitoring these applications is also an important need, such as ensuring that measuring system itself runs as expected, sensor sends PD-data to control center as configured, and host/system that support the analyzing runs properly (memory, CPU load, and hard disk monitoring). While in order to offers best services to the clients, SCG DNVGL do analysis to the incoming PD-data, applied defined knowledge rules, communicate to the client for certain state of their cable circuit.

To fulfill both measuring system monitoring and communication to clients regarding circuit status, SCG DNVGL has two types of analyst, system analyst

and circuit analyst. System analyst ensures that all the system that support operational processes run well and even if it is possible avoiding crashes on the system. The circuit analyst has to be up to date with the circuit status in order to able to communicate the current state of the circuit to the circuit owner. In the other words, both system and circuit analyst should be well informed of the system progresses and the current circuit status accordingly.

The monitoring that is done by analysts is really helped by the presence of dashboard that is displayed on the big screen at data room office. The main challenge on this research is displaying real time and voluminous number of data that captured by the sensors. There is also a need to prioritize and visualize data very well in the dashboard to easier understanding of data in a glance.

2.0 RESEARCH METHODS

This research is analytical and implementation. It tries to understand the nature of processes in Smart Cable Guard (SCG) system and the structure of data source that should be presented in dashboard. Our research was conducted by applying approaches using the following steps:

1. Conduct literature study on the basic concept of dashboard such as dashboard characteristics, rich information display, dashboard formatting and layout [6, 7, 8, 9, 10], and the most important things related to gather key performance indicator for SCG system.
2. Analyse the nature of SCG system, the business process and the relations to the customers. Define critical information that should be communicated to the customers and when to consult.
3. Explore and analyse data sources including applications that feed the data and identify the most important data and its priority that should be monitored and displayed on the dashboard.
4. Building a dashboard with formatting and layout that should also represent the critical information that should be monitored.
5. Analyse the evaluation result in order to summarise the research question and conclude whether the problem was answered or not.

3.0 ANALYSIS

3.1 Role of Dashboard

The most important defining characteristics of a dashboard when compared to other means of presenting information, is that it is used for monitoring. Dashboard is the solution when the nature of the works is to monitor day-to-day operational such as monitoring strategic information, operational information that changes daily. The need for a dashboard is not triggered by the frequent changes to the information but because the needs for monitoring the information. So no matter how frequent the information changes when monitoring the information play an important role in the nature of working, dashboard is the solution – it is the purpose of monitoring that differentiate the dashboard. A correctly designed dashboard will conclusion at a glance while viewing it, but a poorly designed dashboard will not help to maintain awareness of what is going on and will stop using it altogether [2].

To enable effective monitoring, dashboards must be designed to support the following sequence of activities [2]:

1. Begin by presenting a consolidated overview that can be quickly scanned to see what is going on at a high level and to rapidly identify any items that need attention.
2. Provide enough information when particular items demand attention to help the person viewing it determine if further investigation and potential action is required
3. Provide the means to quickly access additional information about those items that need further investigation to determine if action is required and what action to take.

3.2 Dashboard Design and Layout

Key performance indicator can be used to measure the effectiveness of the activities and processes that are being monitored. To do its job as an informative communication tools, a dashboard must not only present the right measures of what is going on, it must also:

1. Put the information into context by including meaningful comparison,
2. Display the information with timely, correct, and reliable data,
3. Express information in a manner that directly assesses performance, and
4. Display information in a way that communicates clearly, accurately, and rapidly within the confines of a single screen. This point will be furthered detailed in the next sub chapter.

Most of the dashboards barely scratch the surface of its potential to be an informative communication tools. Some of the dashboards communicate too little by displaying the information poorly. This is primarily a failure of design. In order to be able to present the information in a way that people can rapidly monitor, fully understand, and effectively respond to, dashboard design must follow visual design principles for formatting and arranging information on the screen.

Visual design principles helps to display and the deliver the information well by minimizing the different perception between the users about the displayed information together with what is intended to be.

3.3 KPI and Requirement for SCG Dashboard

Business users and their requirements impact almost every decision made throughout the implementation of the dashboard. The requirement gathering is down by top-down approach, that is started by defining the business decision that need to be made first and then works its way out into the data needed to support the decisions [3]. SCG dashboard is used by two types of analyst they are system analyst and circuit analyst. The lists of information that should be presented in dashboard for system and circuit analyst are listed in below:

1. System Analyst:

a. System panel, show each system and server name and all main components depicted in it. The colour indicates the status. Indicator such as meter can depict the CPU load or storage space off a system. System analyst needs to monitor the current server status, such as the remaining space, CPU load, and memory. The CPU load helps the analyst to identify how well a computer is and is not running. A server/computer that is consuming 100% of CPU load for long time could mean that an application is frozen or a process is crashed. The analyst then will be able to fix the problem, for example by closing the affected program [4]. Computer random access memory or RAM is an essential hardware component that plays a large role in determining how fast a computer operates. When the information in dashboard showing that the high memory usage, the analyst can defined whether the computer needs additional memory to speed up the process. Hard disk usage monitoring can be used to identify whether server still has enough space in order to run properly [5].

b. Monitoring the activity of measuring system while receiving files/pulses that are read, validated, stored, and measured by Data Combiner application. It is intended that at most one hour; the Data Combiner should be able to complete the entire processing to avoid the queue for the next coming files/pulses. The number of incoming files/pulses is monitored by Post Client application. System analyst needs to monitor the progress of the receiving files/pulses by Post Client application and as well as the progress of Data Combiner from reading to storing the data to database.

2. Circuit Analyst:

a. Consistency status panel covers the operational status of the system/sensor. Through the dashboard, analyst should be able to view the measuring system configuration error and non-operational measuring system. There are three categories of measuring system configuration error , they are:

   i. Measuring system sensor. Usually after analyst setting up a master and a slave sensor to an active measuring system, he will register this setting to database. Due to human error, there is a chance that some of measuring systems that is still active but unintentionally left unassigned. This dashboard should be able to notify this error to the analyst, so they can repair the configuration.

   ii. Sensor without defined measuring system. It is intended that each sensor is assigned with at most one measuring system.

   iii. Sensor that is defined in many measuring system. For the analyst assigned each sensor to measuring system manually in the field, one sensor can be unintentionally assigned to multiple measuring system. This type of configuration error should also be informed to the analyst through the dashboard.

At this moment, analyst found that it is very difficult to identify this type of configuration error. Sometimes, they even do not know that this error is exists. Furthermore, even if they have figured it out, it takes time to go through each sensor and see where the error configuration exists. Apart from measuring system configuration error, the analyst needs to see the list of non-operational measuring system. Measuring system is categorized as non-operational when the sensor that is attached at both end of the cable circuit does not sending files/pulses to the database. This information can also be categorized into two types of lag; they are non-operational measuring system for more than 6 hours to 3 weeks, and non-operation for more than 3 weeks.

Based on this information analyst will check the measuring system activity though KEMA website. This website displays the partial discharge of the measuring system. It can be the case; the non-operational problem arises from internal system or from client side. In case of internal problem, the analyst should go to the field and fix the problem manually, however when in later case, the analyst should communicate to the client and give guidance how to solve the problem.

b. Circuit status panel, display list of risk circuit (highest risk first). Categorizing circuit into certain risk level is done by knowledge rule that is still in improvement. DNVGL ensures that after putting the knowledge rule in operational, the client should be more aware about the importance of SCG system.

Future knowledge rule should be able to group circuit in probably five risk levels, and identify the location of the defect along the cable.

At this moment, circuit analyst will see the list of the risk through the dashboard, and by go to the website to see the location of the defect, and if it is needed, analyst will contact the client. Later on, the client should also be able to view their own circuit and risk level through circuit dashboard.

3.4 Requirement Prioritizing

Design A truly effective dashboard can become a tool that is used every day; there is a need to validate the importance of information that should be displayed. For each analyst the most important information is ordered from the highest to lowest importance:

1. System Analyst

a. Health monitoring that displays the information of each server and module that is resides on it. The rest of the other monitored system will depend on the information that is displayed on health monitoring data. For example when it is displaying that certain server in which Data Combiner application runs does not started, without seeing any further to the next graph of Data Combiner process, the analyst will notice that the exception in this graph is caused by the server condition.

b. Assuming that there is no problem identified in health monitoring data, the analyst needs to monitor the current process of Data Combiner and Post Client application.

c. Server status details, indicates the detail of server including hard disk, memory usage, and CPU load.

2. Circuit Analyst

a. Circuit Risk, this is become the most priority for circuit analyst because the main business context of PD-OL system is for online monitoring and locating partial discharges (PDs) in medium-voltages power cables. The incoming PD data is then analysed and measured by applying knowledge rules. When dashboard displays circuit with risk, the analyst should inform the client if they ask so. A cable circuit has life duration; a risk can represent the life of the cable, so the client has to decide whether they repair the circuit or wait until it is broken and replace with the new one. A client has contract how the analyst should contact them when a risk is identified, based on the contract circuit analyst know how to act when monitoring the circuit risk information.

b. Non-operational and configuration error measuring system, non-operational measuring system can be affected by the risk identified in the circuit. While the configuration error usually can be solved internally by the analyst.

Information that should be displayed in dashboard spreads in two different database that using MySQL and MS. SQL Server RDBMS. Data related to server detail and server status are stored using MySQL, Data related to server detail and server status are stored using MySQL, Data related to server detail and server status are stored using MySQL, while the rest are using MS. SQL Server RDBMS.

This data is fed by some applications; application that monitors the progress of Data Combiner and Post Client application, Server health monitor application, Server Status Application, application for calculating circuit risk, and lag hours for the last received files/pulses from a measuring system. Globally the architecture of PD-OL dashboard is depicted in Figure 1 PD-OL Dashboard Architecture below. Detail information for each application and stored data is explained in the next section.

3.5 Feeder Application and Data

Data source that will be displayed on the dashboard was feed by applications below:

1. Monitor Data Combiner/Post Client Application

This application read the number of files that is sent by the measuring system each one hour. Later on the number of files should be processed and inserted by Data Combiner at most within one hour. DNVGL analyst needs to know the number of files that is currently received by the Data Combiner. There is a condition that within one hour Data Combiner cannot completely processed (till inserting to database) the files. It can be due to the MS. SQL

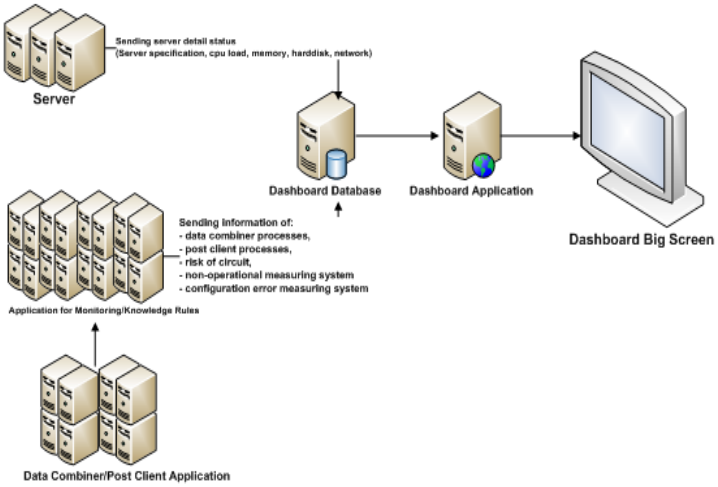


Figure 1 Dashboard architecture

Server query performance or too many files received at one time. When this condition happened, the Data Combiner has to processed the file queue when it has spare time for the next processed. In this case, DNVGL analyst needs to get informed this condition and Post Client should always inform the number of files that should be processed at that spare time. All of this information should be presented within System Dashboard.

2. Health Monitor Application

This application checks the status of each host of the module that supports SCG system. This data is updated each minute.

3. Server Status Application

Server status application collects the information of each server capacity and also resource usage and sends them to database. Application sends server's data each 15 seconds and because there is no need to keep a long past time data in database it will erase data for the next three months. However, this "three months can be changed in the future as well, because actually the analyst only need to monitor

the resource in short past time instead of three months data.

This application should be installed in each server that is going to be monitored. Application sends information of the server that is being monitored and saved into a table in database. Each server will have one record, while many cores and hard disks that tight to each server are stored by using semicolon delimiters. Detail resource usage for each 15 seconds will be stored in another table for monitoring computer.

4. Circuit Risk Application

This application applied defined knowledge rules to calculate the risk of circuit. The pulse that is sent by the measuring system is read and then measured to come out with a certain risk level. However the knowledge rule for risk calculation is still in improvement. The future risk level might be range from 0 to 1 or 1 to 5, where 1 is the highest risk, but the reverse can also be the case as well. Furthermore, the next circuit risk application should be able to identify location of the risk along the cable circuit.

Application stored data to a table each hour, and erase the previous data each time a new data is inserted.

5. Non-operational/configuration error measuring system application

This application applied defined knowledge rules to calculate lag hours of a measuring system from receiving files/pulses. Lag hours of receiving files/pulses can be used to identify cable circuit performance. Application sends and stores data to the database each hour.

3.6 Analysis of SCG Dashboard Characteristics

Application Based on the gathered requirement for dashboard application, it can be concluded that analyst needs to monitor the current process of SCG system that includes the process of Data Combiner, Post Client, Risk circuit, non-operational and error configuration of measuring system, server health monitoring and server status detail. In able to support analysts to do monitoring, dashboards must be designed to support the following sequence of activities:

1. Give overview that can be easily scanned at a glance the information that is needed by either system analyst or circuit analyst. System analyst can scan the information of server and server component status such as memory usage, hard disk space usage, and CPU load; monitoring the progress of Post Client and Data Combiner application.
   For circuit analyst, at a glance he should be able to see the list of circuit that is in risk, non-operational and error configuration of measuring system. By viewing this information, circuit analyst, if it is needed, will see more detail information though the website.
2. Provide enough information when particular items demand attention to help the person viewing it determine if further investigation and potential action is required. Dashboard should apply the right coloring choice to draw the attentions.
3. Provide the means to quickly access additional information about those items that need further investigation to determine if action is required and what action to take. The detail of the current information will be displayed in detail pages that will give the hints to the analyst of what is going on with the running processes. This information will be most provided for server detail information.

3.7 Design Approaches

Application System dashboard is viewed mostly by two types of analyst; they are circuit analyst and system analyst. Circuit analyst focuses/prioritizes on viewing the information of circuit risk, non-operational and configuration error of sensor; while the system on information of Data Combiner and Post Client current processes and server status.

This whole information, regardless the different types of analyst, will be placed in one big screen and put in a place where both analysts can easily see it. This one page screen will be designed based on the best practices of the layout and formatting guidance that is written in the literature.

Referring to the literature, the most important information should be putted in the upper left corner of the screen (reader's left hand) [2]. However each analyst has different priority for the information. So instead of defining the most important information and putting it on the upper left corner as in literature, the screen was divided into two categories based on the analyst information. So for example, the left half page will display information for system analyst, and the rest for circuit analyst or the other way around. In addition, for each analyst information is ordered based on the priority, in which the highest priority is put on top of the page.

So Figure 2 Positioning Content on Dashboard is the layout of positioning content on dashboard based on the analyst and the importance of the information

EMPHASIZED	EMPHASIZED
NEITHER EMPHASIZED NOR DEEMPHASIZED	NEITHER EMPHASIZED NOR DEEMPHASIZED
DEEMPHASIZED	DEEMPHASIZED

Figure 2 Positioning content on dashboard

After reorganizing the information that should be displayed on dashboard and querying the information based on the KPI that should be monitor, depicted the sample of dashboard capture in Figure 3 below.

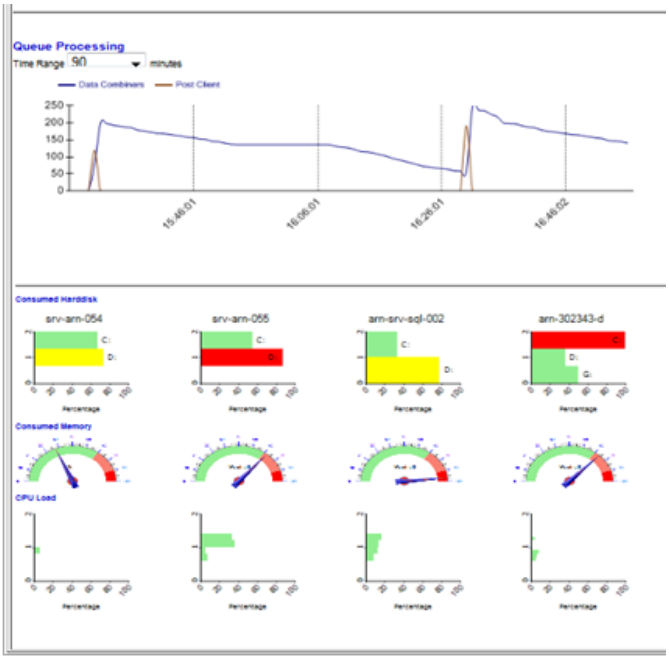


Figure 3 Sample of system dashboard

The first visualization is used to monitor the progress of the system that read data from sensors and saved it to database, while the second visualization displayed the current status of the server that are monitored in hard disk space, memory consumption, and CPU load; failed to monitor those servers might lead to disaster in saving the data from sensors.

4.0 RESULT AND DISCUSSION

1. Separating and grouping the system information from circuit information, makes a clearer division of information for both system and circuit analyst.
2. Clear identification of the importance/priority of the information and located it from top to bottom based on priority makes easier for the analyst to focus on certain information. For example, for system analyst, viewing red cross on module Data Combiner at the top of page (health monitor) will notify him that there are problems with the server and directly can conclude that the next information (graph of Data Combiner and Post Client) will also be affected as well.
3. Design choice and information that should be displayed in dashboard were based on the requirement gathering also reviewed by the team members and analyst that will use the dashboard.
4. Information in dashboard especially for circuit and measuring system information are changing dynamically. In order to keep the layout is neat; information in main page is limited to a certain number (top 10 for risks and non-operational measuring systems). The rest of the information can be viewed in detail page by linking from the main page.
5. New dashboard displays the information using the default chart/graph provided by ASP.NET. However, it was found default graph/chart does not support for color blind users. For example in Data Combiner and Post Client graph, it will difficult for user who color blinds to differentiate, because both are displayed using line with different color. To display shape in chart/graph (differentiate flow by providing dot or cross across the line) means drawing our own graph/chart.
   Dashboard database that is intended to handle the future requirement and the new database design is already implemented and build in the current database environment.
6. Currently, feeder application still accessing dashboard database that is run in MYSQL. So in order to be able to use the dashboard immediately, the migration from current database to dashboard database in MS. SQL Server is done. This migration will keep the data in new dashboard design up to date even if the feeder applications and knowledge rules behind it have not yet been modified and improved.
7. Dashboard design is not about art that usually found in website application. Dashboard should focus on how to display the right information and keep the right perception/understanding for common users.

Acknowledgement

This paper was published based on author's experience in DNVGL Company, thanks for the invaluable experience especially to my academic supervisor Prof. Guido Bakema and company supervisor Dr. Paul Wagenaars. My thanks also go to Del Institute of Technology for supporting this publication.

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