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CIGRE US National Committee
2023 Grid of the Future Symposium

Keeping Up with the Landscape: Developing a Modern Alarm Philosophy for a Rapidly Changing Distribution Control Center

R. HEMMATI
The University of Oklahoma
USA

R.C. CUSTER*
OG&E Energy Corp.
USA

F. MA
OG&E Energy Corp.
USA

J.N. JIANG
The University of Oklahoma
USA

SUMMARY

OG&E's Distribution Control Center (DCC) applies advanced digital methods to monitor and control high to low voltage utility assets. This Advanced Distribution Management System (ADMS) allows Distribution System Operators (DSOs) to respond to unplanned outages or other immediate system contingencies within seconds rather than hours. Along with OG&E's efforts over the past 50 years to modernize the grid, the number of these Supervisory Control and Data Acquisition (SCADA) equipped devices increased exponentially, consequently exploding the number of alarms appearing in the DCC. The DSOs must acknowledge and manage thousands of alarms each day, many of which are not actionable or even operationally relevant. This paper suggests that, by developing a modern alarm philosophy unique to their own system, utilities can provide clarity, prevent unnecessary alarm fatigue and provide a holistic awareness of the distribution system for the DSOs.

KEYWORDS

Distribution Control Center (DCC), Advanced Distribution Management System (ADMS), Supervisory Control and Data Acquisition (SCADA), Distribution System Operator (DSO), Alarm Fatigue, Alarm Management, Grid Modernization

custerrc@oge.com

INTRODUCTION

OG&E's DCC (Distribution Control Center) houses an ADMS (Advanced Distribution Management System) that runs the entire substation and distribution (high, medium, and low voltage) system in OG&E's territory. With all the devices on the circuits represented in this model, SCADA (Supervisory Control and Data Acquisition) equipped devices will generate alarms that Distribution System Operators (DSOs) see and respond to when problems arise. Along with OG&E's efforts over the past 50 years to modernize the grid, the number of SCADA equipped devices has increased exponentially along with the number of alarms that the DCC sees from those devices.

The DSOs must acknowledge and manage thousands of alarms each day, many of which operate independently based on local information, thus are not actionable or even operationally relevant. This mismanagement of data causes alarm fatigue in the control center, which is a leading contributor to switching incidents across the electrical industry. The findings of this project will provide clarity to the operators by restructuring their alarm screens and other alarm attributes. By presenting only actionable and relevant important alarms to the operators, we can prevent alarm fatigue in the DCC and increase the total awareness of the system.

ALARM MANAGEMENT PHILOSOPHY

Alarm management refers to a process of understanding, designing, implementing, maintaining and monitoring an alarm system [1]. The purpose of an alarm system is to notify DSOs about potential deviations from normal operations and enabling them to take necessary actions. The alarm notification and the subsequent DSO response is a critical first layer of protection during instances of faults or other abnormal incidents. For various reasons, alarms are essential to operations, especially when operating the electric distribution system. The alarm system generally can be used in the DCC as an early warning system that provides operators with situational awareness needed for fault detection, troubleshooting, operational efficiency, and reliability improvement.

Control centers have been experiencing a steady rise in both the volume and complexity of alarms received [2]. Over the past few decades, there has been significant progress in control systems technology, leading to a remarkable increase in the deployment of indication and control (I&C) devices within the power grid. Moreover, the configuration of alarms in control systems has become much easier, resulting in a substantial rise in the number of alarms generated in power management systems. Even though, the industry advances towards automation, alarm management is often underrated and underutilized [3]. This prevailing approach of alarming everything has become extremely overwhelming for DSOs in OG&E's DCC.

It has been consistently demonstrated that alarm systems designed without considering alarm management principles tend to exhibit undesirable performance, commonly leading to unplanned outages, damaged equipment or property and environmental and economic concerns. In worst-case scenarios, improper alarming methods can also contribute to safety concerns and increased risk of poor reliability. When implemented, a modern alarm philosophy offers guidelines that lead to the development of effective alarm systems within a DCC. Such systems should be capable of:

- Enabling operators to respond appropriately and promptly to abnormal conditions by taking the correct actions at the right time.
- Rerouting the other alarms to relevant internal groups for further corrective actions.
- Providing an accurate and reliable view of the alarms that the DSOs trust and understand.
- Allowing DSOs to manage all system alarms at an appropriate rate to avoid alarm floods [2].

DEVELOPING OG&E'S ALARM MANAGEMENT PHILOSOPHY

To develop our own unique alarm philosophy that follows OG&E's internal guidelines and procedures, we followed three basic steps. First, we gathered all data from the ADMS to assist in analyzing OG&E's alarm history. Then, from the data we gathered, we developed the philosophy by prioritizing all the device alarms. Finally, we used the prioritized data along with DSO input to create a new process for displaying alarms in the DCC from within the ADMS.

STEP ONE: ALARM BASELINE ANALYSIS

At OG&E, there are hundreds of thousands of SCADA points that are connected to devices in the field. All these points have the capability of generating alarms in the DCC if configured properly. Once connected to the network, all information gets processed into OG&E's SCADA database for the ADMS to utilize for I&C, alarming, or any other DSO need.

To begin this project, we first downloaded the first 5 months of 2023 from the DCC alarm event log via an Oracle database. Once we had the data from this log organized, we then began to filter out the entries to reflect the DSO user profile so we could start representing only what the operators have seen over this time period. With this base dataset, we then began to map the alarm events back to the SCADA points of origin to perform bad actor alarm resolution.

STEP TWO: ALARM PHILOSOPHY DEVELOPMENT

Part A: Alarm Group Categorization

Without any previous alarm categorization or separation, we decided to group alarms based on device-type categories as shown at the bottom of Figure 1 to begin developing our own alarm philosophy.

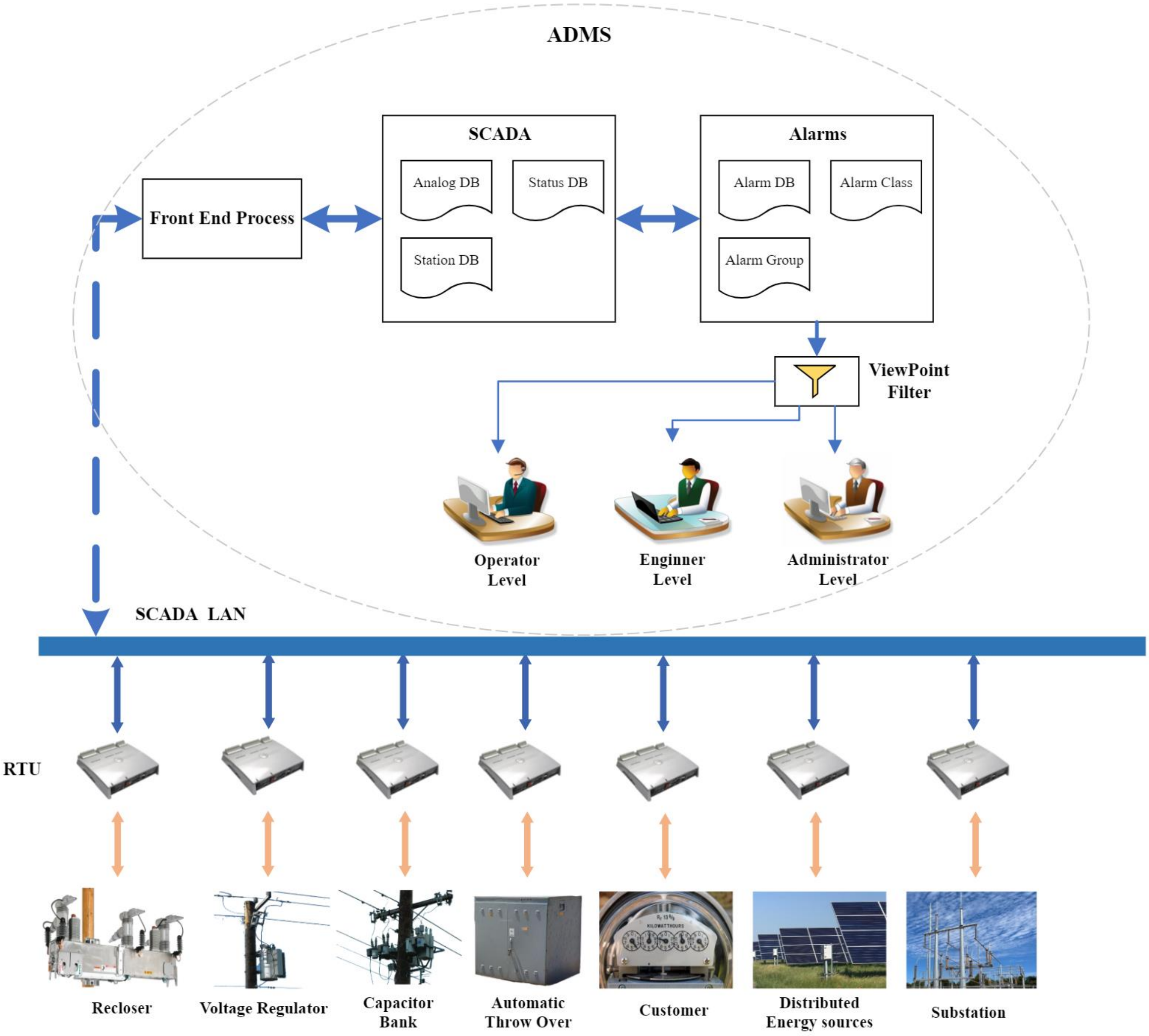


Figure 1: Physical device network diagram

Once the categories based on each physical device group had been created hierarchically, we then implemented data filters to group each point to each category from our SCADA point databases based on the associated device. Depending on the manufacturer, each device has a template of SCADA points that exist and that can be used to create alarm groups based on point attributes. By creating these relationships, we developed an alarm group structure that is represented by Figure 2.

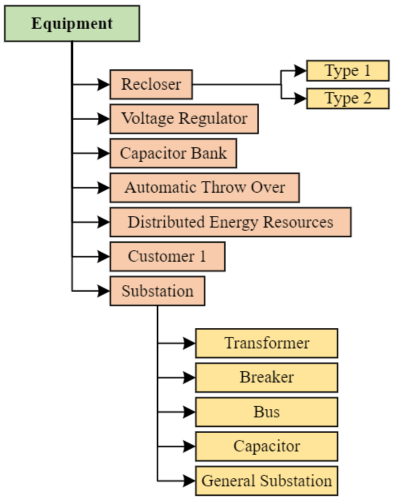


Figure 2: Alarms based on device type

Part B: Prioritization of Alarm Groups

For every alarm group and subgroup that was developed, an alarm priority had to be assigned to each point associated with that group. This priority, inspired by EPRI's classification, consists of two parts. The first part is either Alarm (A), Status Indication (S) or Passthrough (P) [2] which will help us sort the alarm into the appropriate screen in ADMS. The second part is a numerical prioritization on a scale of 1 to 8, with 8 as the highest priority. Only items A6-A8 will appear on the DSOs Alarm display, while all other items will appear on a System Information display to provide situational awareness to the DSO. Any alarm that requires an action and appears on the Alarm display has response time associated with the number assigned. An A-8 requires immediate response, an A-7 requires immediate analysis to determine the needed response time, and an A-6 requires a response following normal operation protocols within a day. All other events that are prioritized as lower than 5 will be handled as S and/or P events and will not appear in the Alarm display in the primary monitoring window.

For the scope of this paper, we will focus on the Recloser alarm group, including both subgroups Type 1 and Type 2 to illustrate the idea. Before prioritization, Recloser Type 1 had a total of 57 associated points to its subgroup and Type 2 had a total of 45 points. Once these points had been determined, we met with the Distribution Automation (DA) group with recloser experts to discuss each alarm and its priority. After this discussion, we followed up with senior DSOs from the DCC and confirmed that the assigned priorities follow safe operational procedures. At the end of this process, only 9 total points remained as actionable for the recloser alarm group, which is shown below in Table 1.

Table 1: Recloser rationalized alarm table

Operational Point Name	Point Type	Priority	Type 1	Type 2
A, B, & C Phase Current	Analog	A-6	X	X
A, B, & C Phase Open	Status	A-6	X	X
Device Tripped to Lockout	Status	A-7	X	-
Device Open	Status	A-6	-	X
Device Closed	Status	A-6	-	X

Part C: Event Management Process

Based on the prioritizations of the events that are generated, we will sort each event between two windows on the ADMS following the logic shown in Figure 3 below. This process guarantees that the DSOs will bypass non-actionable or irrelevant events on their primary alarm window while still maintaining situation awareness. This logic will be built into the new alarm windows within ADMS once this philosophy is implemented. The events classified as either S and/or P will show up in the system information display rather than on the main alarm page.

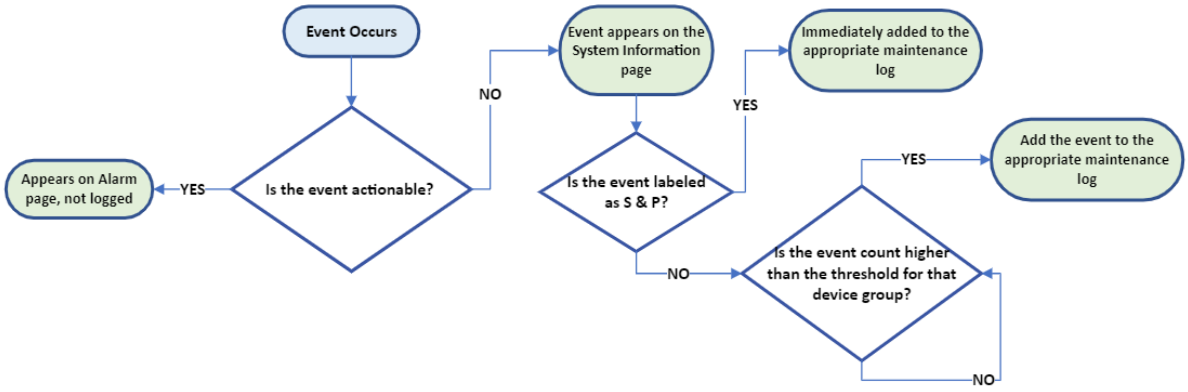
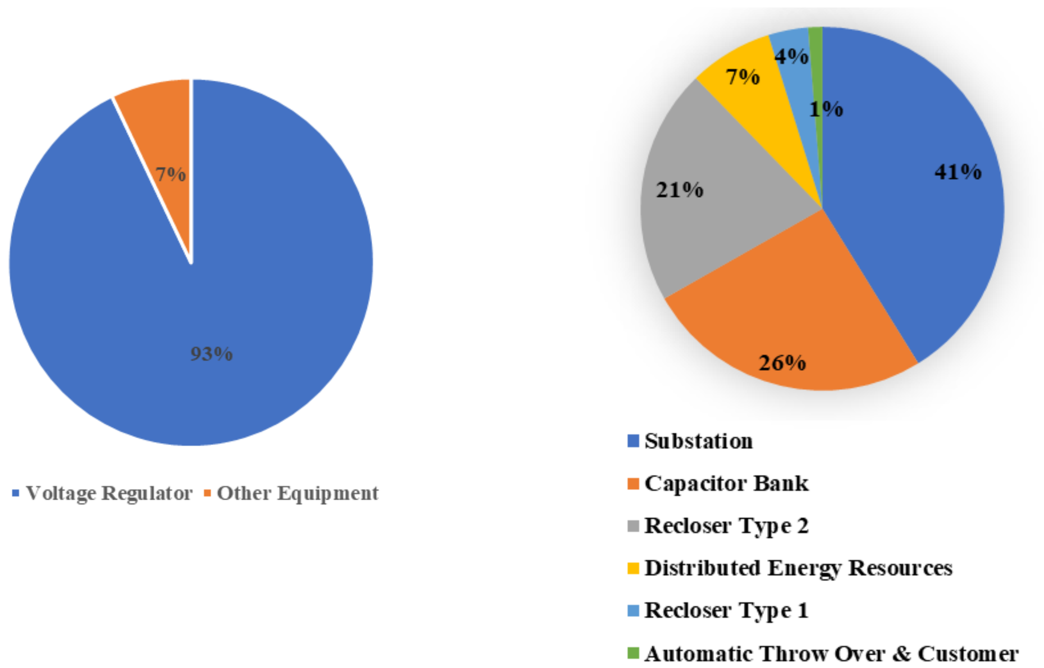


Figure 3: Proposed event management process

The prioritization review process that was followed for the recloser alarm group will be amended and followed for all other alarm groups to ensure that correct prioritization is shown in this new alarm system by beginning with experts in the field and ending with the DSOs in the DCC.

DATA ANALYSIS RESULTS

To determine the state of our current alarm system, we performed data analysis on the alarm history log by month using the alarm groupings that we created in the philosophy development process. For this project, a Python programming language along with other plugins were used to process these large amounts of data due to its easy learning curve and processing power. The charts in Figure 4 show the share of alarms in January 2023 based on the associated alarm group after the philosophy had been curated.



(a) (b)

Figure 4: Alarm percentage for alarm group – January 2023; (a) total system alarms and (b) system alarms excluding voltage regulators

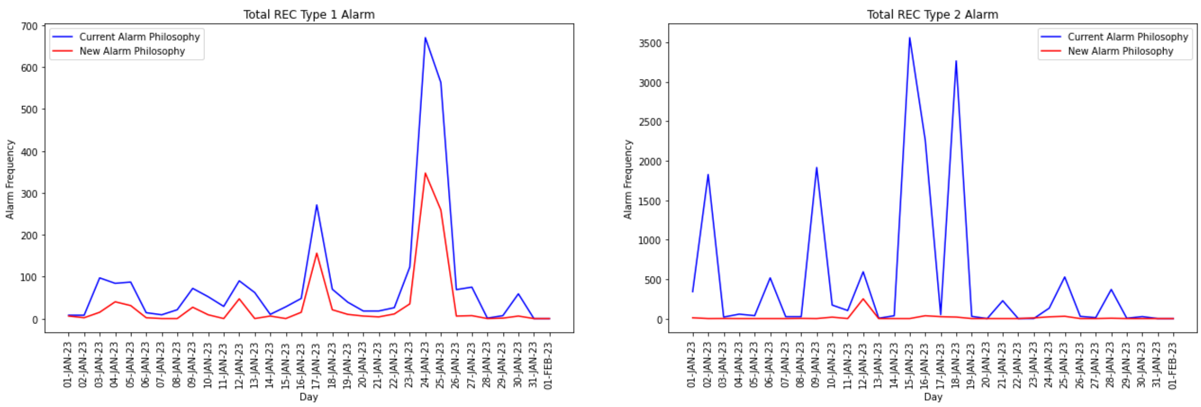
As shown in Figure 4a, we found that voltage regulators contribute to 92.9% of the alarms logged in the Oracle history, while all other groups only contributed to a 7.1%. After further inspection, we discovered that with the current alarm system, timing is not considered when making an alarm entry. While the alarm log shows that over a million alarms originating from voltage regulators occurred in the month of January 2023, they flickered in and out of alarm so quick that the events never populated on the DSOs alarm screen. To accurately evaluate what alarms the DSOs saw, we removed the voltage regulators from the dataset and focused on the remaining 7% of the system alarms. In the future, we will implement a slight timing delay into the backend alarming conditions to filter out the vast amount of data generated by the regulators. After doing this, we were able to get to a closer representation of what the DSOs experienced in ADMS during January. The data shows that the substation group generates 41% of the alarms, capacitor banks generate 26%, and reclosers generate 25%.

In Table 2, the number of alarms generated by Recloser Type 1 and Type 2 between January-May 2023 are presented. The group of alarms associated with Recloser Type 2 generated many more alarms compared to Recloser Type 1, but after implementing prioritization, the number of actionable alarms for Recloser Type 2 decreased, significantly. For example, in January 2023, Recloser Type 1 generated 2728 alarms. After prioritization, only 1069 alarms are actionable and needed to be shown in the DSO's primary window. All other alarms (1659 alarms) for Recloser Type 1 will be shown in the system information display. In this regard, 60 percent of alarms from the current DSO's window would be removed and transferred to the system information display.

Table 2: Reclosers alarm comparison before and after prioritization for January-May 2023

Month	**January**	**February**	**March**	**April**	**May**
Recloser Type 1					
Before prioritization	2728	15531	3736	2981	184782
After prioritization	1069	1774	1237	1061	1057
Alarm reduction	60%	88%	69%	64%	99.4%
Recloser Type 2					
Before prioritization	15924	14409	24578	9724	14384
After prioritization	423	138	158	64	336
Alarm reduction	97%	99%	99.3%	99.3%	97.6%

Figure 5 shows the total number of alarms per day for reclosers type 1 and 2 that occurred in January 2023, which represents the efficiency of the current alarming method at OG&E. The blue solid line shows all the events that DSOs observe in the current alarm system which include alarms with priority 1-8, status indication alarm and path-through alarms. The red solid line shows the number of alarms that DSOs will be observe after implementing the new alarm philosophy. With the new alarm philosophy, DSOs will see only very important and actionable alarms with priorities 6-8 while other events with priorities 1-5, status indication alarm and passthrough alarms will be shown in the system information display. After implementing the new alarm philosophy as shown in Figure 5(a), the number of alarms for recloser type 1 can be reduced 60% by using the alarm history from January 2023. In Figure 5(b), the number of alarms for recloser type 2 can be reduced 97% using that same dataset.



(a) (b)

Figure 5: Recloser alarms per day current vs new alarm philosophy – January 2023; (a) recloser type 1 and (b) recloser type 2

Some of the large blue spikes can be attributed to small, localized weather events or a loss in communications which often results in an excessive amount of event reporting from type 2 reclosers.

Our new philosophy simplifies this large and daunting dataset down into two relatively simple categories for the DSOs to understand: actionable and non-actionable alarms. Because of this philosophy, the DSOs will be enabled to focus primarily on important alarms and, when they have time, they can monitor the system information alarms. This distinction will become invaluable during the extreme events such as weather storms and other abnormal operating conditions that traditionally would overwhelm ADMS displays in the DCC, often reducing operational efficiency.

FUTURE WORK AND CONCLUSION

After viewing the results of the data analysis across the other months of 2023, the reductions of events on the alarm screen remain significant no matter the month or the events that occurred during that month. The final step for this project includes a final round of quality checks with different engineering departments for all the assigned priorities assigned to each device group. Once all priorities have been double and triple checked, a prototype alarm display and system information display will be built in our quality assurance environment of ADMS to undergo rigorous testing trials, ensuring that all alarm data displays appropriately. After the testcases pass, DSOs will be invited to critique the final product before implementation into our production ADMS environment. If possible, this new system will be phased into use in the DCC. This ends the alarm philosophy implementation but enables the DCC to further utilize more complex alarming methodology. Now that the foundation has been set, we can shift towards a data-driven approach inside the DCC. This approach will allow OG&E to use the valuable data provided from the new alarm management system to support DSOs and other operations staff to make more informed decisions, plan actions appropriately and improve overall daily operations [4].

While this paper focused on the analysis performed on OG&E's recloser alarm data, substation alarms have the highest potential to utilize this data-driven approach due to their criticality and role within in the modern electric grid, especially after using the data provided from the modern SCADA system grid-wide [5,6]. By utilizing the data that a modern distribution system provides, this alarm philosophy can advance along with the utility industry rather than lagging behind like the current system at OG&E. Various intelligent technologies like machine learning, fuzzy theory, and early warning methods can be further implemented into this philosophy as the DCC expands the technology it uses [5-7]. By creating a data-driven alarming system, events that come into the DCC in the future will align themselves with the technology trajectory of the modern control center and enable DSOs of the future to operate proactively rather than reactively.

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