ADVANCING VISUALIZATION FOR A NEW ACTIVE NETWORK ERA

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ABSTRACT

Today's systems for managing active networks have their roots in SCADA, GIS systems or workflow tools. Product revisions have largely been evolutionary in nature providing added functionality to the existing user experience. As we move forward into more active networks, it is necessary to rethink these systems to build a system that can better address emerging operational needs. Systems of the future have more smart devices, decentralized control, and multiple simultaneous optimizations to manage emerging needs such as bi-directional power flow, localized controls, and new grid reliability challenges.

INTRODUCTION

To address this challenge, an initial research project has been completed. Product, customer and user experience (UX) expertise collaborated to define a new paradigm for managing active networks. Discovery, research and design phases were completed. Activities included product and market discovery, user observation, and co-design. The project included, 4 utility companies representing approximately 20M customers across 2 continents. The observations from each of the visits were analyzed and distilled into a set of insights and opportunities. The result was a design vision for managing active networks that is a departure from traditional systems. There are many areas that would be affected in this new vision. This paper focuses on visualization for users in the control room.

RESEARCH INSIGHTS

Because no single system meets the operational needs, users in the control room tend to have multiple systems in front of them. These systems included various combinations of company websites, e-mail, a geographic view of the network, a DMS network management system, substation one lines, SCADA systems, a workflow management tool, and a switching application. In our research, users had an average of 5 monitors, and some had as many as 11 monitors. Work is accomplished by swiveling around the monitors and keyboards, printing out information from one system, to use with another. A single task can involve phones, radios, pen and paper, mouse and keyboard. The following sections describe the insights gained after processing the research data.

Communications

Awareness of the network state must be maintained across many different organizational groups to successfully operate. This means that communications are crucial to utilities. Various communication mechanisms are utilized to set operational strategy, priority, and to orchestrate operations. Users in the control room have a wide array of analog and digital communication options in front of them including radio, phone, e-mail, messaging, applications, paper, and other various applications to facilitate communications. All of these mechanisms are augmented by conversations with their fellow operators and other audible sounds in the control room of importance. In our research, users spent a lot of effort multitasking across these various means. In several cases, an operator would be speaking to multiple crews simultaneously across radio and phone while coordinating actions with the person next to them.

Safety

Safety continues to be of primary concern. Our research showed that providing safety required piecing together information from multiple windows, applications and communications to track field personnel. Users responsible for safety of field crew rely on experience and knowledge more than the tools provided in the system to achieve this. Other utilities have developed their own applications and protocols to track safety information including paper logs. As the network becomes more complex with distributed energy resources, smart devices and bi-directional flow, the challenge of keeping people safe increases.

Transparency

Transparency is increasingly important to utilities to manage the perception of their performance to customers and regulators. Customers we interviewed sited transparency to their customers as their newest top priority. Being able to communicate effectively when power would be restored is critical to customer satisfaction. Regulators require utilities to explain their actions and operations accurately. In some regions, the information is utilized to assess penalties. Users in our research demonstrated the reports and logs required both internally and externally where multiple pieces of information had to be put together from a variety of sources or interpreted from a series of log files to a story that could be consumed by leadership. In many cases,

the record keeping and reporting is delayed until after the work is done. This delay creates a tremendous amount of rework at the cost of accuracy and clear communication.

Situational Awareness

An active network generates a lot of available data to show a user, yet it was clear in our research that showing the information to the user in a detailed manner does not lead to situational awareness. Displays crammed with data, colors and icons confused users. Blinking information further exacerbated the confusion. Alarms can also be confusing. Several users complained that the system generated too many alarms, making it difficult to identify critical items and respond effectively. Yet, even with these challenges, users depend on alarms to put together the story of the network and the current state of the network. For some, it is the first task of the day to review the alarms.

A geographic view can be utilized to show the network in a manner that enables situational awareness. However, when directing or planning specific work, the user zooms into a specific location on the map, thus reducing visibility. Background colors are also distracting. In low light environments, white backgrounds cause eyestrain and further reduce visibility.

When too much data is shown, it makes it difficult for users to see critical information. For example, tabular views with too many columns and multiple views of the same information across systems sitting in front of a user all take away from their ability to effectively manage the network.

Work

To accomplish their goals, users must utilize a variety of systems to organize and manage workflows. To organize their work, users utilize a variety of tools including e-mail, spreadsheets, and paper. Many users who executed switching had printouts of switching jobs sitting in front of them to use alongside the digital version on screen in front of them. In some cases, the print outs were utilized as a way to share work across multiple users in the control room. In addition, a significant amount of work was planned, coordinated, and approved through verbal communication.

Work is inherently asynchronous. Each specific job has its own lifecycle yet the execution of that cycle includes many breaks and interruptions. Retaining context through this multitasking is a challenge. UI components such as pop-up dialogs and modal dialogs that can be hidden underneath other windows aggravate this situation. At a more granular level, the users must complete many repetitive tasks. This makes users highly sensitive to mouse clicks, movements, and moving between keyboard and mouse to complete these tasks. Many users demonstrated paper as the most effective multitasking tool.

Usability

A consequence of users continuing to struggle with existing user solutions is a lack of confidence in those systems. While system solutions contain many preferences and options, many users do not take the time to learn them. Users encountered in the research phase, were surprised when presented with features that applied to the applications they interacted with. In many cases features implemented to increase productivity were ignored, misunderstood, or simply not known. This lack of confidence leads to paper driven approaches and manual systems pervading alongside technology. Moving to a new era of visualization necessitates solving this challenge.

Storm Mode

During the field observation phase of our research, we were only able to view normal “blue sky” operations. However, we were able to speak with several different types of users on the impact of large scale outages. While different regions of the world have different types of triggers that can cause large scale outages, all must be prepared to face them.

During this high activity mode, all planned work is suspended. The same tasks to restore power must be performed, but at a much higher volume and with a lot more scrutiny. It is during this time that digitized systems could be most impactful, yet it is this time when the visualization shortcomings of existing systems are magnified.

In this timeframe, there are a higher volume of people performing tasks both in the control room and in the field. Users in the control room either do the same job in a much smaller geographic area, or they delegate out tasks to others in order to focus on a smaller number of tasks. The most experienced resources focus on maintaining safety and transparency. Many times dispatch that would normally be done from the control room is delegated out to satellite bases.

During this timeframe users are overwhelmed by the digital systems meant to help them. The control room becomes a cacophony of noise that is shut out to focus on tasks making it even more difficult to get important messages to the right place at the right time. Alarms can be overwhelming and communication even more so. Many users must tune out email, messaging, phone and even radio to focus on the job at hand, yet these are the very means field personnel and management has to

communicate critical data.

Ironically, during this time is when digital systems are most needed to maintain a view of the network. Work must be coordinated across the network. More importantly, the leadership and communication experts within the utility must provide transparency to customers and local governments. When the digital systems are not maintained as work is done, the actual work in the control room doubles to include it.

OPPORTUNITIES

To overcome these challenges and present a new visualization paradigm suitable for the active network era, solutions must magnify awareness and safety, standardize data presentation and visualization, simplify alarm management, and streamline workflow and knowledge sharing.

A macro view of the network must be maintained to magnify safety and awareness. Information about crews and field personnel should stand out clearly in the system. Required details should be magnified without losing sight of the overall view of the network. Visual noise should be minimized such that critical details stand out.

Standardize data presentation and visualization through the use of common iconography, colors, and visual semantics. Create common formats for specific tasks to reduce confusion and learning. Standardization is critical to creating a common language that can then lead to better discussion across a wider group of people, thus leading to more improvements in visualization moving forward.

Streamlining workflow and knowledge sharing necessitates intelligent data entry, connected workflows, and the ability to externalize the system operations. Intelligence must be built-in to the user interface such that the work required to complete reporting and logs is minimized. Connect the workflows across the different organizations involved by facilitating clear communications to build communal intelligence. Retain a big picture visualization of the network and key metrics to support external communications.

Simplify alarm management by building a layer on top of the alarms to empower users and improve performance. Current visualization solutions that allow users to filter and sort alarms are helpful, but more is needed. Users must have different ways of aggregating and visualizing alarm data to maintain perspective and awareness of the network.

A NEW DESIGN

The research concluded with a new design vision that takes advantage of these insights and opportunities. This new design includes a new dashboard and navigation concept, and a new manner for supporting work on the active network. It is a revolutionary change to current systems.

Dashboard and Navigation Concept

Traditional systems have largely supported an application launcher pattern that aligns to the Microsoft standard. When a user has a task to accomplish, the appropriate application(s) are selected from the available menu for execution. In this pattern, it is necessary that the user knows what application is required to complete work. In many cases, several applications within the same system are required to complete a specific workflow or task.

In the new paradigm, a dashboard forms the center of attention and work for a user. This pattern brings forward key information from the underlying system or systems and enables users to access work pages specifically designed around a specific workflow. Work pages would be constructed using known patterns for data tables, forms and diagrams; thus standardizing interaction patterns.

The navigation concept is shown below in Figure 1.

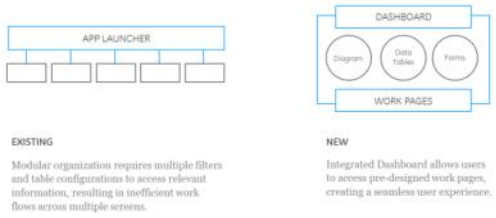

Figure 1: A new navigation paradigm.

Instead of a traditional alarm interface, a user is presented with a dashboard of critical information as the primary interface to the system. The dashboard enables a wide array of information to be aggregated for the user and acts as the primary navigation to work within the system. Figure 2 shows this new concept.

Simplified widgets aggregate specific KPIs and alarm information showing pertinent metrics with indicators of change. Thresholds are configured for alerts. Brief color modulation is utilized to alert the user to change. On alerts, a user clicks the widget to navigate to the appropriate workflow interface. This enables a new concept where data finds the user.

Figure 2 Dashboard concept

Users configure their dashboard with widgets pertinent to their specific job and see the metrics for the area for which they are responsible. This enables the dashboard concept to extend to a wider range of users including leadership looking for a full system perspective.

Alarms are still a necessity in the system. Users view alarms in pre-grouped items for areas of interest. The user could see both the textual alarms and metrics for that group. Similar to the widgets, the user would select the category of alarms pertinent to their role.

An overview map enables a user to maintain perspective across the entire network maintaining situational awareness. A set of overlays can provide pertinent information to the user such as weather, outages, etc.

Communication is another key focus of the dashboard area. This visualization enables an integrated view of communications for voice, chat and video internally and externally. Keywords within messages can be utilized to link to the work at hand much like hashtags in twitter. This helps to match critical communications with the appropriate item.

A notification panel enables a user to manage their multitasking environment. A user can set notifications specific to a specific task, workflow, alarm, or any other user defined need by dragging and dropping, right click menus, or typing. When a notification expires the user's eye is drawn to the item. Navigation is enabled to the specific context where possible.

An overall setting is provided to switch between normal and large outage mode where thresholds are set higher to reduce the visual noise and show the most critical information.

Workflow

In the new design paradigm, work is presented to the user in a combination of diagram and work pages. The diagram enables the user to work in the context required for the task at hand. A user can utilize the schematic. geographic or split view to achieve the task at hand.

The ability to add specific magnifications enables the user to see the details required for a given task while enabling them to retain perspective across a wider area. The overview map already described in the dashboard enables a user to retain a perspective across a wider area.

Figure 3 Diagram concept

Work pages are a combination of forms, tables and diagrams built specifically to have all information available for the task at hand. Since users must switch between multiple simultaneous workflows, dynamic tabs enable multitasking between different jobs maintaining the context of each. Pop-up dialogs are eschewed in favor of dialog areas that are built-in to the right side of the work pages. When modal, visual cues such as color or the message and transparency of the work page are utilized to highlight the response required.

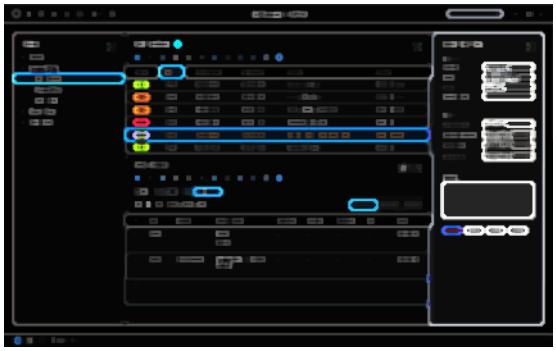

Figure 4 Work page concept

As work is completed, the layout of the work page includes the required reports with intelligence to prefill data thus facilitating completion of documentation alongside work to gain transparency.

Throughout the whole, the color palette and iconography are simplified to reduce visual noise. Color is utilized to highlight important information to the user thus drawing the eye. Figure 5 shows a high level view of this new design paradigm.

Figure 5: Vision for a new interaction

REACTION

This research and resulting design vision has been presented to companies and users across at least three different regions of the world. Reception to date has been highly positive. Users recognize the value of organizing work and extending the visualization of data through the dashboard view.

The biggest surprise in the research was around communications. While the challenges were obvious on observation, perception of product and domain experts was that this would not be a priority. This was proven incorrect during feedback sessions. In discussions, utilities almost unilaterally noted the communications visualization and solution as a key element in the design.

In our current phase, the new design vision is being built to get direct user feedback. While the entire vision cannot be built at once, a prioritization is being applied to get feedback on the overall visualization and then specific elements of it. By having a hands-on interaction, users can get a better sense for the new interaction patterns to provide more informed feedback into the process.

CONCLUSION

Our research demonstrated the current shortcomings of visualization within the control room to manage active networks. The existing environment of digital solutions does not adequately address the operational needs in the control room. This inadequacy will continue to be demonstrated through proliferation of manual systems that act as a barrier to progress. The current pattern of evolutionary change will not achieve the desired changes. Revolutionary change of current visualization tools must be employed to effectively operate systems in the new active network era. Our research and resulting design vision proposes a new visualization that will revolutionize operations in a new active network era.

REFERENCES

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