Comparative Analysis on Data Visualization for Operations Dashboard

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***Abstract*—Excellent data visualization has become a major requirement in today's decision support system especially in a very competitive business domain. Visualization becomes critical when data are huge, comprehensive, and originate from various sources and in a variety of formats. The criticality of data visualization increase even higher when a substantial investment is made to monitor and ensure the overall business operation and infrastructures is in good condition thus avoiding huge loss to any particular company. Yet, choosing an operations dashboard with outstanding data visualization has become a tricky proposition to operational and support personnel. With various technologies, comprehensiveness, visual embellishment, design and aesthetics, visual metaphor, and data memorability as fundamental in selecting superb data visualization, selecting a suitable dashboard is very tricky. Hence, this paper briefly studies data visualization and offer comparative detailed analysis on data visualization with regards to operations dashboard. The result of this comparative analysis is applicable to any business system and a novel contribution to the community. With this study and analysis, it is hoped that it can be applied to define, select, or develop a *well-defined* operations dashboard with excellent data visualization.**

***Index Terms*—Visualization, visual embellishment, graphical user interface, data presentation, data representation, data analysis.**

I. Introduction

There are many aspects or criteria in selecting operations dashboard. Nashriq et. al. [1] has listed five dominant criteria that are required to ensure the selected operations dashboard can be utilized at its maximum potential. One of the criteria is data visualization which earlier is known as data presentation [2] or graphical user interface [3].

The term data visualization is first coined in1993 by the Kellers[4]. It is referred as graphical presentation of gathered data which allowed users to easily studies and understand the actual meaning of collected data [2], [3], [4], [5]. In daily IT operation where operations dashboard is a mandatory tool, data visualization offers a great deal in ensuring smoothness of operations and cost optimization. Excellent data visualization will improve IT personnelability in detecting, measuring risk, and increase confidence level of making necessary decision. On the other hand, a poor visualization in a superb operations dashboard can cause catastrophe to business operation. Although the operations dashboard has lots of information, the dashboard is as good as nothing when the data is unorganized with poor visualization as it will affect the ability to understand and making good judgment. Therefore, excellent data visualization is a mandatory requirement in operations dashboard [6], [7].

Therefore, we construct and propose a set of criteria that can be used to define, select, or develop a *well-defined* dashboard application with excellent data visualization in place. These criteria were derived from in-depth studies on various works done previously in the area of visualization. Based on this, we then conduct a comparative study on various operations dashboard. We limit our study to five major criteria as it is the most relevant and has vital values to a dashboard. Our comparative study is also limited to six operations dashboard to avoid too lengthy a discussion.

Section 2 in this paper discusses briefly on the data visualization criteria which later is used in Section 3 for comparative analysis. In Section 4, we discussed the result of our analysis. The last section describes briefly our conclusion and future work based on this study.

II. Criteria of Well-Defined Data Visualization

Data visualization has become core component in an interactive and intuitive system especially in maintainingcritical operation at reasonable cost and impact. Nachtwey [26] claimed that *well-defined* data visualization is the main factor to get the attention of users in improving the efficiency of information delivery. In the same article, Nachtwey listed four criteria of *well-defined* data visualization [26]. Hansen and Johnson [27] have also shared some of them in 2005. We have taken a step further by performed an in-depth study on data visualization with regards to operations dashboard. Our studies show that only five criteria are important and significantly relevant. The five criteria as shown in Table I are discussed further in the following subsection.

TABLE I: Criteria of Data Visualization in Operations Dashboard

Criteria	Definition	Main points
Comprehension[9][11][20][9]	Define all crucial data	• Graphical images that are readable and understandable • Clear organization and right data presentation flow

Manuscript received May 2, 2012; revised June 6, 2012.

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Visual Embellishment[9][11][12]	Connect real situation using graphics	Moderately included in dashboard as excessive graphic would distort the crucial message.
Design and Aesthetics[11][22]	Use of aesthetics value for user attention	• Interactive and dynamic • Without losing attention to the crucial data
Visual Metaphor[20][22]	Graphical representation of critical data	Statistical representation or visual analogies of data
Data Memorability[9][20]	Increase of memory and focus	Highlight sections that need to be prioritized

A. Comprehension

In operations dashboard, it is important that the crucial information are delivered to the users without any distortion as this would be the baseline of any decision making process. Failure to act fast on the real and correct data would result in unwise judgment of operative decision for any critical disaster of IT infrastructure. Complexity of certain data or trends especially in monitoring critical IT infrastructure sometimes does not always have to translate into writing but in need of information graphics to assist with understanding and increase of efficiency of information communication [8]. In addition, the information shall also berepresented according to interest and roles of viewers due to nature of work and understanding capability to ease in understanding and making necessary decision [7] and [9].

B. Visual Embellishment

Through visual embellishment, we can connect data appearance with reality thus showing important facts about relationship between the imaginary graphics and real world data [10]. According to Holmes [11], data graphic must be able to engage user interest of the certain important data and this can be obtained using graphic imaginary. In operations dashboard, sometimes a single textual description or lengthy report would not help the user to have quick analysis on what is happening in our infrastructure hence limits the crucial decision making process especially when it comes to critical disaster to IT infrastructure. However, it should be moderately included in dashboard as excessive graphic would distort the crucial message [10]. People should be minimizing this criterion and only use it to boost or highlightunderstanding of certain topics [9].

C. Design and Aesthetics

Few [7] found that if we correctly display data in balance with emotional response, we can keep the audience interested in the data that we show. Pertier [13]added that for business process, charts need to be designed in an effective way as well as interactive, dynamic and fast to convey data and well-understood. If right amount of aesthetics value is used in operations dashboard to display the crucial data, we might grab the users' attention and focus to important events that the data conveyed.

D. Visual Metaphor

Visual metaphor is useful when we want to have a synopsis of data comparison. A lot of data points can be represented using only single data to constitute trends of any crucial data. Visual metaphor can be crafted either in statistical representation or visual analogies [14]. In operations dashboard, most of the time, we need to rely and analyze trends data in order to make judgment during critical situation [15]. Graphs and charts are used because they can represent qualitative data comparison in single form without excessive textual description that might distract user distraction and the user might miss important messages [16].

E. Data Memorability

When we use charts to represent data, we tend to improve level of memorability of the crucial data that highlighted to us [9]. By carefully working with graphics tone and colors, the charts can really give high impact to data memorability. Sometimes when there are too many important data, users tend to memorize the one that come with most highlighted by color and graphics. Research carried out by Mather and Nesmith [14] found that during an incident task, user tends to remember positive- negative pictures rather than simple plain pictures. Although this is one of the important criterions, some of operations dashboards are actually can be customized and re-arranged accordingly to highlight sections that need to be prioritized.

III. Comparative Study on Operations Dashboards

Data visualization is used to maximize understanding and conveys the crucial operation data to user effectively. We understand that there are many dashboards in the market nowadays demonstrate a quite astounding data visualization concept but how well they meet the data visualization objective is still questionable. In this section, we conducted a comparative study to find out the gaps between existing dashboards in implementing criteria of data visualization as discussed in section 2. The scope of this study is limited to commonly used dashboards such asZenoss [17], Nagios[18], Ganglia[19], OpManager, [20], Cacti [21] and MIMOS Operations dashboard[1]. Based on the criteria in Section 2, we analyze and compare these six dashboards as listed in Table II.

TABLE II: Comparative Study on Six Operation Dashboards Based on Rating for Each Criteria of Data Visualization

Criteria	**Zenoss**	**Nagios**	**OpManager**	**Cacti**	**Ganglia**	**MIMOS Operation**
Comprehension	• Best for complex and large infrastructure[1	• Not suitable for large infrastructure [1][23]	• Comprehensive monitoring for network and infrastructure[1][	• Extensive network graphing solution[24]	• Link and manage hundreds clusters with	• Offers high level view of total infrastructure MIMOS[1]

Criteria	Zenoss	Nagios	OpManager	Cacti	Ganglia	MIMOS Operation
	][8]		12]		thousands of nodes [12]	
Visual Embellishment	• Network map and Google Maps API for multi-location monitoring[8]	• Not available	• Not available	• Network weather map [21]	• Not available	• Specially designed in graphical representation - one page showing all network links [1]
Design & Aesthetics	• Customized dashboard according to needs [8]	• Focus yet customizable layout, design, and preferences[18][23]	• Intuitive design and customizable [12]	• Limited design but customizable graphing template [24]	• Not available by default [12]	• Heavily dependent on graphical representation[1]
Visual Metaphor	• Default and customizable report. [8]	• Detailed and flexible historical views [18]	• Provide on-demand reports [12]	• Advanced graph- RRD Tools [24]	• Advanced graph – RRD Tools [25]	• Only provide bird view of architecture health [1]
Data Memorability	• Customized status and performance monitors [8]	• Provide at-a-glance access to powerful monitoring information and third-party data[18]	• Good range of real-time dashboard [12]	• Uses advanced graphs as means to highlight critical data [24]	• Graphs as sole means to highlight data and critical information [12]	• Use specific color codes, indicator and network links [1]

IV. Discussion

A. Comprehension

Zenoss possesses an indeed comprehensive interface to manage large and complex IT application and infrastructure [1], [22].The applications and systems are visually grouped according to their category and this sort of information organization is best to convey massive and complex infrastructure.In contrast, Nagios is having problem with displaying data for large infrastructure, it might contribute to crucial information are not properly communicated in certain disastrous events [1], [23]. OpManager on the other hand offers complete, end-to-end network and IT infrastructure monitoring of comprehensive fault and performance management in astounding graphical display [1], [12]. While Cacti provide extensive network graphing [21], [24], Ganglia works best in linking and managing hundreds of clusters with thousands of nodes [1], [12]. On the contrary, MIMOS Operations dashboard offers high level view of total MIMOS infrastructure. It includes networked diagrams of all critical servers and services as well network connectivity for MIMOS IT infrastructure. These critical servers and services nodes are functionally grouped according to its class so that user can easily scan and focus sections that they want to monitor [1].

B. Visual Embellishment

Zenoss is able to show visual mapping of network using graphic connectivity that links thought the IT infrastructure. Using Google Maps API, multiple sites can be monitored graphically using Zenoss[22]. By having this feature, Zenoss is able to simulate total infrastructure status hence connects with user emotional and user experience while they are working with Zenoss. Unlike Zenoss, Cacti can only provide weather map for networkmonitoring [21]. Compared to others, MIMOS Operations dashboard is specially designed in graphical representation so that status, availability and network links of overall application and servers can be viewed in single page [1].The rest of the dashboardsseem lack of this criterion.

C. Design and Aesthetics

OpManagerpossesses intuitive design of networked diagram of infrastructure and services health status [12]. Users are able to capture needed information though the graphical display of overall infrastructure. Unlike OpManager, the rest of the dashboards have limited design and aesthetics by default. However, users are provided with means to customize layout, design and preference according to users using their own plugin or third party plugins. In the meantime, MIMOS Operations dashboard is heavily dependent on graphical representation that enables user to interactively interact with the dashboard without losing its function to notify user on the important status or data. Based on this, it fulfills this criterion although some of the sections need to be improved to include details of the specific devices [1].

D. Visual Metaphor

Through our overall observation, we can see that all tools providevisual metaphor to represent the critical data. The only difference is quality and mechanism used to display the history logs and reports[12], [18], [22], [24], [25].Ganglia and Cacti provide extensive industry standard, high performance data logging and graphing system for time series data (RRD Tools) whereas the others are built-in reports and graphs and can be customized according to interest and needs. On the other hand, MIMOS Operations dashboard relies on trends and graphs that obtained from various off the shelf dashboard. It can onlydisplay ‘bird’s eye’ view of MIMOS total infrastructure in one page. In order to get into details, one need to login to the specific dashboard linked to respective devices or services [1].

E. Data Memorability

Data memorability criterion is actually depends on visual embellishment and beauty and aesthetics of the operations dashboard. From the previous section, by playing around with graphics and colors, we can catch users’ attention and

bring the focus the crucial and priority data. For this reason, Zenoss has the ability to rearrange the dashboard hence providing customized dashboard that would help crucial data memorability [22]. Nagiosallows user to define items to be monitored in order toincrease data memorability[18].Similarly, OpManager provides extensive dashboard with widgets that can be added, removed or customizable to show data according to needs and priority[12]. Cacti and Ganglia are highly depended on their advanced graphing tools to highlight important and critical information to their users [12], [24]. In MIMOS Operations dashboard, every single device and application is crucial to the IT infrastructure. By displaying status and brief details on these areas according to specific color codes and indicators, users are able to come out with clear picture of MIMOS infrastructure health at that current of time. By having this status and availability linked up through lines of connectivity, users are also able to scan possible root problem that contribute to future disaster [1].

V. Conclusion and Future Work

It is hoped that through the above discussion, we can understand the five criteria that can contribute to gooddata visualization in operations dashboard. We have compared five off-the-shelf operations dashboards and one in-house developed dashboard and presented the advantages as well as the disadvantage for these six dashboards and come out with the discussion result. This result should be used as a baseline for people to choose the best visualization dashboard for their IT environment.

We plan to improve MIMOS Operations Dashboard to include trend charts and graph without relying on external dashboard. Moreover, we should include more devices and applications into the visual presentation with detailed attributes so that people can value the graphic presentation of the infrastructure health.

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