Reusability and Sustainability in Operations Dashboard
Comparative Study

Noor Nashriq Ramly and Mohd Haris Aziz
InfoStructure Lab, MIMOS Berhad, Kuala Lumpur, Malaysia

Keywords: Paperless, Green It, Paper-like Interface, Sustainability, Operations Dashboard, Monitoring.

Abstract: In managing IT data centers and critical operations, it is imperative for companies to be able to rely on specific mechanism in order to have visibility of overall infrastructure health. Failure to act proactively against any disaster that could happen in future would bring major losses to companies that depended greatly on their IT operation. However, looking at the current trends and technologies, these tools can come in various forms; from manually collecting data and offline paper reports to some astounding paperless operations dashboard that everyone in the company would be able to see and rely for any critical operation decision-making. While focusing only for real-time monitoring activities, there is an urgent need for companies to embed tactical and strategic function in their operations dashboard. Companies can no longer relying on manual analyzing critical operation to proactively improve their IT operation business. Thus, this paper discuss on the four reasons that of companies starting to change to paperless operations dashboard as well as three principles that we need to adhere in order to implement an effective paperless dashboard initiatives in a critical operation company. Apart from that, several criteria for choosing the best paperless operation dashboard for specific company derived from previous research are discussed in detail. A comparative study is then carried out between five off-the-shelf dashboards and one in-house developed dashboard against the researched criteria. With this, it is hoped that this paper would be a useful guide to companies when venturing in paperless operations dashboard arena.

1 INTRODUCTION

The idea of paperless operations dashboard started when people started to be aware that they need to take into account time, effort and criticality of managing IT operation. By relying more on paper and offline dashboard, people tends to spend more time in gathering and constructing repetitive data and report before they could have time to analyze them. By the time they even finish the analysis; the result may not be even the latest reflection of current status and cannot be the accurate baseline for decision in future. Before it becomes too late, companies are willing to spend more and more on the gadgets and widgets to help them minimize time and effort to overcome potential issues and address them proactively through dashboard visualization.

The term dashboard refers to the art of displaying multiple of information in various forms and styles from different sources into one screen [Wikipedia, 2001], [Matt, 2005] and [Maarten, 2010]. According to Eckerson (2006), performance dashboard can be categorized into three types; operational, tactical and strategic.

Operational dashboards usually focus on real-time data that comes from actions triggers by opportunity or issue. The dashboard will have to provide real-time or instantaneous status or near real-time of any possible occurrence of downtime. Normally it will serve as detailed or summarized data pulled directly from infrastructure. Tactical dashboards on the other hand are not all real-time data and normally used to guide user to make decision on certain areas. It is useful in decision support activities by relying on the historical data along with business intelligence feature through trend prediction. The focus is to analyze performance over time and what is displayed in the past and how to improve them. The last type of dashboards; strategic dashboard is used while dealing with measuring performance against the high-level objectives. This dashboard is normally associated with data on company goals or requirements versus performance data during some specific interval.

For IT operation companies, dashboard is used to

Ramly N. and Aziz M. (2012).
Reusability and Sustainability in Operations DashboardComparative Study.
In *Proceedings of the Sixth International Symposium on e-Health Services and Technologies and the Third International Conference on Green IT Solutions*, pages 89-96
DOI: 10.5220/0004475000890096

help to project current performance and health of infrastructure as well to support decision making against any disaster in future. This mechanism is crucial to the organization in minimizing disaster impact on the core business. While there is increasing needs for IT critical operation to monitor and measuring performance real-time in line with tactical and strategic initiatives, companies now are looking for any other alternative operations dashboard that could meet all these functions in one platform. It is believe that while technology advanced, people will start to look at high technology equipment and gadgets rather than relying on traditional paper and offline methods as means of monitoring, predicting and analyzing (Steurbaut, et al., 2010). It is predicted to be the inevitable result of technology evolution to match with emerging risks of critical IT operation.

However, given varieties of operations dashboard in the market, people might face problem to choose the perfectly matched dashboard for their company. Balancing between needs and cost of the dashboard, this paper is designed to help the companies to choose the best paperless operations dashboard while at the same time utilizing the paperless features for managing their mission critical operation.

For that reason, a comparative study was conducted on a few several top operations dashboards in the market. However, we limit our discussion on dashboard known as Nagios, Zenoss, Ganglia, OpManager and Cacti to avoid lengthy a discussion.

Section 2 in this paper discusses briefly on the principles that company need to adhere and conform to ensure a successful paperless dashboard implementation. In Section 3, we will cover a few criteria that one should search for a successful paperless dashboard which will later be used in section 4 for our comparative studies. The last section describes briefly our future work based on this study.

2 WHY PAPERLESS OPERATIONS DASHBOARD?

There are a few reasons people starts to move to paperless dashboard rather than working with paper and offline data. According to Seelan and Harper (2003), there are three problems rises while dealing with paper reports.

The first point is paper symbolize an old-fashioned past technology (Steurbaut, et al., 2010) and (Eckerson, 2006). People tend to relate masses of paper on the desk as ‘outdated’ and not representing futuristic technologies, especially when dealing with IT critical operation center.

The cost of paper storage and maintenance also remains the core problem of IT operation business nowadays (Gormish, Piersol, Gudan, and Barrus, 2009), (Steurbaut, et al., 2010) and (Bassignani, Dierolf, Roberts and Lee, 2010) Companies are more willing to spend more on the high technology gadgets to do all the automated monitoring that can guarantee IT improvement and saves more time as well as minimizing human error in the process rather than traditional paper trails and reports that would require more time to prepare and generate when needed. Moreover, cost of paper disposal remains one of the crucial items that companies need to provide while dealing with paper reports (Webber and Wallace, 2009). Although the individual cost might be small, but the aggregate cost of overall process is reasonable high and can help companies to save some operation cost.

As paperless dashboard is web-based application, it is self-maintained and do not require any paper throughout the process and in that context, it should be considered environmentally safe (Webber and Wallace, 2009). However, it is still open for debate as paperless dashboard requires hardware infrastructure and capacity planning need to be arranged so that energy can be use efficiently.

Apart from that, IT personnel tend to realize that there are limitation and interactional problem dealing with paper (Steurbaut, et al., 2010), (Eckerson, 2006) and (Petrakis and Engiles, 2000). This includes physical space, physical delivery, and versioning process throughout IT operations reviewing, analyzing and cross-reference process. By having paperless operation dashboard, people can use the dashboard as tool for easy monitoring and predicting trends of infrastructure health efficiently rather than manual data collection and data analysis. This will help to save time and efforts as well as avoiding frustration among the technical personnel while dealing with this repetitive task.

3 PRINCIPLES OF EFFECTIVE PAPERLESS DASHBOARD IMPLEMENTATION

There are three principles that we need to adhere to guarantee an effective paperless operations dashboard implementation.

3.1 Role of Paper

The first principle is, before going deep in paperless area, one need to understand the role of paper reports that will be replaced or minimized. We need to determine the functions and characteristics of documents that we want to replace in the first place (Gormish, Piersol, Gudan, and Barrus, 2009) and (Sellan and Harper, 2003). In order to do this, we will need to recognize the people and process workflow involved in those specific activities (Bos, Blanken, Huisman, 2011), (Noor Nashriq, Ahmad Zuhairi, Mohd Haris, Nurul Haszeli, 2011), (Plimmer, 2010), (Zhu, Nii, Fernando, Cheok, 2011) and (Plimmer, Mason, 2006). This might be derived from the dashboard angle or perspectives – whether it is meant solely for operational, tactical, strategic or combination of all [4]. After we have defined that, we are now able to determine which area and function that we want to focus on with these paperless initiatives.

3.2 Technology Must Support Paperless Environment

The next point is paperless technology must be developed to support the same paper environment (Gormish, Piersol, Gudan, and Barrus, 2009) and (Sellan and Harper, 2003).Computer system needs to be able to adapt to existing human system. Insufficient understanding of IT activities involved will result to false interpretation that could bring IT disaster when we want to replicate it into a system (Bassignani, Dierolf, Roberts and Lee, 2010) and (Eckerson, 2006), Translating all the processes just for the sake of transforming a paper process to paperless would not bring any good but would bring down the organization motivation in the long run. The dashboard need be better crafted so that people would not have the tendency to change to old paper process in future.

3.3 Paperless Initiatives Must Be Supported by Top Level Management Direction

The final point that organization should think about is whether the paper office initiatives comes from significant organization change to match computer system or it is superficial desire to not use paper (Steurbaut, et al., 2010). When one organization chooses the latter to start move on the paperless office initiative, they can be sure that the use of paper will totally fade out in certain tasks in future.

4 CRITERIA OF WELL-DEFINED PAPERLESS OPERATION DASHBOARD

There are many criteria that contribute to good paperless operational dashboard for particular environment. Based on studies, the important criteria are summarized and tabulated in Table 1.

Table 1: Criteria of paperless well- defined operation dashboard.

Criteria	Description
Comprehensive	Completeness - cover only what key business and system needs while ensuring all performance indicators included.
Process mapping	Ability to adapt and replicate current paper process to paperless
Automation	Ability to automate repetitive dashboard activity
Real-time & accurate data	Current, instantaneous and precise data available to view.
Personalization	Distinguish dashboard according to viewers – operational, tactical, strategic
Audit capability	Ability to store log events for analysis and comparison purpose.
Alert / Notification	Action trigger based on specific rules.

As tabulated in Table 1, these five criteria are the main contribution towards having a good paperless operation dashboard.

The first criterion is the dashboard must possess comprehensive coverage according to purpose of the dashboard (Petrakis and Engiles, 2000) and (Noor Nashriq, Ahmad Zuhairi, Mohd Haris, Nurul Haszeli, 2011). The selected performance indicator must be able to show business performance and real-time status according what business and system needs (Bharosa, Meijer, Janssen, and Brave, 2010). A good information organization and flow can help users to highlight critical data that we can want to convey (Marshall, 2009) and (Triola, Feldman, Pearlman and Kalet, 2004).

The paperless dashboard must be able to map current paper process to its new paperless system (Sellan and Harper, 2003), (Bos, Blanken, Huisman, 2011), (Petrakis and Engiles, 2000) and (Zhu, Nii, Fernando, Cheok, 2011). The technology that the paperless dashboard has should be able to support current paper environment in order to make it work

*(*Gormish, Piersol, Gudan, and Barrus, 2009) and (Noor Nashriq, Ahmad Zuhairi, Mohd Haris and Nurul Haszeli, 2011). The paperless operations dashboard must be able to accommodate offline process mapping of operational, tactical as well as strategic process as needed in order to succeed in meeting this criteria. If people are kept coming back and forth from paper to paperless dashboard, this initiative will eventually be washed-out in the near future.

The third criterion is job automation that we wanted to capture over time. Ability to generate automatic data and reports would be the most important feature of paperless dashboard. With this feature, user would not be wasting time generating data and reports that turns out to be repetitive job over time (Eckerson, 2006), (Petrakis and Engiles, 2000), (Bos, Blanken and Huisman, 2011), (Jain, Arim, and Li, 2008). By automatically running scripts through the back end of the dashboard, this feature definitely is an added advantage to any paperless dashboard. This feature will help the user to focus and concentrate more on monitoring, analyzing and prediction of the data.

The fourth criterion is real-time and accurate data available for analysis whenever users needed for either analysis or reviewing current performance (Noor Nashriq, Ahmad Zuhairi, Mohd Haris and Nurul Haszeli, 2011) and (Plimmer, 2010). By using scheduled task, monitoring scripts can be done automatically while eliminating any human errors thus; can help to guarantee data accuracy of the dashboard especially when dealing with operation, tactical and as well as for strategic purposes.

With dashboard personalization, users are able to customize dashboard page and look and feels according to their job roles (Bharosa, Meijer, Janssen, and Brave, 2010), (Marshall, 2009) and (Triola, Feldman, Pearlman and Kalet, 2004) and (Nagios, n.d.) The most important point is the dashboard is able to customize according to user technical and management background – whether it is operational, tactical and strategic. This feature will help user to utilize the dashboard functionality thus improve business and operation management.

When there is analyzing data process involved, system admin will have to rely on audit capability of our dashboard (Steurbaut, et al., 2010), (Sellen and Harper, 2003) and (Triola, Feldman, Pearlman and Kalet, 2004). By storing historical data and retrieving for auditing past data, user will be able to conduct an in-depth review analysis for find root cause of certain problem.

The last but not least is alert and notification messages. This is the capability of the dashboard to alert and notify the admin for any possible issues so that they can take action before a huge disaster could happen (Eckerson, 2006) and (Gormish, Piersol, Gudan, and Barrus, 2009). System will be 100% responsible to monitor the system using generated scripts without having human intervention.

5 COMPARATIVE STUDY

We had briefly discussed seven criteria which contribute to the success of paperless operational dashboard. A comparative study was conducted on a few dashboards based on seven criteria of well-defined paperless operations dashboard. For this, the study is limited to dashboards commonly used such as Nagios, Zenoss, Ganglia, Cognos, OpManager and Cacti and MIMOS Operations Dashboard.

5.1 Comprehensive

Zenoss offers cataloged view state of managed servers and services (Zenoss, n.d.) This means that the services can be grouped according to their classes and functions. Nagios on the other hand, can only handle medium size infrastructure. Hence it would be very suitable for small to company with medium IT operations (Cacti, n.d.). For complete end-to-end IT network and infrastructure monitoring with advanced fault and performance management, Opmanager would be the best choice to implement (Opmanager, n.d.). Cacti and Ganglia provide RRDTool charting of industry standard with high performance data logging and graphing system for time series data (Cacti, n.d.) and (Ganglia, n.d.). On the contrary, MIMOS Operations dashboard offers high level view of networked diagrams for critical servers and services as well network connectivity of the whole infrastructure in one page (Plimmer, 2010)

Cacti and Zenoss can monitor most of the basic information of servers and services (Cacti, n.d.) and (Zenoss, n.d.). This includes system heartbeat or availability of the servers and services. Nagios, Cacti and Opmanager offer more performance indicators to monitor especially for advanced monitoring e.g. outages or performance degradations for CPU, memory and disk space, network traffic, temperature of host of the servers (Nagios, n.d.), (Cacti, n.d.) and (Opmanager, n.d.). Compare to others, Ganglia can only monitor physical information on particular nodes (Ganglia, n.d.). For MIMOS Operations Dashboard, there three sets of performance indicators that are monitored – server uptime and availability as

well as disaster recovery status (Noor Nashriq, Ahmad Zuhairi, Mohd Haris and Nurul Haszeli, 2011).

Result of comprehensive criteria is tabulated in Table 2.

Table 2: Comparison on comprehensive criterion.

Dashboard	Comprehensive
Zenoss	• Offers catalogued view of servers and services involved • Monitor most of the basic information of server and services
Nagios	• Handle small to medium infrastructure • More advanced monitoring provided
Opmanager	• Complete end to end monitoring with fault management • More advanced monitoring provided
Cacti	• High performance data logging for time series data • More advanced monitoring provided
Ganglia	• High performance data logging for time series data • Monitor physical information on particular notes
MIMOS Operations Dashboard	• High level networked diagram of infrastructure • Three sets of performance indicator – uptime, availability and disaster recovery status

5.2 Process Mapping

As listed in Table 3, among the six dashboards, only Zenoss (Zenoss, n.d.) and Cacti (Cacti, n.d.) are capable to conduct trend prediction even though it is still minimal activities at the moment. Nagios (Nagios, n.d.), Ganglia (Ganglia, n.d.) and (Opmanager, n.d.). and MIMOS Operation dashboard only provides real-time monitoring and manual trends analysis on the historical logs and events provided. None of the dashboards serves strategic functions in their dashboard.

Table 3: Comparison on process mapping criteria.

Dashboard	Process Mapping
Zenoss	Operational, tactical with trend prediction
Nagios	Operational and tactical
Opmanager	Operational and tactical
Cacti	Operational, tactical with trend prediction
Ganglia	Operational and tactical
MIMOS Operations Dashboard	Operational

5.3 Automation

All of the dashboards have specific automation scripts designated for every application and system. The users only need to key in the respective IPs and other information before the scripts will go and retrieve the needed status and return it to the dash board.

Zenoss automatically build and maintain service dependency mappings with real-time discovery and topology modeling in one single click (Zenoss, n.d.). Nagios uses external plugins that runs intermittent checks on hosts and services in some predetermined interval (Cacti, n.d.). Similar with Zenoss, Opmanager also depended on its automated network discovery to scan the network, servers and services status (Zenoss, n.d.). Cacti possess a mechanism which allows users to generate custom scripts that can be used to gather data before dumping it on the dashboard (Cacti, n.d.). Ganglia comprises of three daemons that together they will run on each cluster nodes being monitored and collect states of the result (Josephsen, 2007). The web-based frontend will ensure that the collected data will be presented in real-time dynamic web pages graphs. MIMOS Operation Dashboard backend engine will run custom scripts every 2 minutes to collect performance indicator data and validating them with some specific validation rules before sending it for visualization. The summarized findings are tabulated in Table 4.

Table 4: Comparison on automation criteria.

Dashboard	Automation
Zenoss	With real-time discovery and topology modeling
Nagios	Runs intermittent checks some predetermined interval
Opmanager	Automated network discovery
Cacti	Generate custom script for data gathering
Ganglia	Daemons run checking and collect states in predefined time
MIMOS Operations Dashboard	Backend engine runs scripts to collect performance

5.4 Real-time and Data Accuracy

As tabulated in Table 5, all dashboards provide real-time data with probability lagged status of maximum five minutes. However this interval can be configured depending on business needs. For accuracy purposes, respective dashboards will set specific rules to send repeated scripts to validate the status if negative status is passed during the first

result. This is crucial to IT operations as they do not want to focus their effort into some false alarm of respective devices.

For Zenoss, the network and devices will be checked by ping collector (Citrix, 2012). By default, ping timeout will be 1.5 seconds and if it fails to response, collector will send out 2 retries. If the devices or network fails to responds in 1.5 seconds in three tries, an event will be created and highlighted in the dashboard.

Scheduling for check events for Nagios is customizable. By default the interval length for every check is 1 minute. There is a retry check option that can help to double check any negative result and validate them (Josephsen, 2007). This is to ensure that the service is down for certain amount of time before notifying the technical people. Max check attempt option will help to limit the attempt checking the services in any negative cases. However, these options only applicable to services monitoring. Host checks will be only carried out when needed, usually when services on that specific host failed to respond in the predefined time (Josephsen, 2007).

For OpManager, ICMP ping will be push over to the monitored devices every 2 minutes (Manage Engine, 2012). If there is no response after two consecutive pings, then OpManager will consider the device as unavailable. The number of pings and their time interval can be assigned depending on our business needs. Opmanager will use Telnet to monitor non-ICMP environment. The default polling interval is 5 minutes and this can be customizable. Moreover, Opmanager also has mechanism of alarm propagation that rely on a few negative consecutive polls namely attention, warning and critical state. Color coded label will be also used to differentiate these alarm state (Manage Engine, 2012).

Cacti and Ganglia both are using RRDTool charting for in their dashboard. Cacti graphs usually will take two or three polling intervals to show up with 5 minutes of default polling interval (Nuryani Arisal, Suwarningsih, Wirahman, 2007). Ganglia on the other hand, sets 15 seconds of polling interval by the default (Ganglia, n.d.). However, this value can be reconfigured according to its data source – whether it is grid or cluster.

MIMOS Operation Dashboard provides custom scripts of ping for every critical hosts and telnet for services check. The interval length of every check is about 2 minutes and the system will poll three consecutive checks before releasing 'DOWN' status to the dashboard. In between the three consecutive checks, the dashboard will display 'WARNING' status to pre-notify the technical people to stand by.

Table 5: Comparison on real time and data accuracy criterion.

Dashboard	Real-Time & Data Accuracy
Zenoss	Ping timeout is 1.5 seconds with 2 retries
Nagios	Check interval length is 60 seconds with retry check option and max check attempt
Opmanager	ICMP ping interval length is 2 minutes with 2 retries Telnet polling interval is 5 minutes Has alarm propagation and color coded label.
Cacti	Polling interval is 5 minutes
Ganglia	Polling interval is 15 seconds
MIMOS Operations	Polling interval is 2 minutes and 3 retries

5.5 Personalization

This feature is useful when people are from different background and expertise wants to use the paperless operation dashboard to their advantage. Since users may come from operational, tactical or strategic functions, dashboard may need to be customized according user needs. However, Zenoss (Zenoss, n.d.) and Cacti (Cacti, n.d.) are the only dashboard that provides this features embedded by default. The other dashboard will need to be customized to add this feature. Result of personalization criteria is tabulated in Table 2.

Table 6: Comparison on personalization criterion.

Dashboard	Personalization
Zenoss	Possess this feature
Nagios	Do not possess this feature
Opmanager	Do not possess this feature
Cacti	Possess this feature
Ganglia	Do not possess this feature
MIMOS Operations Dashboard	Do not possess this feature

5.6 Audit Capability

By default, all dashboards have the audit features although the presentation of logs events may varies between them. Users are able to see historical events of any opportunity or issues especially tactical and strategic teams. However, MIMOS Operation dashboard does need to rely on other tools in order to process and analyze past data (Noor Nashriq, Ahmad Zuhairi, Mohd Haris, Nurul Haszeli, 2011). Table 7 briefly summarized this finding.

Table 7: Comparison on audit capability criterion.

Dashboard	Audit Capability
Zenoss	Possess this feature
Nagios	Possess this feature
Opmanager	Possess this feature
Cacti	Possess this feature
Ganglia	Possess this feature
MIMOS Operations Dashboard	Do not possess this feature

5.7 Alert and Notification

When there is a server or services outage, a paperless operation dashboard should be able to trigger and send a notification to the technical team for them to act on. The normal alerts or notifications are email, SMS or telephone. As listed in Table 8, among the six dashboards, Ganglia are not able to send to send notification to their respective standby team (Ganglia, n.d.) by default. Other dashboards can use either email or SMS for outage notification [Zenoss, n.d.), (Nagios, n.d.), (Opmanager, n.d.), (Cacti, n.d.) whereas MIMOS Operations Dashboard depends on other plugin to send alerts and notification. The summarized findings are tabulated in Table 8.

Table 8: Comparison on audit capability criterion.

Dashboard	Alert and Notification
Zenoss	Email, SMS or telephone.
Nagios	Email, SMS or telephone.
Opmanager	Email, SMS or telephone.
Cacti	Email, SMS or telephone.
Ganglia	Do not possess this feature
MIMOS Operations Dashboard	Email, SMS or telephone.

6 CONCLUSIONS AND FUTURE WORKS

Based on the above discussion, we have summarized seven criteria that a paperless operations dashboard should have in order to ensure that these paperless initiatives will be carried out successfully in an organization. We have compared five off-the-shelf operations dashboards and one in-house developed dashboard and briefly listed the features related to these criteria in the later section. However to make these initiatives a success, understanding of the principles and reason of carrying out this initiatives is imperative. It is hoped that this paper can assist in deciding the best paperless operations dashboard for their organization as well as ensuring that the initiatives last, usable and sustainable throughout the years.

We plan to improve MIMOS Operations dashboard to include historical logs and events for trends analysis as well as incorporate some business intelligence feature for trend predictions. Moreover, there is a need to come out with at least one mechanism to minimize energy savings through scripts and automation that we listed above. Lastly, our dashboard will be equipped with intuitive approach for strategic teams to rely on.

REFERENCES

Wikipedia. 2001. Dasboard (Software). [Online]. Available: http://en.wikipedia.org/wiki/Dashboard_%28software%29

Sorenson, M. 2005. What is Dashboard [Online]. Available: http://searchcio.techtarget.com/definition/dashboard.

Maarten, M. 2001. *Digital Dashboard: Web Parts Integrate with Internet Explorer and Outlook to Build Personal Portals* [Online]. Available: http://msdn.microsoft.com/en-us/magazine/cc301617.aspx

Plimmer, B., Apperley, M. 2007. *Making Paperless Work.* In Proceedings of the 7th ACM SIGCHI New Zealand chapters international conference on Computer Human interaction design centered HCI. ACM Press, pp. 1-8.

Steurbaut, K., Colpaert, K., Van Hoecke, S., Steurbaut, S., Danneels, C., Decruyenaere, J., De Turck, F. 2010. *Design and Evaluation of a Service Oriented Architecture for Paperless ICU Tarification*. Journal of Medical Systems. pp. 1-14

Wayne W. Eckerson. 2006. *Performance Dashboards: Measuring, Monitoring, and Managing Your Business*. John Wiley and Sons.

Gormish, M., Piersol, K., Gudan, K., and Barrus, J. 2009. *An E-Writer For Documents Plus Strokes.* In Proceedings of the 9th ACM symposium on Document engineering (DocEng '09). ACM, New York, NY, USA, 157-160.

Matthew J. Bassignani, David A. Dierolf, David L. Roberts and Steven Lee. 2010. *Paperless Protocoling of CT and MRI Requests at an Outpatient Imaging Center*. JOURNAL OF DIGITAL IMAGING, Volume 23, Number 2, 203-210.

John M. Petrakis and Michael J. Engiles. 2000. *Creating A Paperless Municipal Court*. In Proceedings of the 32nd conference on Winter simulation (WSC '00). Society for Computer Simulation International, San Diego, CA, USA, 2029-2035.

Abigail J. Sellen and Richard H.R. Harper. 2003. *The Myth of the Paperless Office.* MIT Press, Cambridge, MA, USA.

Bos, T., Blanken, M., Huisman, H. 2011. *Towards A Paperless Air Traffic Control Tower*. In Proceedings of

the 2nd international conference on Human centered design (HCD'11), Masaaki Kurosu (Ed.). Springer-Verlag, Berlin, Heidelberg, 360-368.

Noor Nashriq, R., Ahmad Zuhairi, I., Mohd Haris, A., Nurul Haszeli, A. 2011. *Operations Dashboard: Comparative Study*. International Conference on Graphic and Image Processing [ICGIP 2011], 2011.

Plimmer B. 2010. *A Comparative Evaluation Of Annotation Software For Grading Programming Assignments*. In Proceedings of the Eleventh Australasian Conference on User Interface - Volume 106 (AUIC '10), Christof Lutteroth and Paul Calder (Eds.), Vol. 106. Australian Computer Society, Inc., Darlinghurst, Australia, Australia, 14-22.

Zhu, K., Nii, H., Fernando, O., Cheok, A. 2011. *E-Letter: A Paper-Based Instant Messaging System Using Selective Wireless Power Transfer.* In ACM SIGGRAPH 2011 Posters (SIGGRAPH '11). ACM, New York, NY, USA, Article 43, 1 pages.

Plimmer B., Mason P. 2006. *A Pen-Based Paperless Environment For Annotating And Marking Student Assignments*. In Proceedings of the 7th Australasian User interface conference - Volume 50 (AUIC '06), Wayne Piekarski (Ed.), Vol. 50. Australian Computer Society, Inc., Darlinghurst, Australia, Australia, 37-44

Bharosa, N., Meijer, S., Janssen, M., Brave, F. 2010. *Are We Prepared? Experience From Developing Dashboards For Disaster Preparation. 2010.* In: Proceedings of 7th International ISCRAM Conference, Seattle, USA.

Marshall, C.C. 2009. *Reading And Interactivity In The Digital Library: Creating An Experience That Transcends Paper.* In: Proceedings of the CLIR/Kanazawa Institute of Technology Roundtable.

Triola, M., Feldman, H., Pearlman, E., Kalet, A. 2004. *Meeting Requirements And Changing Culture: The Development Of A Web-Based Clinical Skills Evaluation System*. J Gen Intern Med 2004; 19:490-493.

Jain, J., Arim, I., Li, J. 2008.*Designing Dashboards For Managing Model Lifecycle.* In: CHiMiT '08 Proceedings of the 2nd ACM Symposium on Computer Human Interaction for Management of Information Technology.

Nagios. [Online]. Available: http://nagios.com/ [Assessed: Apr 20, 2012]

Cacti [Online]. Available: http://www.cacti.net/ [Assessed: Apr 20, 2012]

Ganglia. [Online]. Available: http://ganglia.Source forge.net/. [Assessed: Apr 20, 2012]

Opmanager. [Online]. Available: http://www.manage engine.com/network-monitoring/ [Assessed: Apr 20, 2012]

Zenoss. [Online]. Available: http://www.zenoss.com/ [Assessed: Apr 20, 2012]

Zenoss Community. [Online] Available: http://community. zenoss.org [Assessed: Apr 20, 2012]

Citrix. 2012. How to Manage NetScaler 9.2 Using SNMP by Cacti. [Online]. Available: http://support.citrix.com/ article/CTX125187. [Assessed: Apr 20, 2012]

Nuryani Arisal, A., Suwarningsih, W., Wirahman, T. 2007. *Monitoring Cluster On Online Compiler With Ganglia.* Whitepaper in EEPIS Repository.

Josephsen, D. 2007. *Building A Monitoring Infrastructure With Nagios.* Prentice Hall. 23-26.

Manage Engine. 2012. Availability Monitoring. [Online] Available: http://www.manageengine.com/network-monitoring/availability-monitoring.html. [Assessed: Apr 20, 2012]

Bowling, J. 2008. *Zenoss And The Art Of Network Monitoring.* Whitepaper. Linux Journal, Aug 01, 2008.

Webber, L., Michael Wallace. *2009. Green Tech: How To Plan And Implement Sustainable IT Solutions*. AMACOM.