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REVIEW PAPERS

Improvement of system performance in an IT production support environment

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Abstract The paper aims to be to identify how dashboards can be used to help Information and Communications Technology (ICT) production support teams to manage systems better and giving business stability and performance to be able to be more competitive. This includes forecasting potential problems that can occur as well as prescribe possible solutions before there are any major system outages. Dashboards will track and monitor behaviour of systems to allow for faster turnaround time in resolving issues when it occurs. The analysis and design show how the technologies work together to create a prescriptive dashboard, e.g. alerts sent through to mobile devices (phones) which create a quick reaction time and staff not on site (vendors, remote locations, etc.) can be informed and reduce downtime to the business. The proposed method provides knowledge management requests/incidents/problems and existing monitoring tools can all be integrated to provide the support staff with possible solutions. This paper will explain how dashboards can assist ICT, with the focus on production support areas, to help resolve ICT incidents, problems, and requests. A few concerns were highlighted however these concerns form part of the continuous improvements to the prescriptive dashboards. The system model will help minimize the run around between various ICT teams for troubleshooting. The flow diagram shows how it would provide early warnings and recommended solutions based on calculations of previous ICT incidents and problems. This model is complementary in the sense that it will work/integrate with existing system monitoring tools. Various types of technologies have been identified and researched through the review of the literature. The research was conducted to identify the feel for dashboards, how they can be used, and the various technologies that can complement each other to get the success of a prescriptive dashboard.

Keywords Information and communications technology · Information technology · Production · Central Database Information Store

1 Introduction

ICT has become the engine of the organization where business units continuously seek faster and improved systems for them to be profitable and to stay competitive. In doing this the appetite for system downtime or unavailability of some systems is not acceptable in the fast-paced business world. The cost of downtime and business users' nonproductive hours costs millions when added up over an annual period, which indirectly costs the company massive losses (Help Net Security 2020). Technology changes daily and businesses are continuously looking for cutting edge technology to stay competitive and improve. The

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integration of new and existing systems requires monitoring. Preventing and/or resolving issues before or as they happen should be minimal or should not occur. Dashboards can prescribe solutions automatically to ICT support staff to resolve outages faster. Strict governance in terms of accurate knowledge management and ICT requests such as changes, incidents, business requests, and problems will allow for prescriptive dashboards to be implemented. A clients' experience is about the company and not departments within the company. A typical production support environment is used where the focus is on two separate business units sharing common ICT systems and resources. The ICT Dashboards will provide an insight into how all systems and information can be displayed in a single view giving the support team enough information to resolve issues timeously as well as being able to provide continuous uptime through prescriptive data and dashboards. In many businesses, several systems are used by businesses to be competitive as well as provide a service to their clients. ICT production support teams are the first line support and must be able to respond to any of the system's performance problems as well as any system outages. Dashboards are what will solve this problem as it would provide a single view of systems for a specific area with the important items of the system. McKown (2016) noted the benefits and uses of dashboards highlight that better decision making and accountability are some of the benefits and usage of dashboards. With accountability been covered across businesses units and showing the hot spots that will require improvements. While with better decision the company's overall performance can be monitored. This can also allow ICT dashboards to be transparent in an entire organization and not just the ICT department. A dashboard will look at how the necessary information can be extracted from a Central Database Information Store (CDIS) into excel as well as create a resolution prescription guide of how the issues can be resolved. Besides, the CDIS must be flexible to allow for new or extra information to help forecast any trends that may occur shortly. The purpose of the added information is to be able to build up a database that will be able to manage the ICT infrastructure and application that goes with it. However, once the system is implemented, it will require ongoing maintenance to ensure that the information is always up-to-date. This can also be seen as a problem if the ongoing maintenance is ignored or not done properly. The uptime of systems cannot be dependent only on human resources, there has to be automated monitoring and solutions at times where support staff are not present.

The approach to be followed is to use databases, internal based servers and client-facing servers which cover the important components of internal applications and external client applications. Interviews are conducted with seven people from different areas of ICT to show what the prototype will look like as well as how it will function. This interview will provide clarity if it will and can be used in their environments. An internal survey, i.e. a department consisting of 130 ICT staff from different departments of ICT will participate in this survey. These include ICT Service Desk, Project Managers, Business Analysts, Developers and Production Support. The internal survey will indicate if dashboards will benefit all support teams as well as other departments within ICT.The research is based on the current issues in an ICT production support environment in which dashboards can be used to enhance and enable the ICT application availability to help businesses meet their goals and visions. Dashboards are covered in terms of the history and existence in business today and I look into the various options of integrating additional technologies with dashboards for ICT production support teams to resolve issues and outages faster. Surveys are conducted before the initial project work started and after the prototype was completed. The prototype is shown and input provided from management and staff in ICT production support.

Section 2 presents the background of the work. Section 3 covers the analysis and design of the work, which includes the survey carried out. It explains the various options that need to be put together to make the dash-board provide prescriptive information. The explanation gives clarity on how all the sections will work together. Section 4 shows how the design was carried to bring the information together into something meaningful through implementation. Section 5 closes out with the presentation and feedback of the prototype.It also explains the application and limitations. Section 6 concludes the paper with future works.

2 Background

The opportunity was identified to create a prescriptive dashboard to assist staff in ICT production support areas. There are always more systems and fewer staff to maintain these systems. Identifying the information is a very important aspect of building a prescriptive dashboard to give ICT the speed and confidence to maintain applications and systems.

2.1 ICT support—application support

ICT production support which consists of multiple core systems that interface with each other and are dependent on multiple teams to assist in the event of changes and production incidents. Managing systems and applications in the ICT production support environment does become challenging, although there are monitoring tools and server

management. Monitoring is done in isolation and this can be challenging when unknown, critical problems impact the business. With their merger in place, Suncorp's Information Technology (IT) department maintained system availability and Security and this was "*just expected*" by the business (Ashley 2004). An important first lesson for choosing metrics was that the choice of items to measure means something and adds value, i.e. having the right information shown to the right audience who can make the informed decisions (Ashley 2004). Salesforce.com's outage impacted their clients and was defended by staff and management of salesforce.com that there was no outage and this is where clients had experienced 5 h downtime with the company's site (Ferguson 2006). It is important to keep in mind that moving infrastructure that clients are dependent on must have a backup plan. Businesses today are running systems located in various locations and have different Operating Systems (OS) (Hernantes et al. 2015).

2.2 Dashboards

The dashboard has indicators that are linked to the decisions and objectives of the company, which show what has been forecasted and achieved (Nicoleta and Victor 2014). Data-driven decision-making requires assistance from big data; which includes archiving, sorting, analysis and evaluation (Public CIO 2012a, b). Dashboards will provide a clear mission, vision, and strategy of the institution (Butler 2007). The reliability factor was what was important. Speed, fuel, etc. for these cars were secondary issues. However as time had passed, more improvements needed to be done (Shadpour and Kilcoyne 2015). Dashboards are a communication tool as these provide information to managers at different levels (Nicoleta and Victor 2014).The Balanced Scorecard enables the business to drive strategies (Kaplan and Norton), is now applied in IT (Van Grembergen et al. 2003). Dashboards are often put into perspective whereby executives need to make decisions based on what they need to do for the company. We cannot imagine cars without dashboards and the improvements made to dashboards like Ford's dashboards using Blackberry software (Grobart 2015). More detail like misfiring cylinders, fuel pressure and calling emergency services can all be controlled via 3G, the car's built GPS and smartphones or the internet (MIT Technology Review Staff 2011).Communication with dashboards is just as important as the information it has. There should be no misunderstandings, e.g. the sales team not in line with the production team (Karr 2012). Some of these key benefits can be brought in for stability of systems, e.g. (a) Refine Strategy—continually looking for better ways of managing the IT environment, looking for common ways internally and externally, to improve the ways of working, (b) Increase visibility—using past information to make decisions for the future to avoid repetition of issues, (c) Increase coordination—Teams within ICT can work closer together by sharing knowledge and experience to improve performance, (d) Reduce costs and redundancy, (e) Deliver actionable information. Balanced scored cards viewed visually via a dashboard must have meaningful information (Wyatt 2004). The term Responsive Web Design is directed to the design suitable for all devices and browsers where the users of the dashboard won't have to make changes to their devices to view information and that the development is done upfront to create multiple device compatibility.

Designing effective dashboards is a key to a business by creating drill-downs however this may not be the case for executives as they would not want to micromanage the business. This means that they will only want to see the information at a very high level, i.e. at a level where information is rolled up from various business areas and provides the information to executives to solve problems and make decisions which must include the facts (Ballou et al. 2010). WLAN (wireless local area networks) is AirMagnet's distributed solution which includes "rogue management, intrusion detection, vulnerability assessment and policy monitoring along with performance and traffic analysis" (McElligott 2004). With dashboards implemented for staff, managers/executives get a complete view of what is happening in the business (Dover 2004). Working as a team is just as important and if the dashboard is implemented correctly, team members will work towards their common goals and succeed as a team (Dover 2004). This means that the location will not be a problem and staff can support the environment from anywhere.

Data warehousing and business intelligence (BI) are what many companies are turning to for data organization and to make informed decisions. This is all done to give a business a competitive advantage and can be achieved with stable systems (Venkataraman and Brooks 2012). It includes the application that is the key component to a business which makes up the complete system. Big data strategy—Companies have been caught off-guard with a sudden rise of big data which impacts their competitive advantage (Kabir and Carayannis 2013). Big data exists in businesses however the businesses are struggling to use it in a meaningful way and it's not just about having a large volume of data but harvesting it is very important, Wah (Chief Operating Officer, SAS Institute) (Fox 2014). Within the dashboard, the data can be used if it is understood and is meaningful. The need for knowledge management: the typical employee today does not stay for a long time with the organization and knowledge is continuously lost. Employees retire and their trainees move into other positions and this scenario (combined or not) creates

a major gap for undocumented links between data systems and warehouses (Sukumar and Ferrell 2013). Analytics helps organizations make faster and better decisions and actions can be taken confidently based on these decisions (Cokin 2014). The benefits of knowledge management for prescriptive dashboards are as follows: (a) Knowledge is retained if staff leave, (b) Knowledge is available for new staff to learn from, (c) Troubleshooting and resolution time of issues remain the same because the information is stored and sent when during critical times, Business continuity remains the same and can be improved with new skills. The KPMG Hub assists KPMG users globally with a knowledge base (Hughes & Chapel 2013). Continuous improvement of existing knowledge is critical and information must be reviewed and corrected no matter what management system is in place (Workman 2011). This information setup is crucial for prescriptive production support data. Knowledge is based on experience which means that someone will have to learn before knowing (Qureshi and Ali 2014). One of the wrong uses of knowledge management is not focusing on the future yet the knowledge is obtained to inform and influence decision making (Fahey and Prusak 1998). One of the 12 principles that stood out for knowledge management was "*Looser is probably better*", i.e. do not waste the time and energy in managing knowledge to tightly, it changes all the time (Allee 1997). Cloud computing and knowledge management work well together and the positive points are that the company can grow its knowledge base easily and the cloud will control the additional space and storage (Sari and Kurniawan 2015). Big data can potentially be the key enabler of decision making. Information is now gathered across industries and the research departments can use this to provide solid information to make their decisions (Casado and Younas 2015).

2.3 Technology complementing prescriptive of dashboards—virtualization and infrastructure

The virtualization of servers is on the increase and makes business sense to move from physical to virtual servers. Knowledge of cloud technology is also not mature in organizations that will delay the technology to move into the cloud. Virtualization has been increasing in organizations and because it is so simple to add servers to an IT server environment, teams just do it. Beware of server overload, multiple servers can be added on a single server however when it comes to heavy-duty applications, this can/will fail (Gittlen 2010). Basu (2013) discussed the 5 pillars to prescriptive analytics success where knowing what is going to happen and how to avoid or pursue ways of doing business, i.e. "hybrid data, integrated predictions and prescriptions, prescriptions and side effects, adaptive algorithms and feedback mechanism."

Cloud technology allowed a brokerage to continue business as usual even though a few city blocks were out of power due to a power outage due to a blown transformer (Galentine, 2012). Some companies will not move to cloud computing because data security is still an issue (Yushui and Shunpeng 2013). The security issues are to do with the broader cloud computing environment such as physical security, network, storage, data security, etc. Amazon's elastic cloud computing (EC2) allows scalable cloud computing where the end-user has multiple options to choose from including disk size, disk type, types of virtualization (Papadopoulos 2011). Small and medium businesses are welcoming public clouds if they do not wish to invest in their infrastructure, (Conway 2010). What must be taken into consideration are; the data-intensive systems and systems used to process batches are better of being on-premise (Bednarz 2015). Elasticity is the real game-changer for cloud computing (Owens 2010). This elasticity is compared to Henry Ford's automotive production line and mass production, i.e. affordability and improvements on time to the market (Owens 2010). It is about being flexible and responding to clients. Cloud computing should be treated as a journey and not a destination and companies will have to look into each step of the journey to realize the full benefit (Yan 2015).

Bring your own device (BYOD)—Smartphones have changed the way of traditional mobile phones which give the smartphone user more control over their device (Yoonhyuk 2014). Smartphone users customize their devices to suit their lifestyles. BYOD comes with its challenges bringing in additional strain to the company networks as well as security of viewing company information on personal devices. However, there are benefits of using BYOD because mobile devices are being carried almost anywhere in the workplace. Analyzing customer profitability is made easy when using digital devices (Hamilton and Koch 2015). Decisions can be made with handheld devices providing flexibility and accuracy to the right people, at the right time on the right devices. Adaptive design is expensive but matches to the user's device capabilities. Responsive design makes use of Cascading Style Sheets and is less expensive. It adjusts for all devices except old cell phones (Schenck 2013). Jansenn (2015) describes four types of systems integration: (a) Horizontal integration—where a unique subsystem interfaces with all other subsystems. Also known as an Enterprise Service Bus (ESB), (b) Vertical Integration—creating silos however new functions will require new silos which will be more expensive, (c) Star Integration—also known as "Spaghetti Integration". Subsystems are connected to multiple subsystems which look like a star in a diagram. The more

subsystesms will require more connections to each other, and (d) Common Data Format—creates a common independent platform that does the transformation to another application. By standardizing the choice of systems, it will not only provide stability but also lessen problems and if there are problems, ICT support staff can zone in and resolve the problems quickly and easily (Dickerson 2005).

The trends that will influence and shape business in the future are innovation, investing in analytics, moving to the cloud, alignment of devices, people and tasks, to name a few (Andriole 2015). The transparency between business and IT is important to create visibility and flexibility to business (Von KAnel 2006). Dashboards drive a culture of transparency-and accountability-throughout the organization because they monitor progress towards achieving corporate, department, or individual goals (Von Kanel 2006). Management is equipped to make their own decisions timeously with dashboards. The future directions of information and telecommunications' and how they can be used in organizations today are summarized as, Cloud Computing, Software-as-a-Service (SaaS), Platform-as-a-Service (PaaS) and Infrastructure-as-a-Service (IaaS) are the various options that ICT have to run their business environments (Caytiles and Park 2013). Excel and Google Sheets are more than just spreadsheets (Homocianu and Airinei 2015). These sheets can now be interfaced with the business websites to get the data into these spreadsheets. Microsoft Excel and Google Sheets are used for other purposes e.g. graphing pivot tables, and charts. Data can be extracted directly into these sheets/tables. A survey (Computerworld's 2015 IT Careers survey) showed that 40% of the participants said that vendors are now involved in projects, which helps in knowledge sharing and reduction in overall costs (Waxer 2015).

2.4 Production support monitoring—the way it is currently done

Some vendors focus on the same types of monitoring for applications and servers. These are: (a) Server monitoring: RAM, HDD, Performance, and applications, (b) Application Monitoring: Site availability, services, interfaces, response times, (c) Database monitoring: Graphs, log requests with DBA's to investigate and provide feedback, (d) User experience: Users (internal) will always have different experiences and their feedback is never consistent, (e) User experience: All users must log ICT requests for any system-related issues, and (f) ICT production support: All support staff must log ICT Outages to keep record and be transparent with other system owners within ICT and where the business is impacted, the business units must be informed as well.

2.5 Production support monitoring—the way it should be done

Once the dashboard is setup and all information is viewed on the single view dashboard, ICT production staff can now focus on a specific system that is highlighted and the prescriptive dashboard rules for the system will alert support staff. The prescriptive dashboard will assist in dealing with system outages individually and holistically with other dependent systems.

1. Identify trends through tracking user requests and linking this with ICT production support outages.
2. General maintenance of the hardware and software can be inserted into the dashboard to begin a countdown of the next upgrade. This will help in proactive upgrades and not only when there is a major system upgrade or outage.
3. By using these statistics, ICT management can be prescribed with permanent resolutions which will avoid re-occurrence.
4. Recommendations can be provided to make changes to systems and avoid any known issues or future issues that may occur.
5. The dashboard must be flexible to allow input of additional/external information to disrupt the routine information. With this information, we will be allowed to see what difference does it make to the dashboard and what new recommendations can be provided.
6. External fixes from vendors can also be stored for the prescription dashboard. In this way, there is no limit and at times fixes are provided by the vendor. We must be able to accommodate such information. Table 1 presents the some useful terms.

The paper has covered a few key areas that many ICT departments face challenges in; however, it is not unusual. It provides an opportunity to understand where these areas fit into the bigger picture of ICT production support. It has also highlighted where we are currently with production support and where we need to be. This is where we have taken the information and setup it to create the prescriptive monitoring of the information from various systems that make up a complete end-to-end system. The design will include how all the sections in the current chapter can come together to assist with real-time, actionable ways of reducing outages and resolving incidents within the ICT environment. The setup of each dashboard item has to be mandatory for the setup of the automated prescriptive dashboard. The IT request system should contain the following mandatory fields: System Name, Subject (Incident Description), Incident number, Root cause, Resolution, Link to Wiki Page/Knowledge Repository. The mandatory information above must integrate with the ICT

Table 1 Some useful terms

BYOD	Bring your own device
ICT production support areas	ICT staff that support applications
Business	Various departments within the organization including branches or different sites
Central Database Information Store	A central database where information is gathered frequently and passed into the dashboard
Single view	A single view of multiple systems in a dashboard
Root cause	Identifying what was the cause of the problem
Wiki	Knowledge database where all documentation is stored. This is for general knowledge or incident root causes and resolutions

departments' Wiki pages or knowledge repository. Knowledge management is very important because a lot of knowledge loses/leaves when staff leaves the company. When there are problems, it takes even more time to investigate and resolve these problems however if there is governance in place, it will allow for the knowledge to be retained. The benefit of having a prescriptive dashboard will also force staff members to update the internal knowledge repository. From an ICT management view, the setup and continuous building of knowledge will be efficient and will highlight any area that may not be functioning optimally. However, there are always individual systems that can be checked to see if continuous improvements are done. Once the knowledge repository is in place it will provide the IT Support staff with possible resolutions based on what was done previously to have similar issues resolved. The prescriptive dashboard will recommend solutions to the production support staff (Fig. 1).

The recommended solution will gather information from previous logs where the subject has been the same. It will then take the resolution and submit it to the support staff. The resolution is highly dependent on the quality and discipline of the input of the information into previous incidents. Table 2 depicts the database query systems for prescriptive dashboard.

The details of a previous incident above can be sent out for a new incident that is logged and status is open. If multiple incidents fit the information for the open incident, then all the resolutions need to be consolidated and sent. The resolutions should not be duplicated as this will confuse. The some of the automation is considered for this paper. Restarting of services—This will allow for automated restart using System Center Operations Manager (SCOM). Services can be restarted automatically and an email can be triggered to support staff to inform them that the service was restarted. Email Display—the display must be short and accurate. Mobile phone display—this display needs to be high level so that the recipient is aware and can act based on this (Chakrabroty et al., 2014). Cloud—The check of users accessing an application will monitor the threshold to identify how many users are connected (Akash et al, 2019). The database information query is represented below (Fig. 2):

Importance of database knowledge and learning will improve the quality of information passed from the various sources however, Rashid and Al-Radhy (2014), highlight that there are *Transformations to Issues in Teaching, Learning, and Assessing Methods in Databases Courses.* This could highlight an issue early in getting the right knowledge to build, maintain and continuously improve databases for this purpose. They highlight the updating of teaching being practical knowledge to be more beneficial than theory.

2.6 Benchmark setups

The dashboard information shows the thresholds for each system, the minimum and maximum thresholds for each system. The thresholds for each system will work within the algorithm to create alerts for the ICT production support staff. If incidents/requests are opened, the system line must still be highlighted in red so that the details can be completed before closing the log.The Dashboard will trigger an email alert as well as an SMS for both mobile devices. Store a record in the CDIS. It is important to keep messages clear and concise. This will be used for the continuous improvement going forward. Dates and times are important for the system to learn trends and patterns so that when troubleshooting is done, the support team can then analyze what are issues have occurred during the same time. This is only to SMS the support staff so that awareness is created. When the number of connections exceeds the count of active connections, another server must be automatically allocated in the cloud. Here as well date and times are critical for patterns and trends and this information should be stored in the CDIS and learned for the dashboard for new early trends.Fig. 3 shows the detail of

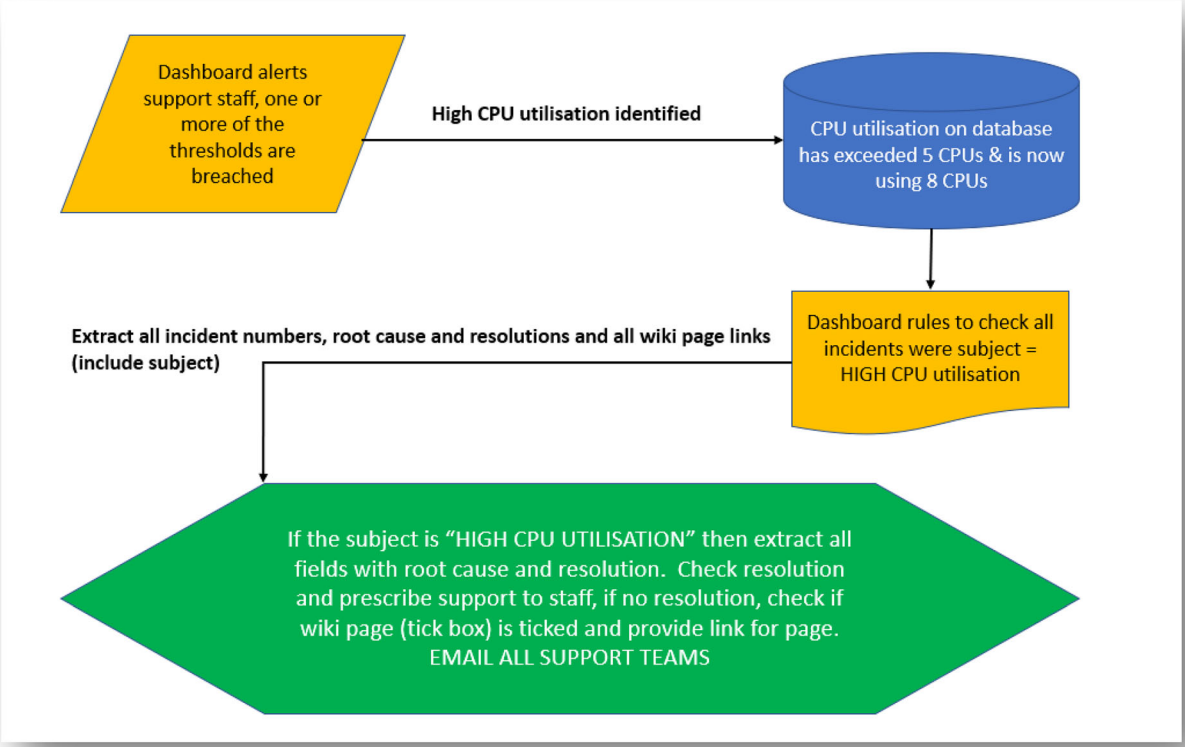


Fig. 1 Prescriptive Dashboard and automated resolution

how the Table 3 information is calculated to be imported into excel.

The display should be the same on any device. Figure 4 shows the mobile phone display in the standard dashboard.

3 Analysis and design

Boeing assembly line's Final Body Join (FBJ) is programmed to calculate how much each component (nose, tail, left and right wings) needed to move to ensure that the adjoining section was an exact fit (Hoske 2012). Knowing where parts have to be makes the join simple. If the data is being stored then extract-transform-load (ETL) needs to use and to do this it will be important to know your data and refresh rate (Calhoun and Srinivasan 2012). Including trusted metricsknown metrics are best to help build the dashboard. Historic data can help the dashboard perform optimally. Continuous Improvement is a vital part of designing dashboards. Change is guaranteed and this means that dashboards cannot be setup as a once-off exercise. It has to be looked at continuously and improved, i.e. change the indicators when required. SkyBitz uses dashboards for fleet management which are simply giving the client easy-to-understand information that assists in planning and faster responses to changing conditions (Huff 2015). The alignment of dashboards will keep everyone thinking about their top priorities (Rosso 2014). The focus on certain items on dashboards will ensure that the thinking amongst all members/teams is about the same things. Too much information should not be crammed into dashboards (Rosso 2014). Dashboards must be available at all times for employees as this is a driver of the business. Dashboards should not harm the staff. They should be setup and used to improve their working conditions. If it is negative, help the staff break it down to a level where they understand and can improve on what has gone wrong (Rosso 2014).Dashboards must be flexible and allow for changes, e.g. change in business processes or KPI's for the client engagement process (Clarkes 2005). The survey was conducted through Survey Monkey (SurveyMonkey Inc. 2015). It consisted of 12 questions related to dashboards. The plan was to get as many IT staff to respond and initially focused internally within a single company. The approach to the people was via email and discussion. Senior management within the ICT department assisted with the participation of the various divisions within IT. They had requested their teams to participate. Access to the

Table 2 Database query—fields to be extracted for prescriptive dashboard resolution

Incidents Query					
System	**Subject**	**Incident Number**	**Root Cause**	**Resolution**	**URL to wiki**
E-Commerce	E-Commerce site unavailable	1001	Web service stopped	IIS Reset did on the application server	http://localhost/ecommerce/webservicestopped

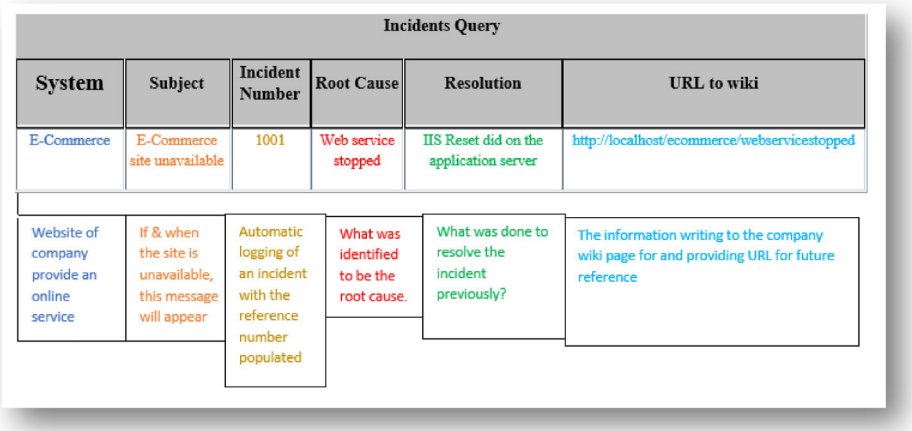


Table 3 Populated fields with color-coded identification fields and display of the imported information from the CDIS into excel

System	Response time—users (s)	Server response time (s)	Number of connections on server	Database processors	Incidents	User requests logged
A	0.03	0.01	150	5	1	7
B	0.01	0.01	200	5	0	12
C	0.03	0.01	200	4	0	1
D	0.04	0.01	1200	2	0	23

survey was provided through the web, i.e. a URL and password to login to the site. The survey consisted of questions that the participants could choose (single or multiple). The survey was fully electronic and the results were updated immediately after completion of the survey. The analysis and collection were done electronically. The data gathered in the survey was to identify if dashboards are used and the responses will show if the prescriptive dashboard will work with support teams. It was also to understand if the participants were familiar and what dashboards are doing or can do for their environments.

3.1 Survey questionnaire

This question will show the target audience for the survey. Figure 5a highlighted that the mix of people within the ICT department was good in terms of all answer choices that were completed. Figure 5b shows people based in and out of the organization including managed services, vendors, contractors and people who don't necessarily work in the office, i.e. remote users. Figure 5c indicates if dashboards are being used so that we can understand what percentage is not using dashboards. Figure 5d shows that the majority of participants are already using dashboards which will be a positive outcome because they have an understanding of what dashboards are doing in their environments and can

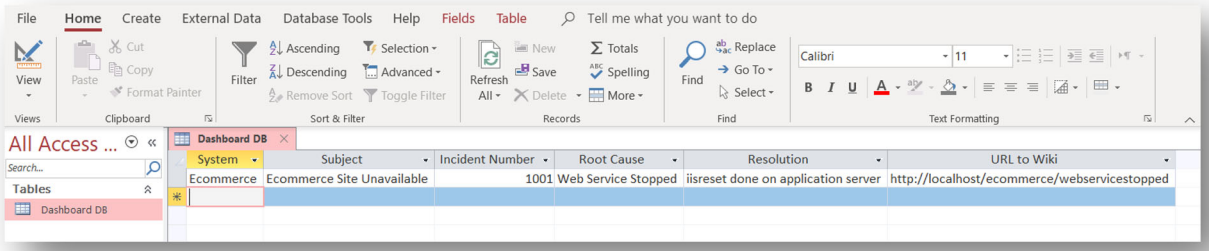


Fig. 2 Database query—consolidated information for prescriptive dashboards

System	Response Time – Users	Server Response Time	Number of connections on Server	Database Processors	Incidents	User Requests Logged
System A	0.03 sec	0.01 sec	150	5	1	7
System B	0.01 sec	0.01 sec	200	5	0	12
System C	0.03 sec	0.01 sec	200	4	0	1
System D	0.04 sec	0.01 sec	1200	2	0	23

Response Time – Users

System A – Min 0 seconds (if longer than 5 minutes) Max 4 seconds

System B – Min 0 seconds (if longer than 5 minutes) Max 4 seconds

System C – Min 0 seconds (if longer than 5 minutes) Max 4 seconds

System D – Min 0 seconds (if longer than 5 minutes) Max 4 seconds

Response Time – Servers

System A – Min 0 seconds (if longer than 5 minutes) Max 3 seconds

System B – Min 0 seconds (if longer than 5 minutes) Max 3 seconds

System C – Min 0 seconds (if longer than 5 minutes) Max 3 seconds

System D – Min 0 seconds (if longer than 5 minutes) Max 3 seconds

Number of connections on Server

System A – Min 10 (not longer than 15 minutes) Max 250 connections

System B – Min 10 (not longer than 15 minutes) Max 500 connections

System C – Min 10 (not longer than 15 minutes) Max 250 connections

System D – Min 10 (not longer than 15 minutes) Max 1250 connections

Database Processors

System A – Min 0 Max 4

System B – Min 0 Max 5

System C – Min 0 Max 4

System D – Min 0 Max 4

Number of Incidents

System A – Min 0 Max 0

System B – Min 0 Max 0

System C – Min 0 Max 0

System D – Min 0 Max 0

Number of User Requests

System A – Min 0 Max 20

System B – Min 0 Max 25

System C – Min 0 Max 20

System D – Min 0 Max 15

Fig. 3 Detailed benchmarks of systems

be complemented with the prescriptive dashboard. Figure 5e indicates if the participant knows what dashboards could do for their environment and if they are using, what will they prefer to use their dashboards for. Figure 5f shows that proactive monitoring is a requirement for 92.16% of the participants and prescriptive dashboards for ICT production support it means that this tool is on the right path to creating capacity that is required by the support teams. Figure 5g presents the usability of dashboards are used for, i.e. Strategic (management), Tactical (Analysis) and Operational (Monitoring). Figure 5h discuss in the detail that is needed to function in ICT production support and, the dashboards used in many areas already, are mainly for operational support. Figure 5i explains the

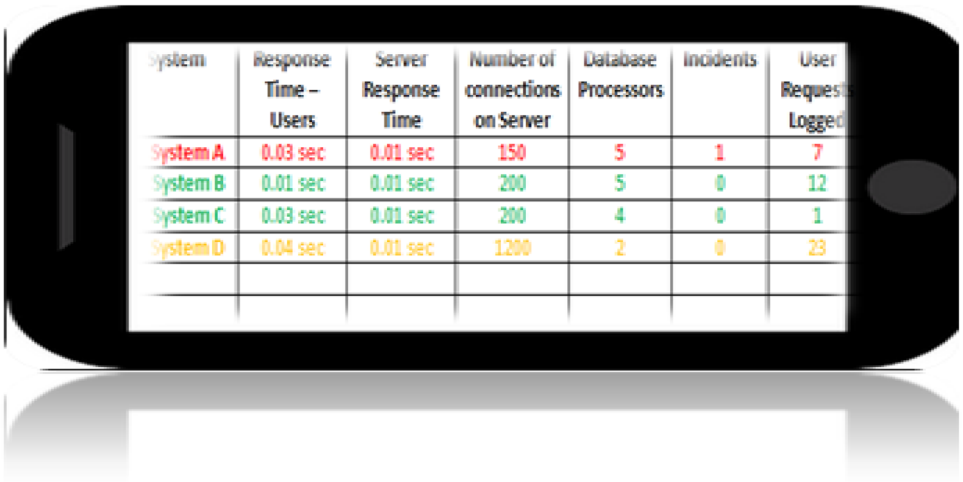


Fig. 4 Dashboard—Mobile Phone Display

lifetime settings of server hardware and software. Figure 5j shows that this is a problem in ICT when it comes to managing the software and hardware and from experience with many team members. Figure 5k shows what operating systems are used and monitored in the ICT environment. The recommendation is important because it will indicate the drive for the future and will close the loop that dashboards will be more than just a view but rather a tool to assist IT, Support staff, that shown in Fig. 5l.

3.2 Information setup

The information to be setup will require multiple areas to be setup as precise as possible to ensure the success of the prescriptive dashboard. In the beginning, it will be challenging to identify the most useful and beneficial information required. (a) *Database Server*—The CPU is an important component that must be monitored in CDIS. (b) *Application Servers*—Current monitoring statistics can be extracted including server response times, uptime, CPU utilization, and Hard Disk space, (c) *Applications*—uptime and response between users and the applications being used. The number of users accessing applications is very important, (d) *Knowledge Management (KM)*—KM has to be a Work-in-progress process. Knowledge in technology is changing and will require continuous updates. This is where we bring in incidents and user requests to help succeed in this project, (e) *Incidents*—must be logged in at the time it occurs. It must allow for mandatory fields to be completed, e.g. date and time of occurrence, so that the information will be useful when used. This is the responsibility of the ICT support staff, (f) *Requests*—are raised primarily by the business users (and ICT, if necessary) which will contain relevant and mandatory information that can be linked up to incidents and dashboards, (g) *Data Warehousing*—CDIS will live in the warehousing department within ICT. This will be managed and maintained by the specialists to gain the best out of the CDIS (Fig. 6), (h) *Frequency of updates*—the frequency of updates will differ between systems even if they interface with each other, (i) *Display*—the display must be setup according to the devices used, including BYOD (cell phones, tablets/iPads, browsers (laptop/PC, windows, android, and apple). It has to be meaningful and displayed correctly for the understanding and convenience of the support staff. In addition to the above setup information, the following subjects will complement and play a huge role in the success of the prescriptive dashboards. We have all the information managed independently. We have all the documentation stored in a central repository. We have external vendors and specialists maintaining ICT systems for business. It will be great to bring all this information together in an automated solution. The information will be sent to the support staffs that are accountable and acknowledged by the responsible participant. The support staff can focus on permanent solutions to maintain stability over a long period. More information stored over time can also help in the success of the company. In the long term, the business has a problem when trying to do historic trends and analysis so it will be important to store important information. *Cloud Computing*—The applications available to internal and external users will always increase as the business improves. If the number of users increases then an additional virtual server must be allocated automatically in the cloud-hosted environment. *Virtualization*—All application servers must be virtualized so that the servers can exist in the cloud-hosted solution or locally.

Table 3 shows the imported information from the various systems. The display is controlled by algorithms that continuously check for any breach in the thresholds set for each system. For example, there is one incident for System A, the entire row will show red as this is a problem.

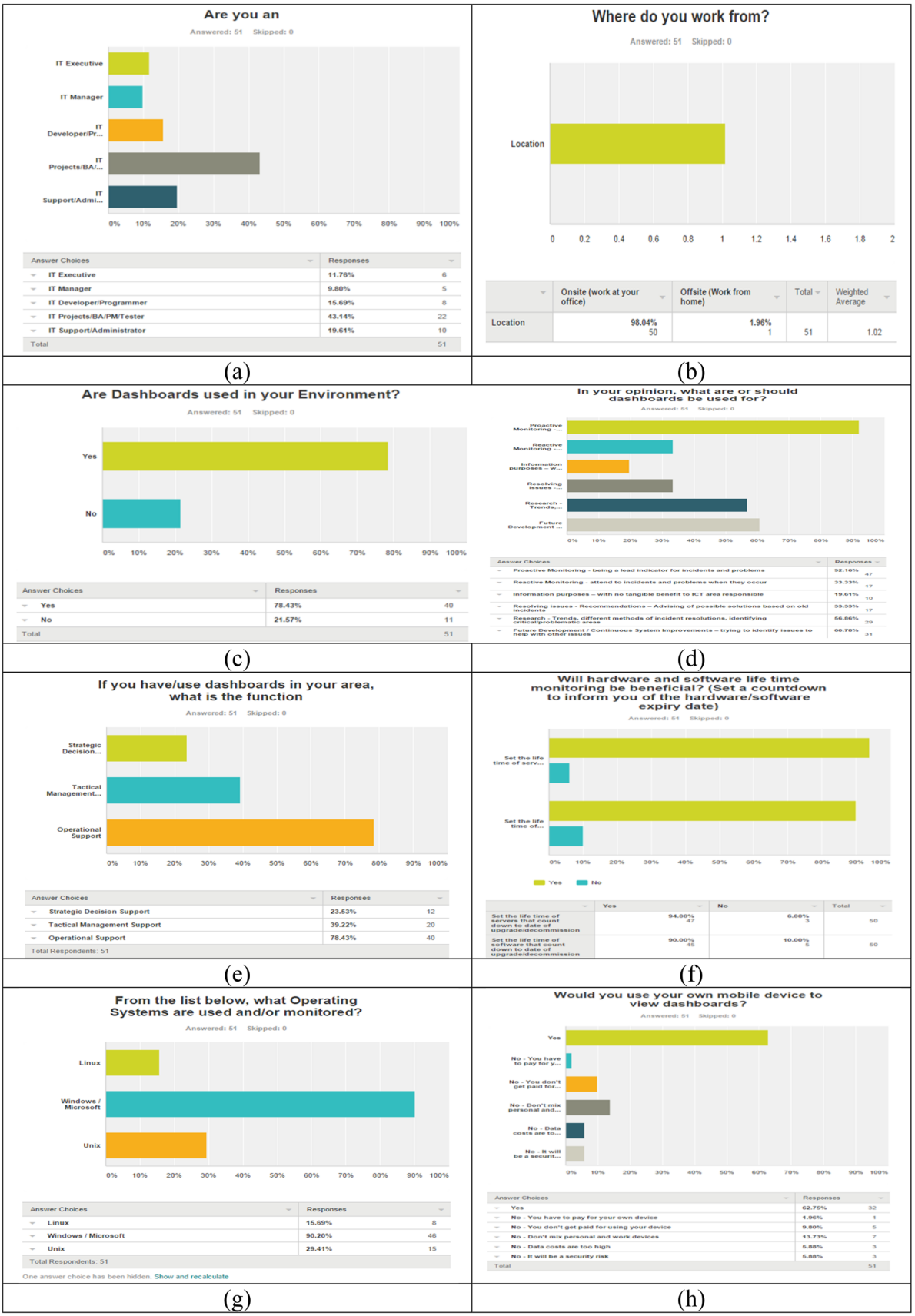


Fig. 5 12-Participants survey questions with their outcomes (SurveyMonkey Inc. 2015)

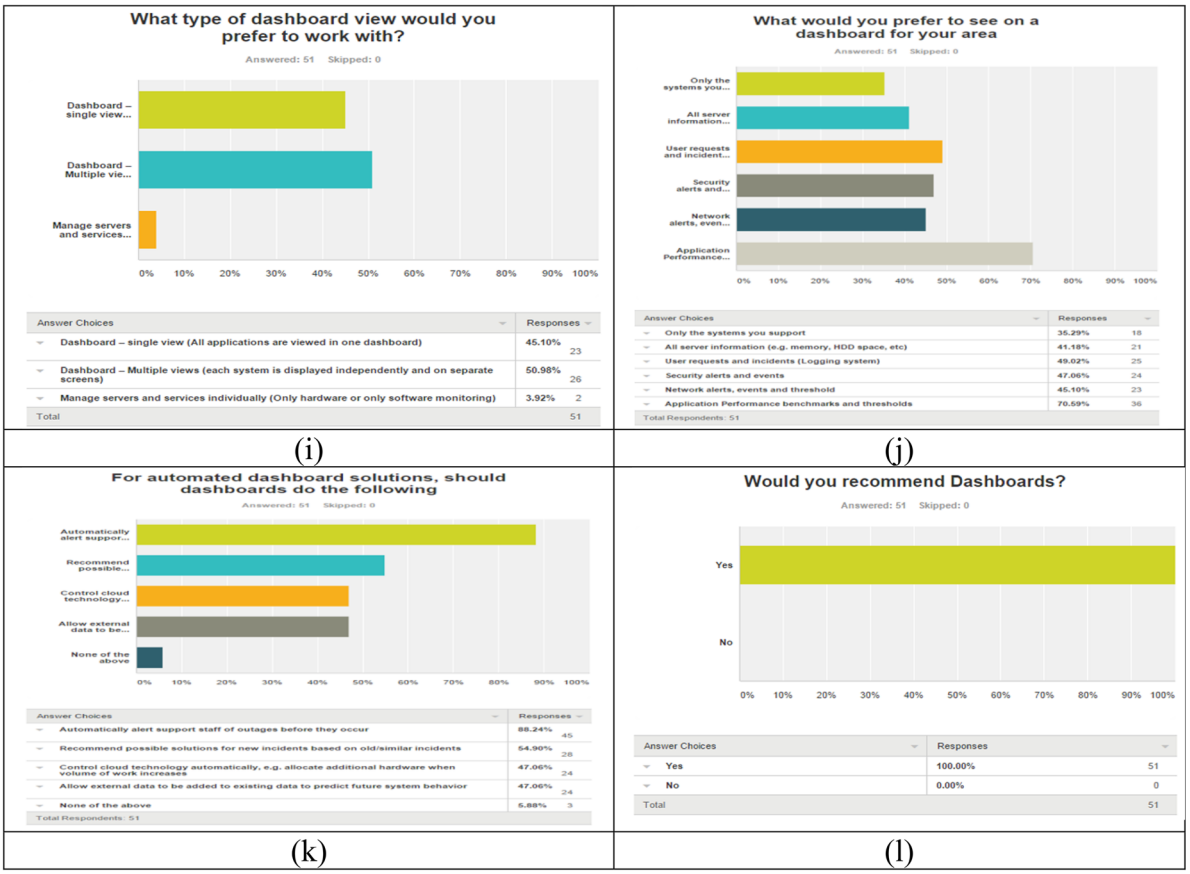


Fig. 5 continued

Apart from only looking at each system, patterns can be shown if System A has a high number of database processors, it will impact System D's user response times. In this case, we could see what are the patterns that will most likely cause issues across various systems. This also shows how interconnected all systems are and the impact the systems have on each other. The setup of dashboard fields shown in Table 4.

3.3 Prescriptive dashboards

Big data and data analytics is explained as using the formal analysis to find patterns, make predictions and recommend decisions. An analytics value chain is as follows; *"Curate → Summarise → Describe → Predict → Prescribe"* (Laskey 2013). When dealing with businesses, their expectations can be quite demanding in the sense that they would require incidents or problems to be resolved immediately. Prescriptive analytics is a combination of descriptive and predictive analytics, i.e. (Laskey 2013). Frame the problem, Identify candidate actions, Predict consequences of actions, Assess the value of consequences, and Suggest the highest value actions. This is important because systems and applications are vital that the team setting up the benchmarks and trends understands the business volumes in terms of workload and how it has been increasing or decreasing, the peak times, e.g. holiday seasons, weekdays (beginning of week vs end of the week), month-end differences, etc. Once the dashboard is up and running, the benefit now is the availability of predictive and prescriptive data to continuously improve the business experience. Prescriptive dashboards will now be activated and use the information from the dashboard to report on real-time issues/concerns. The recommended decisions that are delivered promptly are done through prescriptive analytics which makes use of advanced data-driven decision-making techniques (Hamilton and Koch 2015). Existing analytical tools must be maintained and additional tools can be introduced in the transition of prescriptive analytics, i.e. social media, unstructured data, etc. (Hamilton and Koch 2015).The data flow diagram (DFD) (Fig. 7) below will provide an understanding of how it works.

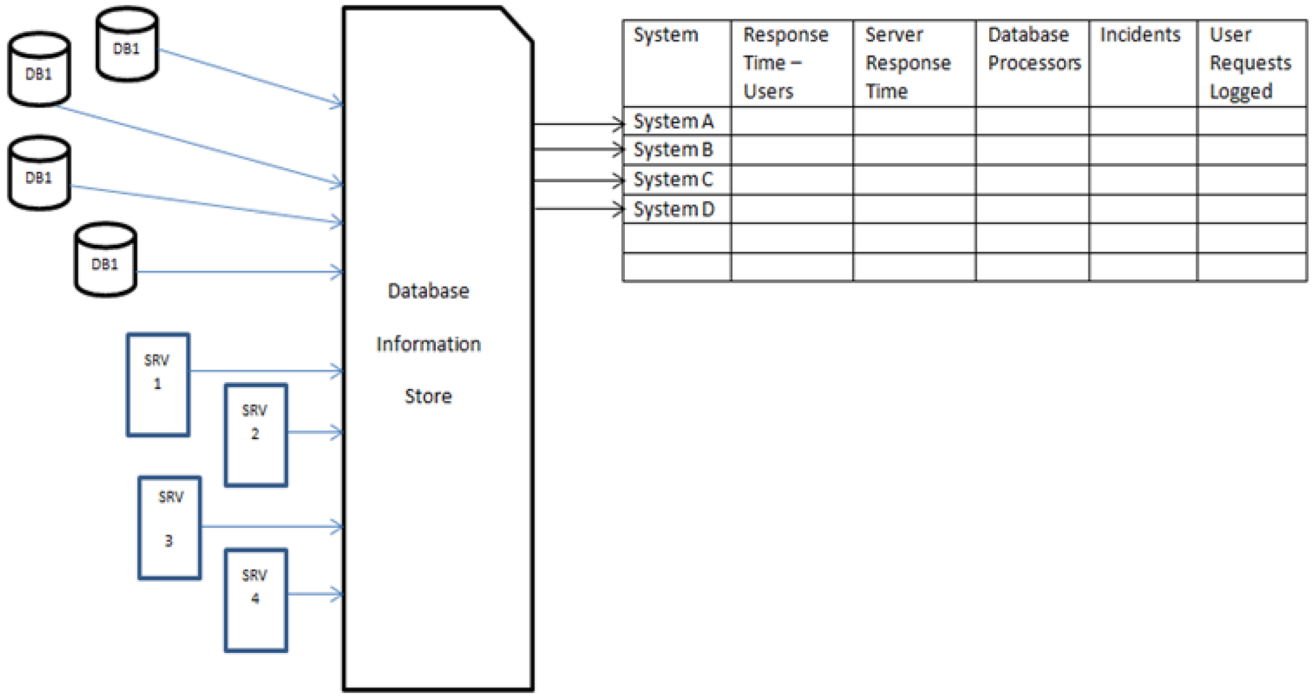


Fig. 6 Central Database Information Store

4 Implementation (realization)

The thought behind this design was more related to the production environment in which we aim to deliver faster service and uptime of systems. The troubleshooting process, which includes, time, understanding of the problem, investigation, and involvement of additional teams, has become quite challenging when there are limited resources, high business users (staff) turnover, and additional workload. In ICT departments there are multiple teams and monitoring systems and this makes it quite difficult when working with large teams. The focus around the prescriptive dashboard takes us through the support from an ICT perspective to business expectations, i.e. keeping systems up and minimal or no downtime. This also includes providing the speed for the business users to meet clients' Service Level Agreements and be competitive. The Dashboard will assist ICT support staff to be proactive and resolve issues faster and where it reoccurs, they will be able to resolve faster each time or improve the system.The initial plan was to run pass 5 IT people in various roles, each providing input around the design. Figure 8 below shows the input format. The design was initially to have the monitoring information updated directly into excel however through the process it was discovered that the data needs to be extracted into a central independent database that will not impact the day-to-day operations of the business. The central data store in Fig. 9 was purposely chosen as the information must be stored so that it can be used for reporting, trend analysis, and patterns. The excel extracts can get the information every 15 s (or the desired frequency) and be updated and/or viewed in excel. This means the excel spreadsheet will be updated continuously.

Once it had been identified that the central data store would be what we are looking for, it now created an opportunity to introduce additional information to the existing dashboard e.g. add incidents and user requests and have them stored which will improve monitoring of ICT systems. The current dashboard is showing all consolidated information based on the environment being monitored, i.e. in this instance a production support environment. This was still standard way of monitoring.CDIS creates a clear view of what is happening in the environment and of the complete system, it was necessary to start using the information to do more.

4.1 Predictive and prescriptive analytics

Models can be built to see how the data works and then you can predict. Prescriptive data prescribes an action which the decision-maker can act by using the information on. Descriptive and predictive analytics both relate to prescriptive analytics. Prescriptive analytics can mitigate risk and provide better decision options (Rouse 2012). The advancement of technology such as mathematical algorithms and machine learning has made prescriptive analytics possible. The speed of computing is also a benefit for prescriptive analytics. Root cause analysis and data mining

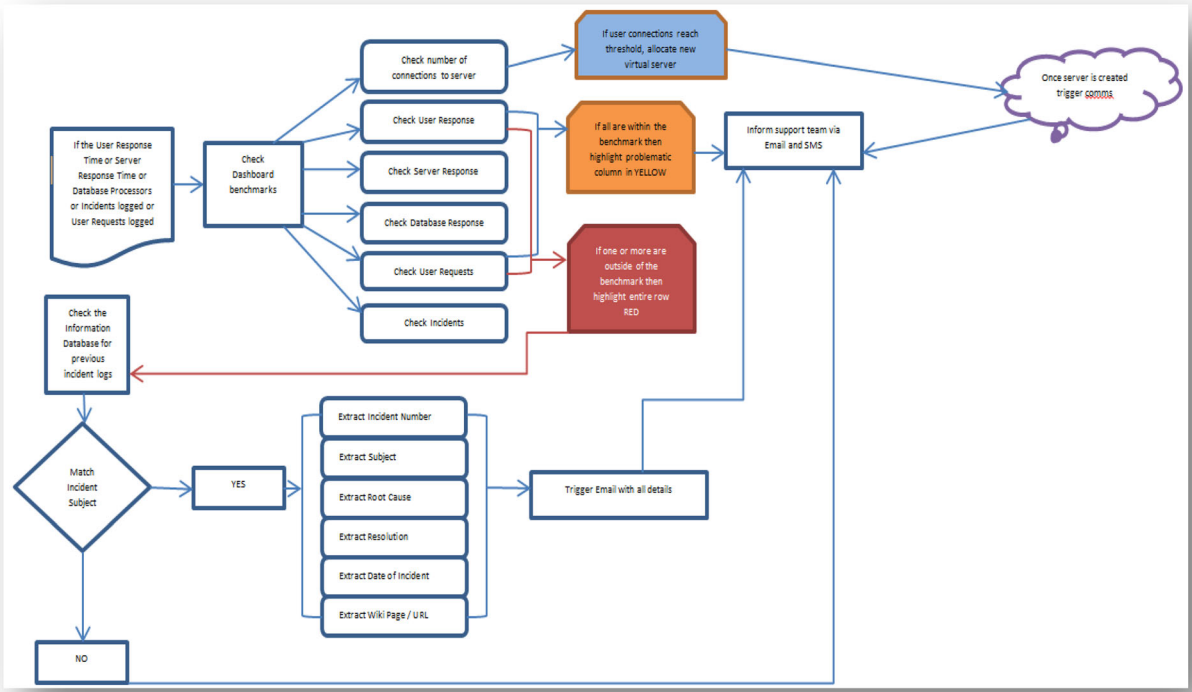
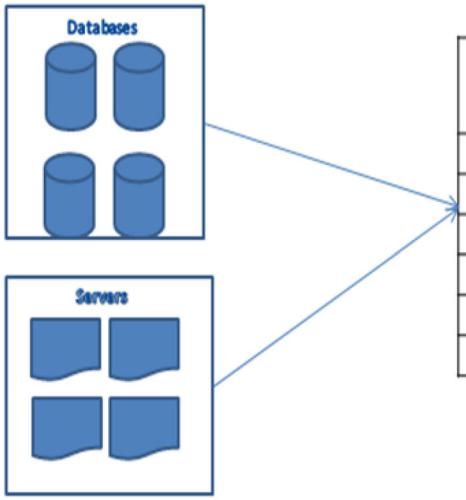


Fig. 7 Dataflow of automated monitoring and alerts

Table 4 Setup of dashboard fields

	Syatem A	Syatem B	Syatem C	Syatem D	
Database processors	CPU usage from Oracle and SQL can be extracted every 15 s to provide real time stats				All stats must be exported to the central database and stored for history purposes
Server	A script can be written to extract memory, processor and hard disk information				
User response time	Application pages for web based applications must monitored when moving through pages				
Number of connections to server	The application serves must have a count of the active connections to the servers for each application				
Server response time	Server response times must be set using a ping program				
Incidents—logging system	The logged requests need yo be setup with default subject options for standardisation purposes				
User request—logging system	The logged incidents need to be setup with default subject options for standardisation purposes				



System	Response Time – Users	Server Response Time	Database Processors	Incidents	User Requests Logged
System A					
System B					
System C					
System D					

Fig. 8 The first method to import information

techniques form part of data-driven decision-making which is required by businesses in the hyper-competitive markets (Green 2015). Prescriptive dashboards provide information that will give the business the best decisions to improve the business e.g. profitability, customer improvement, efficiency, etc. Van Rijmenam quoted Gartner, "prescriptive analytics will take another 5–10 years before it is used across all businesses." Google's self-driving car makes use of prescriptive analytics, knowing the best route is one of its features (Van Rijmenam 2014). Prescriptive analytics allows for automated decision making however the decision model must be setup and decided upon a priori (Vahn 2014).Where predictive data can be used to forecast based on previous information, the idea of the production support dashboard can look at trends based on previous system outages and inconsistencies of the system tables. Prescriptive will be to take the information in the system tables and work out trends based on previous issues and errors. It will look into what was common between the incidents, user requests, database and servers, based on this, the system will work out the closest result based on the benchmarks and incidents. The incidents will be a critical part of the prescription as this will hold information such as the root cause (of all incidents) and resolution (of all incidents). The setup must make these fields mandatory and the incident cannot be closed out with this.

Bill Gates mentioned that the reason communication between people is still a problem is because devices control communication. He uses an example of contact numbers, one you call from and then you request the person to call you back on a mobile number and your office number is different from your home number (Galli 2007). This paper has shown how integrated systems need to be monitored and through current information, the dashboard could learn trends and see patterns of what could happen and what the resolution can be. It is about bringing systems together, they are interconnected whichever way we look at it. Getting these systems to work with or without people is the output that is needed to be achieved. Formula One portrays all of the above information in a great way in that the pit crew and driver work together in monitoring the vehicle's performance, fuel consumption, tyre checks and use of radios to communicate (Ataccama Tech Corner Archive 2012). Formula one is not just about racing but continuous improvement (Scott 2013). Formula one looks at environmental factors, e.g. fuel efficiency. Also, McLaren has helped companies like Glaxo SmithKline improve their toothpaste factory by making it more efficient and reduce power consumption at data centers. The collection of facts while the car is racing helps with speed, reliability, and safety. Decisions can be made while the car is on the track and not have to wait for after the race to do analysis. Communication is filtered and only the race engineer can contact the driver while on the race track (Kemppi Pro-News 2009). These are: Monitoring is part of F1 race performance, Reports provide plain facts, and the driver gets instructions from the trackside. Like formula one, dashboards can assist by providing prescriptive information to the support staff, automatically. Decisions and continuous improvements can be made automatically and can provide continuous benefits to the business.

5 Results and evaluation

The dashboard and prescriptions for the ICT production support staff were done as a one-on-one meeting and a high-level explanation was given to the team members who

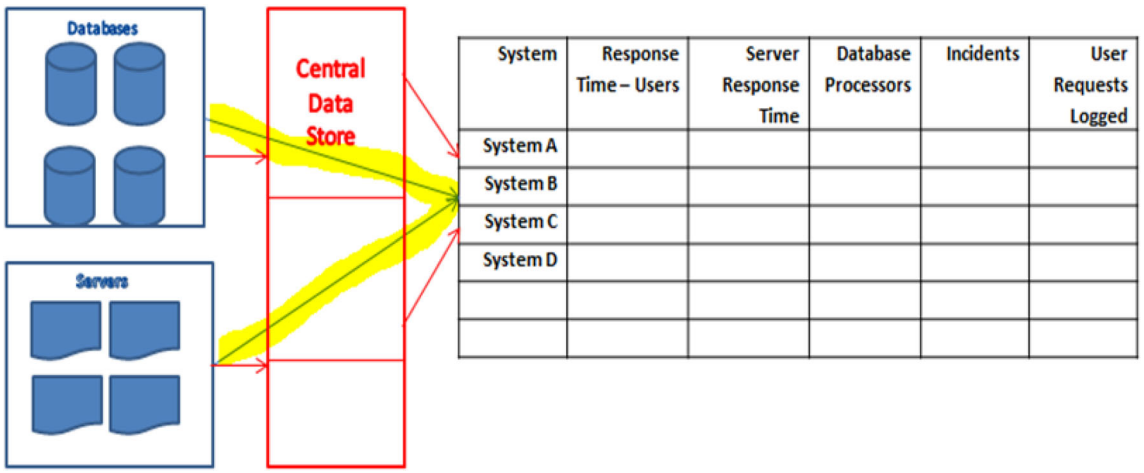


Fig. 9 Central Data Information Store—implementation decision

included application support, technical support, architecture and management, all within ICT. The feedback is discussed here.

5.1 Feedback session

The proposed prescriptive dashboard flow diagram (Fig. 10) will become a complementary and effective way of working for the ICT support staff. This flow diagram is used to assist with the current incidents and problems experienced in our ICT support environment. The flow diagram shows how the flow of the information works. Positive feedback was received from the individuals. The single view of the dashboard will display information such as user requests and incidents that will highlight what users are experiencing when using the system and incidents that are impacting the productivity of business processes. BYOD devices form part of the method as ICT support staff is not always in front of their computers or dashboards but they always have their mobile devices. Capacity will be created across the support team and this will give more time for permanent resolutions and focus on incidents. This will also help teams think analytically, improve problem-solving skills and create a powerful knowledge repository. The idea behind the prescriptive dashboard should not stop at production support but can also help in the project and learning and development departments. Staff appraisals could also be directly linked to the prescriptive dashboard concept. The overall feedback has been positive from the individuals that viewed the data flow diagram. Additional monitoring tools were mentioned in the session that works similarly to the prescriptive dashboard. A few concerns were raised about the accuracy of information captured particularly with incidents, i.e. (a) A category field should be included in the incident template to provide more accuracy in terms of prescriptive dashboards, (b) Does the current environment allow for this type of setup is also a concern for application support?, (c) Does the prescriptive dashboard align to governance, risk and security was also raised in the feedback session?, (d) When building such a tool, security must be the highest priority. One of the highlights identified is that the people, who viewed the DFD, had started looking at other developments where this idea could be beneficial. This showed good interest and expansion to the prototype. All individuals confirmed that the prototype will work if it is implemented. The feedback creates a positive view if the opportunity arises to implement a prescriptive dashboard in any organization and integrate with multiple systems. The approach was to understand from the survey how this flow diagram can be put together and meet the needs of monitoring, early warning alerts and prescribing solutions for ICT support staff to resolve problems and incidents as fast as possible. The feedback session was good in the sense that the participants looked at how this solution would benefit the ICT environment and also a business. They also had opinions on how this concept can be expanded outside of the production support environment.

5.2 Application and limitations

The applications and limitations have been discussed here: (a) Academic perspective—Monitoring has been a key component in terms of supporting environments in an ICT production support space, Not knowing much about dashboards has been a limitation in that we have had to understand and learn about dashboards, Having to bring this figure into a production environment will require a lot of base work and frustration if the information required has not been stored or captured correctly when setting up the baseline, ICT teams will have to work together which will be challenging because all of the requirements differ and

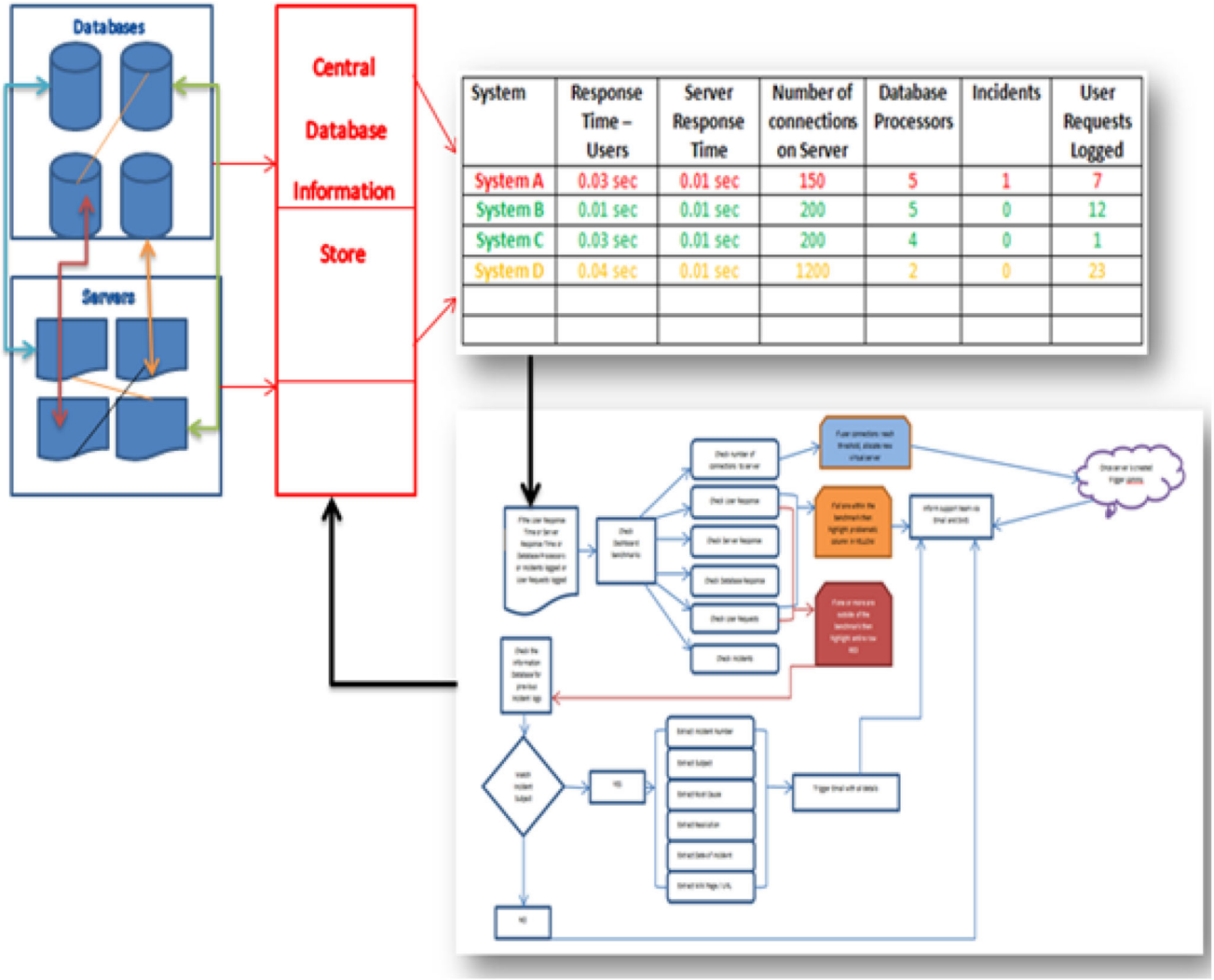


Fig. 10 A cycle of dashboard prescriptions and re-enter of data into the CDIS

also because teams do not want to utilize existing knowledge. (b) Business perspective—In terms of business, it is a challenge to change them to use this type of dashboard, The limitation is the mindset of the business users to accept this type of dashboard, However at this stage, there is no plan to accommodate the business into the prescriptive dashboard. This can be a future development and the business must be at a mature level to deal with this.

6 Conclusion

The paper presents the information setup and captured for various systems that need to be monitored and contribute to the prescriptive dashboard. A twelve question survey (with graphs and mainly ICT staff participation) gives insight into the use of prescriptive dashboards and technologies used. This feedback helps in the design of the prescriptive dashboard and brings the dashboard in use with the various mobile technologies and cloud technology. There are challenges in terms of the limitations but without a doubt, there could be potential ways of using this prescriptive dashboard in many different areas that just ICT. Some useful recommendations for future works are mentioned here: SLA's can be more accurate in terms of resolution time, Business units can be split out accordingly because the dashboard can zone in on specific systems and set the thresholds accordingly, Projects can be monitored and aligned with system outages before implementation, Integration with companies can assist with prescriptive information for dashboards, Include videos, images, sounds (from predictive to prescriptive analytics), Organizational clock speed will be monitor if resolutions are faster allowing business more uptime to meet deadlines and fewer outages, Personalization of dashboards, Business requests can be automatically answered based on previous

resolutions which can allow for each unique system to build a knowledge database based on common queries and resolutions, Display and connectivity to the company's network to view dashboards include views and connectivity for simple solutions.

Declaration

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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