UNDERSTANDING SYSTEM ADMINISTRATORS' WORK PRACTICES AND THE ROLE FOR ENHANCED VISUALIZATIONS IN THEIR TOOLS

by

Jeevitha Mahendiran

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DEDICATION

I dedicate this thesis to "My Dad, Mahendiran Murugan, who stood by me to live my dream" & "My Mom, Parimala Mahendiran, who always kept me grounded".

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ABSTRACT

Visualization can be an effective way to explore and understand abstract data. Due to the rapidly changing technological environment of sys admin work and the scale of data involved, enhanced visualizations might provide benefit in this domain; however, despite research efforts, to-date the tools for system administrators (sys admins) minimally employ the use of interactivity in models and provide limited visualizations in tools. This may be because sys admins have a culture of command-line interface (CLI) use that is at odds to the graphical user interface (GUI) that accompanies most tools that incorporate interactive visualizations. We designed a two phase study to gain a better understanding about the work of sys admins, their current tool environment, their preferences for CLI and GUI based tools, and their perspective about how the inclusion of interactive visualizations in tools and system models might enhance their routines. The first phase of contextual inquiries and semi-structured interviews with 37 participants gave us a rich understanding of system admin work practices and their desired functionality for future tools. In the second phase, an on-line survey with 331 sys admins allowed us to generalize our findings. Based on our research, we generated recommendations for desired tool features in each of the sub-domains of sys admin work (i.e., network, virtualization etc.,). We also conducted an analysis of the type of visualizations that could be implemented in future tools to support the challenging nature of sys admin work.

LIST OF ABBREVIATIONS USED

Sys Admin – System Administrator

CLI – Command Line Interface

GUI – Graphical User Interface

ITSM – Information Technology Security Management

UBC – University of British Columbia

IT – Informational Technology

CCGC – Cyber Command Gauge Cluster

GEKA – Graphically Enhanced Keyboard Accelerator

LISA – Large Installation System Administration

USENIX – UNIX Users Group

HCI – Human Computer Interaction

CHIMIT (Computer Human Interaction for Management of Information Technology)

CI – Contextual Inquiry

KSA – Kingdom of Saudi Arabia

IT Consulting – Information Technology Consulting

Tech Support – Technical Support

SPSS – Statistical Product and Service Solutions

LOPSA – League of Professional System Administrators

IT Infrastructure – Information Technology Infrastructure

RT – Request Tracker

DCSI – Dalhousie Computer Science In-House Conference

WiTS – Women in Technology Society

CS – Computer Science

GEM – Graphics and Experiential Media

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CHAPTER 1 INTRODUCTION

System administrators (sys admins) are considered to be the backbone of every organization, working behind the scenes to configure, maintain, and troubleshoot the computer infrastructure to keep it available and secure. The workspace of sys admins is complex and ever changing in response to technical advances and the evolution of threats [26]; it is necessary to design effective tools to assist the sys admins in handling their work with ease. Prior research has found that the existing tools often do not assist sys admins efficiently and effectively in their daily routines [1, 4, 5,10].

One of the goals of our research is to better understand how the incorporation of visualizations and system models could help system admins in their work. To understand the actual needs of sys admins, we need to understand their routines and goals, the current models with which they work, and the software they use to perform their tasks. In particular, we want to learn about their awareness of the state of the system, its configuration, and the troubleshooting mechanisms involved in their daily routines. We also want to ascertain the problems faced in their work and the features that the software does not currently provide.

We conducted a two-phase research process. In the first phase, a series of contextual inquiries and semi-structured interviews with 37 sys admins explored our research questions. In the second phase, we designed an online survey with sys admins from various IT domains (e.g., database, network, security) to generalize our initial findings and to learn in what ways the addition of models and visualizations could help them perform their tasks. In total 331 sys admins have taken our survey. Our results highlight the difficulties that participants have with the tools, the opportunities for visualization in each domain, and suggest how visualizations could support sys admins in their work. The results also reveal some of their concerns about how the integration of visualizations may lead to vulnerabilities of the system and decrease in efficiency, particularly for remote applications.

1.1 Gaps in Existing Research

We identified six main aspects that are lacking in the existing sys admin research, which were necessary for us to investigate. The aspects include information regarding sys admin desired tool features, the current state of visualization, the research focus on network visualization; in-depth information about different domains of sys admin work and the tools used; solutions or recommendations to solve the reported issues through the presence of visualization; the reasons for the low adoption of visualization and why it is downplayed in this domain. As we discuss each part, we identify how our two-phase research was designed to fill the existing gaps.

1.1.1 Desired Tool Features

Prior research in the field of sys admin is mostly focused on their work routine [1, 2, 5, 32], but did not focus as much on the desired tool features. We designed the contextual inquiries, semi-structured interviews, and online survey to understand more than just their routine. We also tried to gather information regarding the desired tool features so that we could frame a recommendation list for each domain as an outcome of the study. The recommendation list might benefit the designers while designing a tool for a particular domain of sys admin tool (Chapter 6).

1.1.2 Exploring Current State of Visualization in Tools

The existing research did not provide a clear picture about the current state of art in the tools used by sys admin. It mostly focuses on solutions suggested by the researchers in their research work and does not provide information about the ones that are actually present in the tools used by sys admins in their daily routine (Chapter 2). We wanted to explore the existing tools to find the level of visualization available and to know the hindrances in the current tool visualizations in each domain of work (Chapter 4).

1.1.3 Focus of Visualization in Existing Research

The existing research that focused on visualization for sys admin tool was mostly restricted to the domain of networking tools [29, 33]. Considering the existing challenge of restriction of visualization and the debate of accepting GUI in sys admin tools [31], we

focused on looking for visualization opportunities available in other sys admin domains of work. When we designed the study we were very particular to explore the visualization gaps in different domains existing in sys admin work.

1.1.4 Scope for Visualization

The existing literature lacks a lot in motivating the need for visualization in this sys admin research. As explained in section 1.1.2 the focus on visualizations is restricted to certain domains only. So our main goal was to find solutions for the existing problems reported in each domain of sys admin work through visualization. We also wanted to know the need for and potential acceptance of visual based solutions. When we learned of any issues during the studies, we tried to suggest or tried to ask if any visualization solutions could help them in solving the problem (Chapter 4).

1.1.5 Focus on Gathering Information about Different Domains

The researches in the field of sys admin are mostly focused on the work routine of general sys admin work, with some focus on security and network admins [5, 25, 26, 27, 29, 32, 33, 38, 39, 40, 41]. Beyond these three domains the existing research does not explore the routines or the needs of other domains of sys admin work. When we designed the study, we were very careful to attain domain breadth and as we wanted to explore the different domains existing in sys admin work. As an outcome, we learned a lot about each domain of sys admin work (Chapters 4 and 5).

1.1.6 The Reasons Why Visualization is Still Downplayed in this Domain of Work

The existing research does not provide a clear explanation for why the acceptance for visualization is still low in sys admin tools. The only reason that is highlighted is the acceptance of CLI vs GUI and even in that case the reasons are not clear yet. Considering the existing challenges, in our research we focused on understanding why visualizations are still downplayed in this domain and explore the reasons that hinder adoption. The understanding is required so we can mitigate the risks to acceptance when we provide recommendations and guidelines at the end of the research (Chapter 7).

1.2 CONTRIBUTION

We made five major contributions in this research:

1) We analyzed a set of tool features and characteristics that might enhance sys admins' work routine in the future. For this purpose, we conducted a series of contextual inquiries, semi-structured interviews and an online survey to gather the tool features and characteristics that should be considered while designing a tool for particular domains of sys admin work.
2) We explored the current state of visualizations and analyzed the visualization opportunity available in different domains of sys admin work (Chapter 4 & 5). This contribution can inform visualization researchers and help them focus on finding innovative solutions to the existing problems.
3) We expanded knowledge of sys admin work (Chapter 4 & 5). In particular, we focused beyond the network domain in the aspect of visualizations.
4) We identified issues with the lack of support in the decision making process of choosing a tool. We were able to suggest improvements to this process that this could help several inventory lists to update and satisfy the needs of the clients globally and also help tool vendors in the marketing of tools.
5) We analyzed the reasons for why the visualizations are still downplayed in current sys admin tools and their acceptance of GUI.

1.3 OVERVIEW OF THE THESIS

This dissertation is divided into nine chapters. The remaining chapters are as follows:
Chapter 2, background and related work provides an understanding about sys admin work routine, how visualization has been perceived by them and the types of visualization and applications of visualization. It then discusses the ongoing visualization research in the sys admin field. This chapter concludes with a summary highlighting the gaps in this area of research.
Chapter 3, Methodology provides detailed information about the research objectives, research questions, and research approach. It then presents the phase 1 and phase 2-study protocol, study instruments, data collection, data analysis, recruitment, study instruments

and refinement process, and participants. This chapter concludes with a discussion of participants' risk mitigation.

Chapter 4, Phase 1 results and discussion provides detailed information about the results obtained from phase 1 of the research. The results are categorized under each domain of sys admin work. It then describes the participant's prioritization of work, choice of tools, and usage of models in the sys admin work. This chapter concludes with a summary of the findings and limitations in the study.

Chapter 5, Phase 2 results and discussion provides detailed information about the results obtained from phase 2 the online survey. The results are categorized under each domain of sys admin work. It concludes with a summary of findings and limitations in the study.

Chapter 6, Recommendations of desired tools and guidelines provides a list of suggestions that can be imparted for the benefit of sys admin work.

Chapter 7, Visualization opportunity provides detailed information about the visualization opportunities available in each domain of sys admin work

Chapter 8, Limitations and challenges discusses about the limitations and challenges faced while conducting this research.

Chapter 9, Future work and conclusion provides a brief overview about the possible future work that can be carried out on basis of this research, contribution and concludes with a summary of the key findings in this research.

CHAPTER 2 BACKGROUND WORK AND LITERATURE REVIEW

In this chapter, we provide our understanding about sys admin work routine (Section 2.1), from the literature and discuss their acceptance of CLI and GUI interfaces. Then we define how we have perceived visualization and different types of visualization that might be a prospective solution to the problem encountered by sys admins' in their daily routine (Section 2.2). We will later address visualizations in the upcoming chapters based on these descriptions. Finally, we discuss the available research in visualization for sys admins and provide an overview about the existing visual based solutions (Section 2.3), and conclude with a summary highlighting the gaps in this area of research (Section 2.4).

2.1 WORK ROUTINE OF SYS ADMINS

In general, prior researches [1,2,3,4] has identified that sys admins are responsible for the installation and configuration management process and the maintenance of systems hardware, software, and related infrastructure. They also provide support to maintain operating systems, and storing backups in the organization. Troubleshooting and resolving technical issues related to IT Infrastructure is a key part of system administration. Interacting with the end users, communicating with team members, and reporting to management is also an integral part of their work. The security administrators also share similar work routine as stated above but with respect to their domain [5].

It has been found that the work complexity of sys admins and their work practices are interconnected with type of organization, the size of organization and the type of data they deal with [5,6].

Barrett et al. [6] conducted an in-depth study of sys admins, who they considered to be a critical group of highly specialized computer users. Their study consisted of surveys, a diary study, and 12 interviews with sys admins, managers, team leads, and other stakeholders. They found that the tools that sys admins used, whether graphical user interface (GUI) or command-line interface (CLI), exhibited deficiencies in supporting the work practices of sys admins. As a result, sys admins often required additional

information, tool support, expertise, or had to build their own tools before being able to complete their tasks.

Takayama et al. [31] conducted a survey of sys admins; trust issues were found to be an underlying factor of a sys admin's interface choice. They recommended that researchers examine GUI and CLI effectiveness from the standpoint of trust in order to best meet the needs of sys admins.

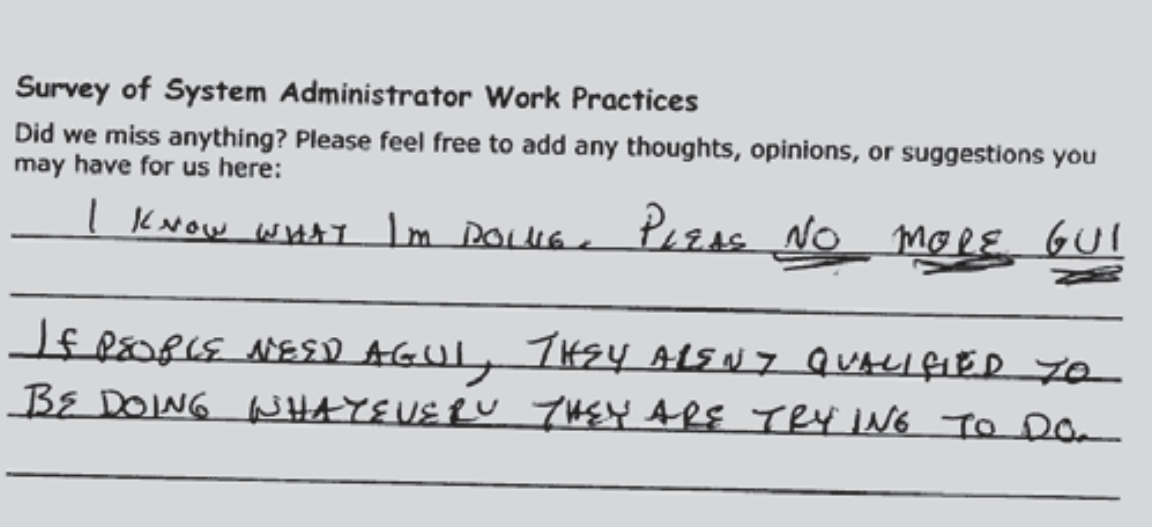

Figure 2.1 An administrator's response to a survey: "I know what I'm doing. Pleas [sic] NO MORE GUI" [31]

Figure 2.1 displays how GUI is perceived by sys admin and did comparative qualitative judgments on CLIs and GUIs based on questions concerned with "perceived speed, ease of use, reliability, robustness, accuracy, trustworthiness, and likeability"[31]. The ongoing debate about the GUI vs command line in system administration tools and their acceptance towards GUI is highlighted in Thompson et al. [30].

Haber et al. [1] examined whether the tools used by sys admins helped them in their work routine. They found sys admins' tools must better incorporate the variety of roles and challenges faced in risk and complexity of sys admins' tasks. They believe that the tool deficiencies identified were due to a lack of understanding about administration work by tool developers. Before developing a tool the developers should be aware of the complexity, the scale that they would be addressing, threats faced by the sys admins etc.,

A survey conducted by Velasquez et al. [4] of 125 sys admins analyzed data using structural data modeling techniques, the results confirmed that the sys admins have unique systems to work with compared to other computer users. Their research also

disclosed four key tool features that should be kept in mind while designing tools for sys admins - accuracy, verification, reliability, and credibility.

Haber et al. [2] conducted a study about how the work of sys admins can be better supported by observing sys admins at their workspace. The results revealed that a single tool couldn't easily meet all the needs of the diversity of sys admins. Better collaboration support can help problems encountered by the sys admins in communicating and establishing shared context. One solution proposed to address the issue of losing information is to enable a persistent storage of communication. Hrebec et al. [3] conducted empirical research on the mental models and situation awareness of sys admins. Their study revealed that sys admins rely greatly on support from manufacturers and third parties regarding unknown issues with hardware.

One key set of research about sys admin work in the IT security domain is that from the HOT Admin project at UBC. Researchers conducted 36 interviews with information technology security management (ITSM) practitioners from 17 organizations and performed several thematic analyses [14, 25, 26, 27]. Botta et al. [25] focused on the organizational processes involved in ITSM and described the various concepts related to cues and norms including the ITSM breakdowns and Jaferian et al. [47] recommend employing both the ITSM and Nielsen's heuristics [42, 43, 44, 45, 46] during evaluation of ITSM tools.

Werlinger et al. [32] identified the main challenges that IT security practitioners face in their organizations. Gagne et al. [26] revealed that security professional's work in a more complex environment than other IT professionals; and in order to balance their routine, they have to incorporate several factors such as security, policies etc. Jaferian et al. [27] framed a set of guidelines to be considered while developing ITSM tools, based upon guidelines and recommendations related to ITSM tools from the literature as well as from the Hot Admin analysis. They also identified the relationship between the guidelines and the challenges in ITSM, to allow developers to determine the importance of each guideline proposed.

2.2 VISUALIZATION

Visualization refers to the visual representation of data or information via sketch, diagram, charts, maps, images, and objects [8]. The types of visualization that we would like to refer in this research are data visualization, and informational visualization. The applications of visualization that we would like to refer in this research are knowledge visualization, strategy visualization, concept visualization, product visualization, system visualization, process visualization, structure visualization, and visual analytics. Every visualization technique appears to have several broad definitions in the literature. Therefore, we have briefly explained how we perceived the visualization techniques and visualization applications for this research. Figure 2.2 displays the periodic table for visualization methods and highlights the important types of visualization with description. Lengler et al. [7] found approximately 160 visual methods and then they reduced to 100 visual methods based on "general context based on graphic format employed, typical content type, application context, scope, difficulty of their application, originating discipline, vicinity over overlaps to other visual methods".

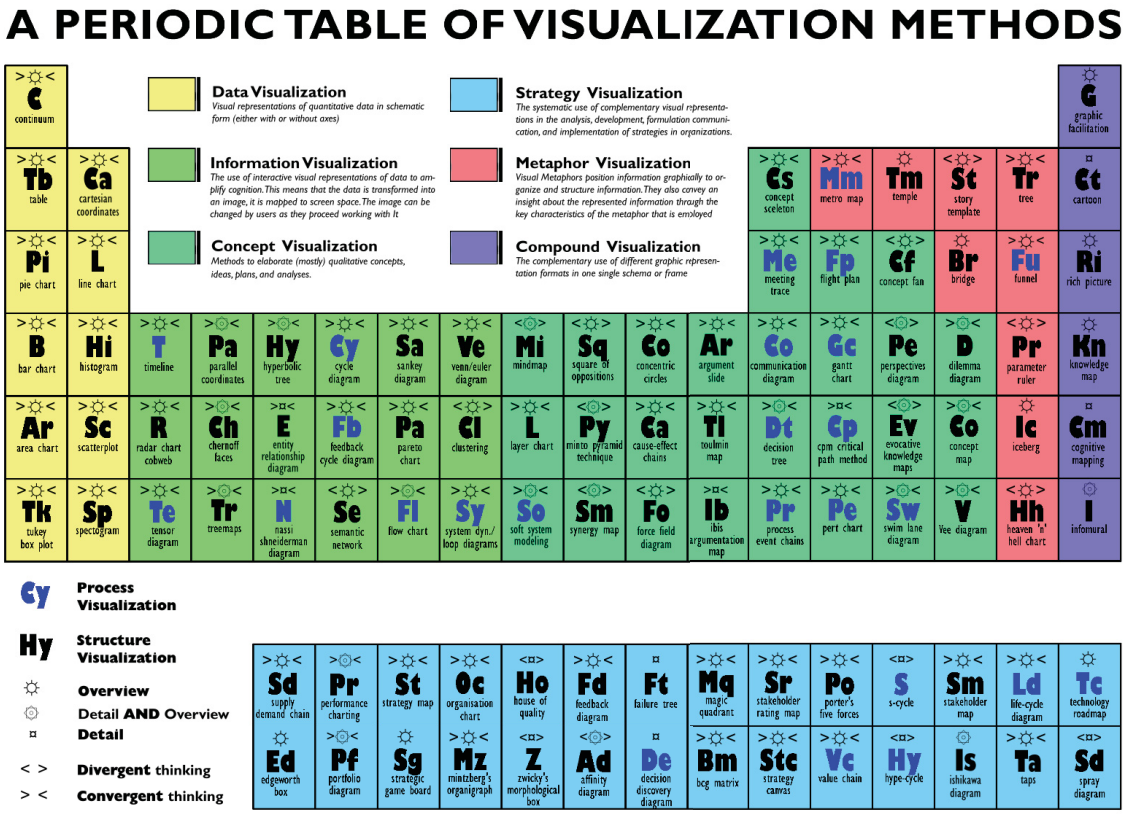

Figure 2.2 A periodic table for visualization Methods [7]

From the existing literature for visualization techniques, we have selected a few that would be relevant to solve the existing issues in sys admin work and defined according to our perception that can be implied with sys admin work.

2.2.1 Data Visualization

Data visualization refers to the visual representation of quantitative data. The main motive of data visualization is to clearly and effectively communicate information through graphical representation. For example the standard data visualization formats includes charts, graphs with or without axes, which provides an overview of the given data [7, 9, 10].

2.2.2 Information Visualization

Informational visualization refers to the visual representation that allows the user to see, explore and understand large amount of information with ease [11, 12]. They use "interactive visualizations of data to amplify cognition" [7] such as tree maps.

2.3 APPLICATIONS OF VISUALIZATION

The applications of visualization that would be a prospective visualization for sys admin tools are briefed in the upcoming sections.

2.3.1 Knowledge Visualization

Knowledge visualization refers to the transfer of processed information to impart knowledge [8, 13]. The transfer of knowledge is the key process of knowledge visualization. The knowledge visualization involves information visualization, but it mainly focuses on categorizing what is the relevant information required to progress the process [14, 15].

2.3.2 Strategy Visualization

Strategy visualization refers to a visually represented procedure. This visualization technique is mostly used to clearly communicate and provide clarity in understanding the steps that should be followed to develop or implement a project. The strategy visualization can be an effective way to explain the implementation of policies clearly to every employees in an organization [7].

2.3.3 Concept Visualization

Concept visualization refers to a visual representation that summarizes the ideas, plans, and analysis. Concept visualizations are often used to get a project approved. They give a brief insight of the plan and the analysis to justify that the plan will be successful. Concept visualization is similar to strategy visualization, but the concept visualization process happens before the strategy is made and their higher degree of visual complexity sets them apart. For example, if a company is coming up with X project, a brief introduction of the new idea, the plan to implement it, and why the plan will succeed would be found in the concept visualization while visual representation to improve

analysis, development, and implementation of strategies would be found in the strategy visualization [7].

2.3.4 Product Visualization

Product visualization refers to the visual information that helps in exploring the product. It provides a proper evaluation of how it fit into an existing work routine. It also helps in comparing the difference between the products, which in turn assists in decision, making process that occurs when purchasing a product [18]. The product referred to can either be a software, hardware, or an embedded product. For example, if a person is about to buy a shirt from an online store, we can visualize how he fits in the cloth and then compare it with other available options in the store [18].

Software visualization

Software visualization refers to the visual representation of the software systems based on their characteristics or features available in the software. It displays a two-dimensional or a three dimensional information about the software when a specific action would be selected [20].

Hardware visualization

Hardware visualization refers to the visual representation of the hardware systems showcasing the peripherals available in the hardware. It displays either a two-dimensional or a three dimensional information about the hardware to provide a clear view of the parts available and how it reacts when actions performed [19].

2.3.5 System Visualization

System visualization refers to the visual representation of the state of the system. It provides detailed information regarding the connectivity of the system, software installed, and mainly the ongoing process in the system [19]. System visualization helps to provide a detailed understanding of the state of the system from which the user can schedule the rest of work. For example, the X system consists of 21software processes, 5 databases in which 3 has backup. The system is connected to a Y network.

2.3.6 Process Visualization

Process visualization refers to the visual representation "either stepwise cyclical in time and/or continuous sequential" of a flow pattern or predicting or showcasing how a particular process will proceed or proceeding [7]. It is very important visualization to check whether the vision is carried out in a successful way to attain the goal. It is more of a visualization that is followed to keep track of the organization in a large scale. The process visualization is one of the key elements that hold an important contribution in making of a successful business models [16, 17].

2.3.7 Structure Visualization

Structure visualization refers to the visual representation of the conceptual relationship such as network linked to particular system, hierarchy etc., [7]. The structure visualization shares certain similarities with the flow visualization (visualization that is used to visualize the flow of the liquid) and system visualization. But the structure visualization focuses more on the connectivity.

2.3.8 Visual Analytics

Visual Analytics refers to informational visualization with analysis, which helps in decision-making [23]. Visual analytics helps in obtaining suitable solutions to solve the problem. Mainly the visual analytics focus on using a data, which is processed and presented in appropriate way [21, 22].

2.4 VISUALIZATION IN SYS ADMIN TOOLS

A new dimension of sys admin tools in the ongoing research is that of visualization. Robert et al [34] identifies that the growing body of research validates the role of visualization as a means of solving complex data problems. Gagne et al. [26] discussed how models could guide non-security practitioners in obtaining security related goals. Visualization of network activity and interactive system models, which allow the sys admins to further explore the performance and security of their systems is an area of

active research [24, 28, 29, 33]. McLachalan et al. [28] presented LiveRAC, a visualization system and conducted an informal longitudinal evaluation. Their system lets system managers view data at multiple levels. This allows both the drawing of inferences from complex data and the ability to communicate those to other stakeholders. Taylor et al. [29] presented Flo Viz, which works with the SiLK Toolkit2 for network data analysis and incorporates three primary visualization modes - an activity plot, the bundle diagram, and the NetBytes viewer. They stated that Flo Viz is in the initial stages of development and needs to address some of the legal and privacy issues involved in sharing data to ensure that it will work across different environments.

Best et al. [24] presented MeDICi, which allows analysts to predict and plan for specific challenges by providing real time network activity. They state a key challenge is to enhance the ability of the tool to pinpoint specific user activities and reduce noise in the model.

Foresti et al. [33] in VisAlert provides high-level situational assessment for network analysts (Figure 2.3). The visualization capabilities don't support a generalized view of the network to facilitate decision makers for their future troubleshooting. The visualization technique does not provide much space to relate different parameters of events. The VisAlert only provides correlation of events with respect to time and space (Figure 2.4).

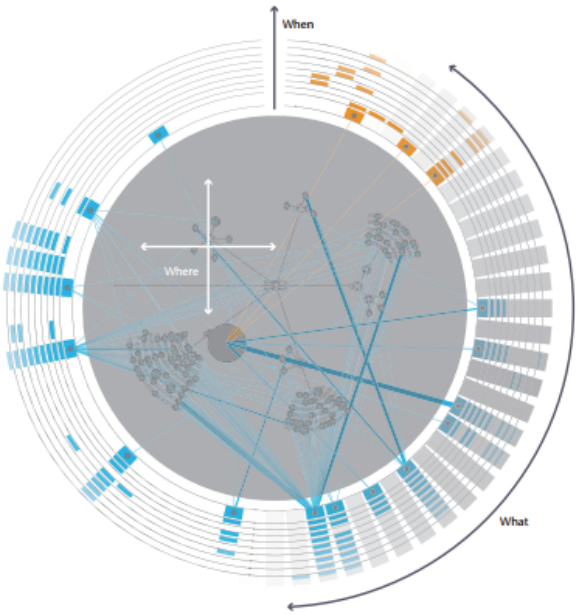

Figure 2.3 VisAlert: High Level Visualizationof Situational Awareness [33].

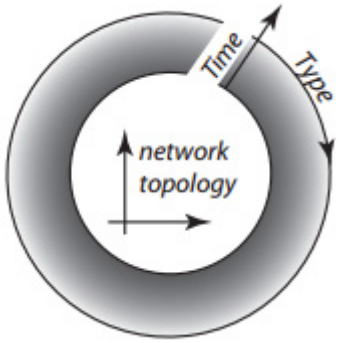

Figure 2.4 VisAlert: Correlation of events with respect to time and space [33].

Robert et al. [34] described visualization technique known as Cyber Command Gauge Cluster (CCGC). The visualization had major flaws such missing detailed history information, scalability, and color issues (see Figure 2.5). Later the visualization experts removed the flaws and came up with new refined visualization. They designed history information by providing rings within each of the dials (see Figure 2.6). But, it did not solve all the issues raised. Scalability issue is one of the key issues in both designs. The system does not seem to be scalable for large networks or network overview of networks. Moreover, the author did not realize that the color would also affect the visualization design.

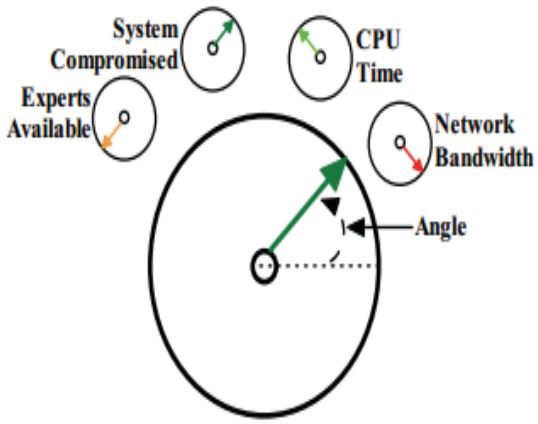

Figure 2.5 CCGC Diagram 1: Showing the lack of Scalability, Color and high level visualization design [34]

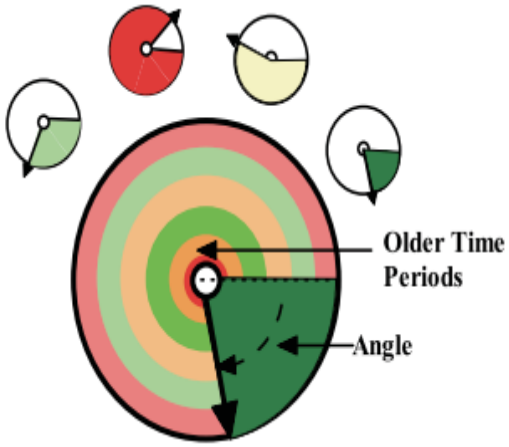

Figure 2.6 CCGC Diagram 2: Showing the impact of Color [34]

Evans et al. [35] cautioned that we should understand the effects of network attacks and how it disturbs the system performance. They wished to explore how automatic response to the network attack will raise the performance of the system.

Itoh et al. [36] said that combination of techniques such as data mining and knowledge management will help in improving the efficiency of the intrusion detection system. They tried to use visualization techniques for log files, especially for a large-scale computer networks.

Hendy et al. [37] believes that the users desires for more interaction in tools but without comprising the speed of the system. The user refers to use any application only when the expectation (speed with interaction) of the user is satisfied. In their study about GEKA

interaction, “a graphically enhanced keyboard accelerator method that provides the advantages of a traditional command line interface within a GUI environment” they tried to analyze the performance of the system over the time and wanted to check how the application works in real world environment.
Itoh et al. [36] stated that it would be difficult for mail server admins to understand statistics about the alerts and to find connectivity between why the alert flag was raised.

2.5 SUMMARY

As highlighted above, the prior work provides several descriptions of challenges, and sets of guidelines that can inform designers of tools for sys admins. However, while it motivates better solutions, it often falls short in providing sufficient actionable details. For example, Barrett et al. [6] state that the existing tools do not assist sys admins effectively in their daily routines and provide a clear overview of the current tools and their deficiencies. They also emphasize the need for coordination in sys admin work, and discuss the importance of situational awareness. Yet the paper did not specify technical details regarding what is lacking in the tools.
Similarly, Haber et al. [1] discussed the limitations of existing sys admin tools, yet their conclusions about how to improve them are vague. Botta et al. [25] listed important challenges faced by the security practitioners as well as the need for security practitioners to cooperate with others, and the technological complexity involved in their work was revealed. Shiravi et al. [38] provide a survey of visualizations for network security, but to the best of our knowledge, nothing similar exists for the broader domain of system administration. Werlinger et al. [32] identified 18 challenges that can affect ITSM.
Itoh et al. [36] explained about the implementation of long-term visualizations. It has not yet been verified if it will be a valuable technique to track the pattern of attack in any domain of sys admin work. To implement the concept, stated by Itoh et al. [36] we need to understand how it can be used in the tools. Mainly we need to check if any existing tools have implemented such concepts and how sys admins receive those tools.
In order to answer specific questions such as when to implement a GUI vs. a command line interface [1, 30, 31], we need to better understand the factors that determine when specific interface choices are effective. A detailed understanding needs to also consider

the work environment in which tools are used. Gagne et al. [26] discuss the need to understand how factors such as organizational size and position influence the difference between security and general IT. Jaferian et al. [27] discuss how a more detailed understanding is needed in order to reveal how ITSM is already practiced and how it could be improved. This will be particularly important with enhanced visualizations, as many research efforts have yet to be validated in practice.

As the technology updates frequently, it would be helpful if we run a study now and learn their current state of tools and expectation of the sys admins.

CHAPTER 3 METHODOLOGY

In this chapter we will discuss in detail the research objective (Section 3.1), research questions (Section 3.2), our overall research approach (Section 3.3), phase 1 study (Section 3.4) and phase 2 study (Section 3.5). For each study we will present the study protocol, study instruments, data collection, data analysis, recruitment, study instruments and refinement process, and participants. We conclude in section 3.6 with a discussion of participants' risk mitigation.

3.1 RESEARCH OBJECTIVE

From the related work, we believe that enhanced visualizations and system models could be a key factor in helping sys admins manage their complex IT infrastructures. In particular, these could provide overview of issues and to highlight and provide insight to problems. However, given the reluctance of sys admins to use GUIs, it is not obvious whether they would be willing to adopt interfaces with enhanced visualizations over the standard command line interfaces. As technology changes rapidly in this domain, we wanted to determine the current issues and work environments of sys admins. We also wanted to examine their use of and perceived need for improvements in the area of sys admin tools, with a focus on how enhanced and system models might play a role in desired tool improvements. From our findings, we wanted to generate guidelines and recommendations for future sys admin tools and provide information about areas of opportunity for innovation visualization researchers.

3.2 RESEARCH QUESTIONS

Our high-level research questions are as follows:

1) What are the issues that sys admins face in their work routine?
2) What are their reasons for choosing or not choosing a tool?
3) What is the state of visualizations in the current tools?
4) What are the domains, models, and tools that might benefit from improvements in visualizations?
5) How might the presence of visualizations make a difference in the sys admin work routine?

6) Why is visualization still downplayed in this domain?

3.3 RESEARCH APPROACH

Our research approach had two phases. In phase 1, we conducted a series of contextual inquiries and semi-structured interviews to better understand the current routines of sys admins and the desired requirements for sys admin tools. Our main focus was to find the problems sys admins have with the models and software used in their work routine. We used this study to brainstorm ideas for possible improvements in the field of visualization. Once we had a rich perspective generated from the contextual inquiries and semi-structured interviews, we wanted to see if the results would generalize to a broader population. In phase 2, we developed an online survey based on the findings gathered from phase 1. This allowed us to generalize our findings about the current and desired use of visualizations and system models in IT management for a variety of sub-domains of sys admin work.

3.3.1 Learning Curve

The field of system administration is complex and it can be difficult for HCI researcher to understand the norms and terminology used in their work routines. It was important for the researcher to have a sound knowledge about commonly used tools and the ability to understand how they function. In order to immerse myself in this research, I audited two graduate courses “Network Security” and “Network Design and Management”. These courses helped me to get familiar with the general terminology, tools, and concepts used in this domain.

I applied for and was given a scholarship (Google & USENIX Grant) to attend the 2012 LISA (Large Installation System Administration) conference. The sessions “Seven Habits of Highly Effective System Administrator”, “A Day Over the Edge in System Administration”, and “ State of the Profession: What are the Unresolved Issues in the Profession” gave me a broad picture about this domain and a sound perspective from which to design the framework of our research.

3.4 PHASE 1 STUDY

We conducted a series of contextual inquiries and semi-structured interviews in order to understand the current state of the sys admins' routine. We believe that these methodologies are appropriate as we can get an in-depth understanding about how the sys admin routine works and learn desired improvements for the tools used in their work routine. We next provide information about the study protocol (Section 3.4.1), study instruments refinement (Section 3.4.2), study instruments (Section 3.4.3), data collection (Section 3.4.4), data analysis performed (Section 3.4.5), recruitment procedure followed (Section 3.4.6), and participant details (Section 3.4.7).

3.4.1 Study Protocol

Ideally we wanted to conduct contextual inquiries with the sys admins in their workspace, so that they can show us their working models and the tools they use. This was important to provide the level of rich detail currently lacking in descriptions of sys admin work. However, given the confidentiality of their work and that their workspaces are often shared, this was not possible for most participants.

Our study consists of either a contextual inquiry or a semi-structured interview with each sys admin participant (see Appendix E). During recruitment, we attempted to achieve breadth in the domain of sys admin work (e.g. security, network), the size of the organization, and the domain of the organization. The size of the organization comes into consideration because in larger organizations there are separate positions for each domain, but in smaller organizations, only a few sys admins share the work or even a single person does all the tasks.

The participants signed a consent form at the beginning of the session (see Appendix E). Afterwards, the researcher outlined the study process and explained that the study will be audio recorded. For three of the contextual inquiries, the researcher was present in their workplace, observing and questioning their activities. In two cases, the researcher was given access to the participant's workspace via Skype. In four cases, the participants were present at a quiet room with the researcher and accessed their workspace systems via Team Viewer (2) or their respective log id (2) to show how their tools work. In the case of semi-structured interviews, a list of questions was prepared in order to understand their

work routine (see Appendix J). The anticipated interview time was 30 minutes but the interview ranged from 20 to 45 minutes based on the quality of information provided by the participants. The anticipated contextual interview was 1 hour but the contextual inquiry ranged from 45 minutes to 3 hours.

3.4.2 Study Instrument Refinement

We tested the study instruments with 4 people (T1 – T4) to determine if the protocol and questions were appropriate. T1 is currently doing a project with sys admin tools and piloting the instruments helped to check whether the questions as framed were appropriate to achieve our goal. T2 is a risk analytics expert who gave a clear picture of how people handle their data and what you should look at in the tools when we do a contextual inquiry. This was more of learning process to understand the data and tools. T3 has conducted a study for their research and helped us to discuss whether the study protocol was designed appropriately. T4 is a non-computer science background student. The input of this person helped in understanding how end users receive the system administrator's instructions and how they report problems regarding their system to tech support or a sys admin. After this participant, we added a few more questions about how sys admin communicate with the end user to solve reported problems.

3.4.3 Study Instrument

In our study, we used an interview guide (Appendix J) for the semi-structured interview, and a coding sheet (Appendix I) for contextual inquiry to ensure coverage of all the topics that we wanted to learn about the sys admins' work.

During the semi-structured interview, we primarily focused on questioning and drilling down into the details as much as we can to obtain a clear understanding about sys admin work routines and the problems encountered in their work. We tried to gain working knowledge about the tools that assist them in their daily routine, and learn their approach towards solving problems. Later we questioned about the desired tool features and the state of visualization in the current tools.

Interview Guide

The questions were designed based on our literature review and research questions (see Appendix J). The researcher had a list of questions framed to answer the research

questions. During the interview, the researcher kept a constant check to ensure all questions were answered. Creating the interview guide helped to design the flow of the interview and used prompts when the participant doesn't reveal required information. During the contextual inquiry, we focused on observing and understanding the tools used by the participants. We tried to understand whether the current tools and models help them to do their work efficiently and effectively. We also focused on how they approached a problem and what are the techniques used in general to solve problems that arise during their work routine.

We also requested the participants to think aloud when they solve a problem or reply a ticket, mainly to avoid constant interruption in their task.

Coding Sheet

The coding sheet was designed based on the literature review and research questions (see Appendix I). The researcher used it during contextual inquiries to keep a check on the topics covered, so that no important topics were missed.

3.4.4 Data Collection

In our study, we collected qualitative data through multiple sources such as audio recordings, note taking and time sheets.

Audio Recording

We audio recorded each session of contextual inquiry and semi-structured interview from beginning to end. This was done to avoid loss of information. In addition, recoding has helped to avoid interruption and/or using extra time for note taking. The researcher later transcribed the audio recordings. The quality of the audio recordings varied from participant to participant. For example, a contextual inquiry session conducted in the private cubicle of the participant or a semi-structured interview in a quiet room had a high quality of audio as it did not have any interruption or noise pollution. However, a contextual inquiry and semi-structure interview done via Skype had some interruptions compared to the prior ones. The data collected was transcribed without any loss.

Notes

During the session, the researcher closely observed the participant so that they could clearly understand the participants' approach to handle the problem occurred. While

doing so, the researcher took notes related to the responses of the participant and on the basis of the observation.

Timesheet

The timesheet was designed with each sections and important topics under each section (see Appendix H). The researcher noted the timing when the participants answered a particular question, to more readily locate that part of the audio recording during transcription.

3.4.5 Data Analysis

All data we collected in this study was qualitative in nature. The advantages brought by qualitative data allows us to sys admins' their perspective about the future needs expected from the tools they use and their expectations about the feasibility of increased visualizations in sys admin tools.

The tools used for analysis are Microsoft Excel, sticky notes, and whiteboard-marker. These tools were used to analyze the inputs given by each participant for each question asked. Later, we categorize them under the broad research questions stated initially. Finally, we examined them according to the various domains of the work involved in the routine of sys admin work.

When analyzing the data, we found that very few participant spoke about individual tools. However, many spoke on general terms about the tools used in that particular domain of sys admin work. The findings provided in the upcoming chapters might not be tool specific, but we tried our best to address the work domain for the tool.

3.4.6 Recruitment

Recruitment of sys admins was done through snowball sampling, where the existing study subjects provided us contacts to recruit further participants. We began with contacts made at a LISA (Large Installation System Administration) workshop entitled "Aligning the Research Interests of System Administrators and CHIMIT (Computer Human Interaction for Management of Information Technology) Researchers", LISA 2012, and personal contacts in the local area (see Appendix D).

3.4.7 Participants

We recruited 37 participants during our study, which ran from October 2012 to October 2013. Information on the primary characteristics of each participant, the gender of participants (Male or Female), type of study (Contextual inquiry; Semi-structured interview), domain of sys admin work (General; Database; Operating System; Network; Virtualization; Monitoring; Configuration Management; Tech Support; Infrastructure; Linux; Backup); type of organization (Academic; Research Lab; IT Consulting; Telecommunication; Software Industry; Gaming Industry; Consultancy; Internet Related Services), workplace(office, remote connection, Skype, away from their workspace)etc., is given in Table 3.1 (Contextual Inquiry participants characteristics), Table 3.2 (Semi-structured Interview Male participants characteristics), and Table 3.3 (Semi-structured Interview Female participants characteristics).

Table 3.1 Characteristics of contextual inquiry participants including participant ID, gender, domain of work, type of organization and participant location. For location we have included the geographical location of the participant's workplace as well as how the researcher connected to the participant (in parenthesis).

Participant ID	Gender	Domain of Work	Type of Organization	Work Location (CI Medium)
P1	M	General & Support to Research Labs	Academic	Canada (Office)
P4	M	General	Academic	Kingdom of Saudi Arabia (KSA) (Remote connection)
P5	M	Operating System& Infrastructure Management	Research lab	USA (Remote connection)
P19	F	Network, Backup, Monitoring	Academic	Canada (Office)
P20	M	Configuration Management, Network, Monitoring, Data Management	Research Lab	USA (Skype)
P23	M	Tech support, Monitoring	Academic	Canada (Remote connection)
P24	M	Tech support, Monitoring	Academic	Canada (Remote connection)
P32	M	Virtualization, Backup	Research lab	Canada (Office)
P36	M	Network, Backup, Monitoring	IT Consulting	India (Skype)

P2 to P18 study was conducted during LISA'12 conference in San Diego.

Table 3.2 Characteristics of male semi-structure interview participants including participant ID, domain of work, type of organization, and participant location. For location we have included the geographical location of the participant as well as the communication channel for the interview (in parenthesis).

Participant ID	Domain of Work	Type of Organization	Work Location (Interview Channel)
P6	Mail Server, Monitoring	Academic	Germany (Co-Located)
P7	IT Infrastructure Management, Monitoring	Academic	Norway (Co-Located)
P8	Virtualization, Monitoring	Internet Related Services	USA (Co-Located)
P9	Network, Data Management, Monitoring	Academic	China (Co-Located)
P10	General - (Team Lead)	Software Industry	Norway (Co-Located)
P11	General - (Team Lead)	Internet Related Services	Ireland (Co-Located)
P14	Linux Admin, Monitoring, Network	Graphics Industry	USA (Co-Located)
P15	General	Consultancy	USA (Co-Located)
P17	General – (Team Lead)	Academic	Germany (Co-Located)
P18	Network, Data Management, Monitoring	Academic	Australia (Co-Located)
P22	Network, Backup, Operating System	IT Consulting	India (Skype)
P25	Network, Monitoring	Telecommunication	India (Google Hangout)
P26	Tech Support, Network, Monitoring	IT Consulting	India*
P27	Data Management, Monitoring, Network	IT Consulting	India*
P28	Data Management, Monitoring, Tech Support	IT Consulting	India*
P29	Mail Server – Intern	Telecommunication	India*
P30	Tech Support, Monitoring, Network	IT Consulting	India (Google Hangout)
P31	Tech Support, Operating System, Backup	Gaming Industry	India*
P33	Tech Support, Monitoring, Network, Remote System Support	Telecommunication	India (Google Hangout)
P34	Monitoring & Network	Telecommunication	India*
P35	Network& Monitoring	Software Industry	Canada (Skype)
P37	Network, Backup, Monitoring	IT Consulting	Canada (Skype)

P2 to P18 study was conducted during LISA'12 conference in San Diego. Participants who have * in their location are currently studying in Canada, but had been sys admins prior to undertaking their studies. The work location in the table 3.2 denotes their prior workplace that they discussed during the study was in that location, but at the time of the study they were not currently employed.

Table 3.3 Characteristics of female semi-structure interview participants including participant ID, domain of work, type of organization, and participant location. For location we have included the geographical location of the participant as well as the communication channel for the interview (in parenthesis).

Participant ID	Domain of Work	Type of Organization	Workplace
P2	Remote System Support, Virtualization – (Intern)	Software Industry	USA (Co-Located)
P3	Operating System, Network	Academic	Canada (Co-Located)
P12	General	IT Consulting - Startup	USA (Co-Located)
P13	General - Team Lead	Research Lab	USA (Co-Located)
P16	Data Management, Monitoring	Internet Related Services	China (Co-Located)
P21	Data Management, Tech Support	IT Consulting	India*

P2 to P18 study was conducted during LISA'12 conference in San Diego. Participants who have * in their location are currently studying in Canada, but had been sys admins prior to undertaking their studies. The work location in the table 3.3 denotes their prior workplace that they discussed during the study was in that location, but at the time of the study they were not currently employed.

3.5 PHASE 2 STUDY

In the Phase 2 study, we administered an online questionnaire using opinio survey software where the participants are sys admins from various domains. The questionnaire has been designed to validate our findings from the Phase 1 portion of this research, which consisted of semi-structured interviews and contextual inquiries. Questions have been designed to investigate whether the obtained results generalize to a broader population of sys admins and also to obtain quantitative responses about the issues sys admins face and lack of visualizations in their tools. We chose an online questionnaire so that we could reach sys admins from a wide variety of locations and organizations.
We aimed to have at least 200 participants complete our survey so that we have participants from a broad base of company domains (e.g., educational, financial services, industries) and with a range of responsibilities (e.g., security admins, network admins, database admins, etc.).

3.5.1 Study Protocol

The recruitment script (see Appendix F) was sent to various groups and potential participants contained a link to the survey. A click on the link leads to an informed consent form (see Appendix G); this form was presented as the first page to the online questionnaire. Potential participants read the study information, and if they consent to take part, clicked the "Click if you agree to take part in the study, to continue on to the survey questions" button.

3.5.2 Study Instruments

We investigated available survey software, considering the ethics restrictions about the hosting location of the survey. Finally, we ended up with two survey software options, Opinio and Lime. We opted to use Opinio survey software as we found the interface was quite simple and provides ease in implementation.

3.5.3 Survey Design

The survey was designed so that only if the participants agree to the terms and conditions in the consent form they will be allowed to proceed with the survey (see Appendix G). The beginning of the survey consists of few demographic questions to categorize the participants such as gender, type of organization, and location. Later sections of the survey questions were focused on each of the various domains (network, general, security, backup, tech support, documentation, virtualization, troubleshooting, monitoring, remote system, and team lead). If the sys admin agrees to the description provided (i.e., click 'yes') about the work performed in that particular domain, only then the participant will enter the section. Otherwise, if the participant clicked 'no' or 'not applicable' or 'skip' proceed to the next section of the survey. In the general section, we questioned about their interface preference (CLI or GUI or both) and the reason for their choice of one over the other. Irrespective of the domains mentioned above, our main focus was to determine the role of visualization in that particular domain, what is lacking in the current tool, and the sys admins' expectation for future tools.

3.5.4 Survey Refinement

We tested the questionnaire with 6 people (P1 - P6) and refined it based on their feedback. P1 is a HCI expert who helped in the design of the survey. P2 is a graduate student who has used the Opinio survey software for their study purpose; the feedback provided cautioned us about the issues to be faced with the data. P3 is a database and virtualization sys admin who helped time check the whole survey and gave feedback on the virtualization questions. Based on the feedback obtained from P3 we included the types of virtualization questions in the survey. P4 is a general sys admin who went through the whole survey and gave feedback about whether the questions are appropriate. P5 is a team lead that gave essential feedback on the activity of troubleshooting and added new questions in the team lead section. P6 is a security and a network admin who provided feedback on the survey questions. Their inputs were used to understand the flow and the questions that would be useful for the study.

3.5.5 Data Analysis

All data we collected in this study was from the online survey, which was primarily quantitative in nature. The advantages brought by quantitative data allows us to present the perspective of a broader population about the future needs expected from the tools used and the need for visualization in the current tools. There were several open-ended questions that allowed participants to expand on their answers.

The tools used for analysis are Microsoft Excel, SPSS, sticky notes, and whiteboard-marker. These tools were used to quantitatively analyze the results obtained from the survey as well as the reasons provided in the open-ended questions. We also by classified the findings according to the various domains of the work involved in the routine of sys admin work and put them in the same format as the phase 1 results. This allowed us to compare the two and develop the recommendations (Chapter 6).

3.5.6 Recruitment

Recruitment of sys admins was done through snowball sampling in the study, where we asked recruited participants to forward our study information to future participants. We began recruitment with contacts made at the recent Large Installation System

Administration Conference (LISA'12) and personal contacts in the local area. We also distributed the survey links to different sys admins online groups (e.g., LOPSA, Systers, USENIX, Linkedln - sys admin groups, Blogs). Because the survey is online, participants from outside the local area were able to take part in the study.

While we were attempting to recruit a wide variety of participants, no screening measures to ensure the diversity of the participants were done. An email or post about the study was sent to the professional groups with the recruitment script (see Appendix F) attached. If the online group was moderated, we obtained permission before posting.

3.5.7 Participants

We recruited 331 participants during our study, which ran from August 2013 to January 2014. Information on the primary characteristics of the participants such as domain of sys admin work (General; Database; Operating System; Network; Virtualization; Monitoring; Configuration Management; Tech Support; Infrastructure; Linux; Backup) and the number of participants participated in each section of survey; type of organization (Academic; Research Lab; IT Consulting; Telecommunication; Software Industry; Financial; Health Services; Government; Advertising; Manufacturing; Internet Related Services) is given in Figure 3.1 displays the percentage of participants who completed each section of survey, Figure 3.2 displays the number of participants participated from different type of organization. For information about the location of their workplace, size of the organization and team size see Appendix L.

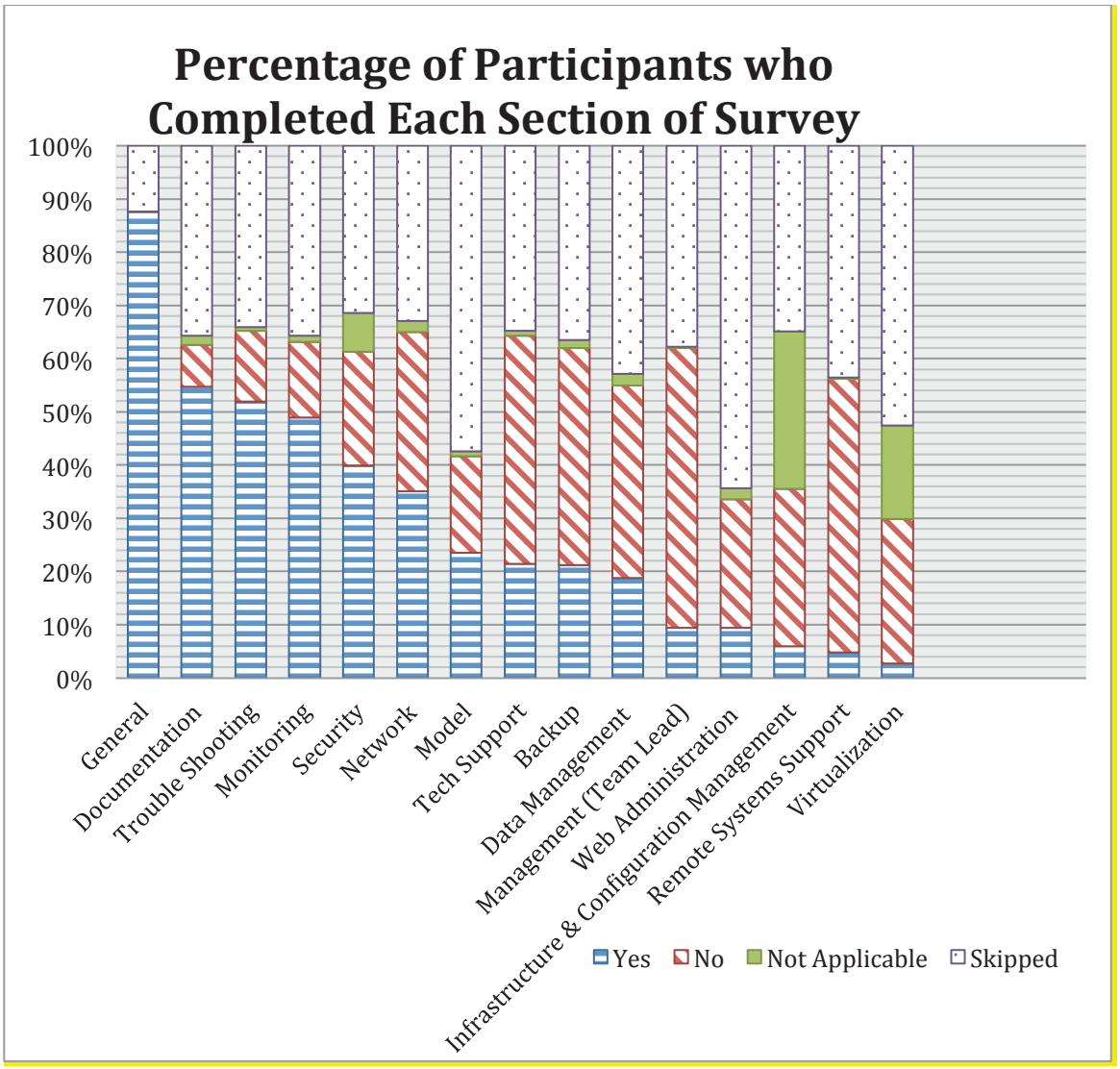

Figure 3.1 Displays the information about how many participants participated in each section of the survey. (Yes – the given description of work is performed by the participant; No - the given description of work is not performed by the participant; Not Applicable - the given description of work is not applicable for the participant's work domain; skipped – participants who skipped the section).

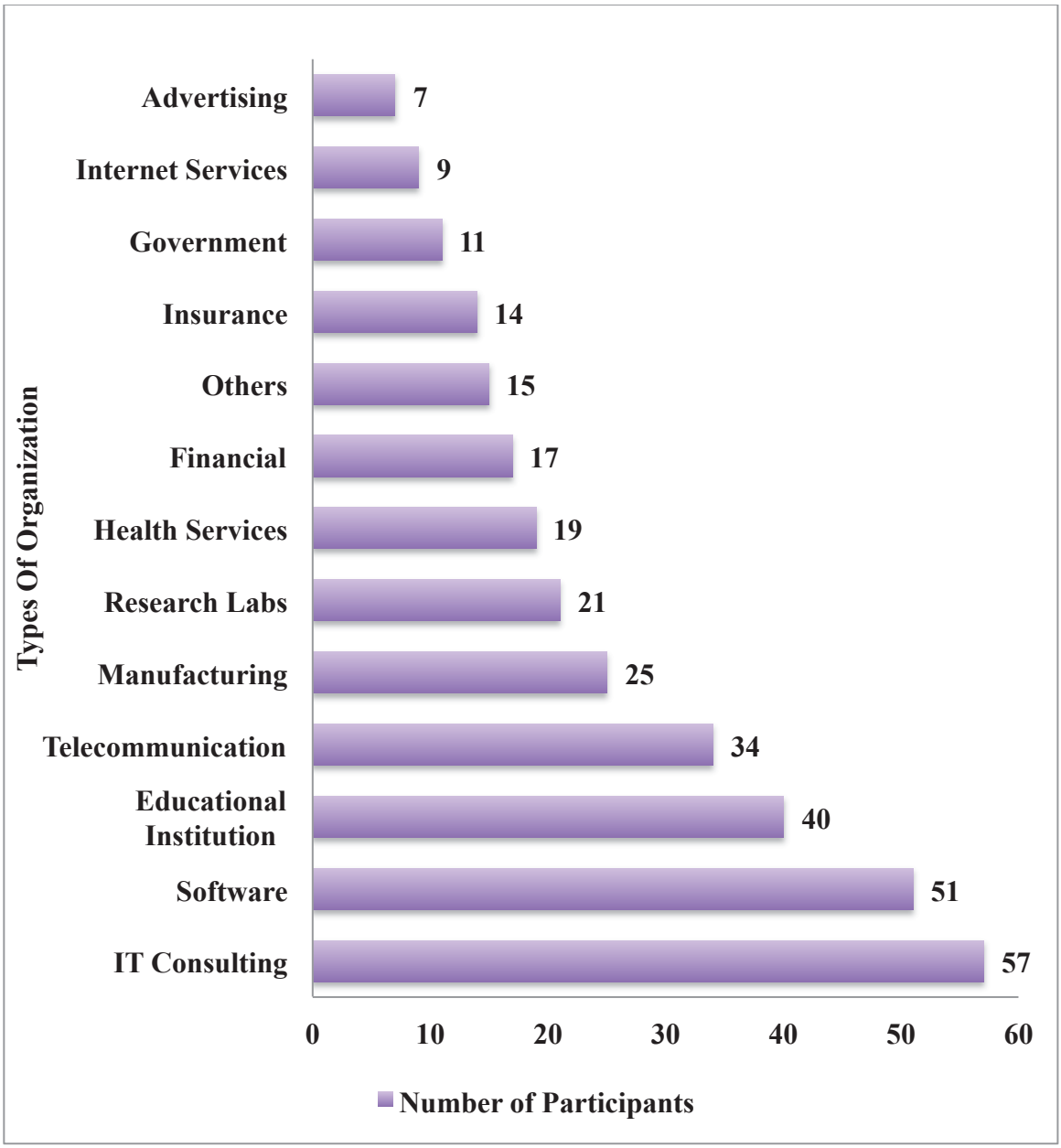

Figure 3.2 Displays the number of participants who participated from each industry. 11 participants opted for "Prefer Not to Answer Options"

3.6 Risk Mitigation

It was not anticipated that participants in either study would be subject to any physical risks or discomforts beyond their daily routines. However, there were concerns that participants might put their companies at risk or put themselves at risk if their work practices were not in compliance with their company's standards. As the participants

spoke about the current models, tools in use, design and their company goals, we ensured that their identity and that of their company would not be disclosed at any point.
The participants were advised not to answer anything that breached the confidentiality agreement of their organization. The participants were also told that they could avoid answering any question that they thought would be a risk to them in anyway. Once the data was transcribed, any content that identified the individual or the organization was anonymized. We used alphanumeric codes and generic terms to mask any identifying participant or company information identity to preserve the anonymity of textual data.

3.6.1 Confidentiality and Anonymity

We now explain the measures taken to preserve the confidentiality and anonymity in each study.
In phase 1, an audio recorder was used to collect the study data. The researcher later transcribed the file. After transcribing the data, any data related to disclosing the identity of the organization or the system admin was made anonymous. The identifying information was simply removed and replaced with more generic words e.g. replace 'James' with '[P12]' and 'ACME Co' with 'Financial Co' in the transcript. There was a code list that connects participant information with the different codes; that was kept in an encrypted folder separated from the anonymized data. The audio files were destroyed once transcribed and the data was checked. The hard drive was wiped and rewritten with 0s.
In the both phases of the study, any participant quotations used when reporting the findings were attributed anonymously, with any identifying information removed. Permission to use quotations was obtained as part of the informed consent process. (see Appendix E, G)

CHAPTER 4 PHASE ONE RESULTS AND DISCUSSION

In this chapter we will discuss in detail the results obtained from phase 1, the contextual inquiry and semi-structured interview study. The results are categorized under each domain of sys admin.

The upcoming sections showcase in detail the sys admins' routine (Section 4.1); their reasons for choosing between a CLI and a GUI interface (Section 4.2); the process involved in maintaining and handling security incidents (Section 4.3); their issues and visualizations expected in networking tools (Section 4.4), monitoring tools (Section 4.5), ticketing tools (Section 4.6), troubleshooting tools (Section 4.7), data management tools (Section 4.8), backup tools (Section 4.9), management tools (Section 4.10), documentation tools (Section 4.11), infrastructure and configuration management tools (Section 4.12), virtualization tools (Section 4.13), web administration and mail server support tools (Section 4.14), and remote system support tools (Section 4.15); prioritization of work (Section 4.16); choice of tools (Section 4.17), and usage of models (Section 4.18). Later we discuss the state of visualization in current tools based on observation (Section 4.19) and we conclude with summary of the findings (Section 4.20) and limitations of the study (Section 4.21).

In phase 1, we have conducted the study with 37 participants; 28 were interviewed and 9 were contextual inquiries. Twenty six participants (70%) work in organizations such as IT consulting 8 (24%), research labs 4 (11%), telecommunications 4 (11%), internet related services 3 (8%), software industry 3 (8%), graphics industry 1(3%), gaming industry 1(3%), and consultancy 1(3%), while 11(30%) were working in academic institutions.

4.1 SYS ADMIN WORK ROUTINE

Table 4.1 Interview question about the sys admin routine; after the participant response the prompts were used if necessary.

Question	Prompt
What is your **role within the organization**?	*Duties? Implement controls? Solve end user issues?*

The results confirm that the general routine followed by sys admin is similar to ones listed in prior research [1,2,3,4] when questioned (table 4.1). The work of the sys admin differs from domain to domain but the basis of their work routine is similar. For instance, a system admin in general does monitoring tasks, with the difference being that the network domain will look for the network traffic and the security admin will look for whether any security codes have been breached. Based on the results, we have generated a detailed summary about the various domains of sys admin work.

4.1.1 General Sys Admin

In general sys admin work, the sys admin is responsible installation, configuration, operation, and maintenance of systems hardware, software and related infrastructure. Troubleshooting, resolving technical issues, and documentation are the key aspects of their routine. In addition to their regular routine, the sys admins working in research labs should keep the system running on based on the requirements of research similar to providing tech support to run a project in an organization.

4.1.2 Security Admin

The security admins have to implement security controls; design services incorporating security requirements; solve IT security issues of end users; keep track of security breaches; mitigate vulnerabilities; threat evaluation; risk analytics and respond to security incidents. The results were similar to [32].

4.1.3 Network Admin

The network admins have to keep the network up and running. They need to monitor the network traffic, system performance, and status to maintain the service infrastructure and prevent outages. In addition to maintaining the servers and the standard software and hardware on the network, and ensuring the compatibility of all computer hardware and software, the network admins also needs to identify, diagnose, and resolve complex problems affecting network performance.

4.1.4 Tech Support Admin

The tech support admins have to effectively troubleshoot the software and hardware problems. Mainly they need to identity and provide solutions, as well as document the process and the solution. Certain tech support admins need to perform root cause analysis in order to provide recommendations to avoid the scenario.

4.1.5 Tech Lead of Sys Admin

The team lead is supposed to contribute to maintaining the system standards in the organization. They mainly need to keep track of the developments in the team, to check on the resources required to keep the projects running, and to communicate with the upper and lower hierarchical in the organization.

4.1.6 Infrastructure and Configuration Management Admin

In addition to the regular sys admin routine the infrastructure and configuration management sys admin will have to maintain records of the configuration provided to meet the requirements. They also need to perform hardware upgrades; resource optimization; and configuration of devices, memory, and disk partitions.

4.1.7 Data Management and Backup Admin

The database and backup admins should perform backup operations on a regular basis to ensure that the file systems and system data are backed up and stored.

4.1.8 Web Administration and Mail Server Maintenance Admin

The web admins are responsible for installing, updating and maintaining organizations' webpages and websites. They also need to of traffic patterns, the efficiency of the network, and server performance in order keep their webpages and websites accessible. In addition to the web administration work, the mail server admins should create and manage the user accounts. They must also keep track about trending spam emails before the spam alters the filter configurations.

4.1.9 Remote System Support Admin

The remote system support admin should keep track of system supported. They must also be aware of catastrophic effects. Certain remote system support admins also keep track of network traffic to provide quality service.

4.1.10 Virtualization Admin

The virtualization admin should be aware of the deployment of the virtual systems. They need to understand the dependencies in order to avoid catastrophic effects.

4.1.11 Size of Organization

We also noted that the work of sys admin depends on the size of the organization, type of organization, and number of people they need to support. If the organization is big, then they will have a dedicated team for each domain; if the organization is a small just one admin may handle all the work. The type of organization also contributes to the number of sys admins. If the organization involves a lot of systems in their work, they will have different domain of sys admin work or single admin will handle all the domain of work. In general the team size for each domains is based on the population they need to provide support.

4.2 CLI vs GUI

Table 4.2 Interview question about the sys admin preference; after the participant response the prompts were used if necessary.

Question	**Prompt**
What do you **prefer – GUI or CLI or Both**?	*Tasks? Advantages? Disadvantages?*

We next discuss participants' responses to the CLI vs GUI section of the study. When questioned about their preference (table 4.2) in general, 14/37 (38%) of participants prefer to use CLI for their work and the other 23 (62%) participants said that they prefer both, as their work deals with web interfaces and monitoring.

4.2.1 Reason for their Choice

The reasons given for their choice of CLI were that it is comfortable, saves time, and is available on all machines irrespective of the configuration. As P18 described "automation, configuration, scripting, and drilling down the data - makes us favor CLI". P21 stated, " availability is key aspect for choosing CLI". When asked about the issues with GUI, 18/37 (49%) said it requires more interaction; therefore it takes more time to complete a task.

4.2.2 Preference over Task

All 37 participants agreed that GUI's are best for monitoring tasks, especially to get an overview of the state of the system. All 37 participants agreed that CLI's are best for scripting and automation.

4.2.3 Desired Improvements

Desired Features

All 37 participants stated that they prefer a GUI when it sits on top of a CLI. They also expressed the desire to be able to easily switch between CLI and GUI. This is because in the GUI they can find out the issues triggered, and in the CLI they can implement the changes.

Desired Visualizations

Fourteen (38%) participants suggested that interactive visualizations that allow them to drill down into the raw data would increase their trust and acceptance of using GUI tools.

4.2.4 Partial towards CLI

Table 4.3 Interview question about the sys admin partial towards CLI; after the participant response the prompts were used if necessary.

Question	Prompt
Are you **partial** towards CLI?	*Influence? Familiar? Prominent?*

When asked whether sys admins are partial towards CLI (table 4.3), the majority 32, 86% replied that using CLI is one of the criteria to be a sys admin. Six (16%) sys admins said it is because CLI was more prominent when they started their career. Two sys admins

made sarcastic negative comments about GUI's such as "GUI's were made so that my grandma could use a computer" (P17) and "the GUI's t-shirts doesn't fit on sys admins chest"(P4).

Table 4.4 Displays the information about how many participants performed these tasks as part of their daily routine.

Task Performed	Phase1 (N=37)
Models	**37 (100%)**
Documentation	**34 (92%)**
Troubleshooting	**32 (86%)**
Security	**23 (62%)**
Monitoring	**21 (57%)**
Network	**19 (51%)**
Ticketing	**12 (32%)**
Data Management	**7 (19%)**
Backup	**6 (16%)**
Management - Team Lead	**4 (11%)**
Infrastructure & Configuration Management	**3 (8%)**
Virtualization	**3 (8%)**
Remote Systems	**2 (5%)**
Web – Mail Server	**2 (5%)**

4.3 SECURITY RELATED TASKS

Table 4.5 Interview question confirm the presence of separate security team; after the participant response the prompts were used if necessary.

Question	Prompt
Does your organization have a separate security team?	Are you a part of the security team? Clash?

When questioned about security in their organization (table 4.5), 11 (30%) participants said that they have a separate security team to handle security related tasks, while 26 (70%) participants did not. When prompted the 11 participants with dedicated security terms, all indicated that they were not a part of the security team. They also indicated that they don't perform any security related tasks; they just follow the instructions that are given by security team while doing any task.

Table 4.6 Interview question about the security related work in their routine; after the participant response the prompts were used if necessary.

Question	Prompt
Is security a part of your routine?	Tasks? Policies? Incidents? Tools? Visualization?

When questioned 26 participants whether security is part of their routine, the 23 of the remaining participants responded that it is part of their routine (table 4.4). When prompted (table 4.6), the participants said that scanning for viruses, and keeping a tab on filters are a part of their routine.

4.3.1 Security Admins vs Sys Admins

The eleven admins who had separate security team in their organization were prompted to discuss whether there were any clash or complications in their work due to the security procedures in place. Five out of eleven (45%) participants reported that it complicated their routine. Two admins sarcastically quoted “we provide them work” (P4); and “they mess our life – we are just miles apart” (P32). The other 6 admins (55%) were quite comfortable with the security admin team. P11 said that “security team and us go hand in hand”; P21 also stated “they are part of the decision making process, so things never clash”.

4.3.2 Desired Improvements

Desired Characteristics

Twenty security admins raised concerns about using third party tool for security tasks. Fifteen admins said that they used internal tools and scripts. Twenty-one admins expressed that tools used for security purpose should be “accountable” (P7).

Desired Features

Fifteen security admins felt that automation with monitoring features should be present in order view the state of the system. This is in addition to automate for regular tasks such as scanning for viruses, firewall check etc.

Desired Visualizations

When questioned about what kind of desired visualizations they would like, the participants suggested that data visualization and visual analytics would be helpful. They believed that visualizations would help them in understanding the data and in the process of decision-making. For example, suggesting automatically with prospective visual about the solution, when trying to solve the problem based on how the past security was handled.

4.4 NETWORKING TOOLS

Table 4.7 Interview question about the network domain task related to their routine; after that participant response the prompts were used if necessary.

Question	Prompt
Does network related tasks are part of your routine?	Tasks?

When questioned (table 4.7), 19/37 (51%) of participants said that their routine involves network related tasks (table 4.4). These include monitoring the network traffic, maintaining server (refer 4.1.3).

Table 4.8 Interview question about the network related work in their routine; after that participant response the prompts were used if necessary.

Question	Prompt
State of current tools and problems faced?	
What are the desired features in future networking tools?	Scenario? Lack in current tools? An example for visualization?
Do you think that enhanced visualizations can help in your work routine?	

4.4.1 Issues Reported

When questioned (table 4.8), 18/19 participants performing network admin tasks felt that, "there were too many steps to do a process" (P3). All 19 participants reported scalability

as a key issue in the domain of networking. As P19 stated, “The current tools doesn’t support when we handle more number of hosts”. Three participants said that it is important to know how a server is about to react once the server update. As P36 stated, “Any solution for the server update issue will help in avoiding such scenarios that leads to catastrophic effects”.

When asked to brief the scenario about the problem faced, P25 described a scenario, “If a node goes down, the tool is not aware of it and ends up showing false alarms as if the node is still alive. The software won’t show the error properly as the tool has no features to update itself to respond to new errors. Hence the new errors are not reported. Only way to solve the issue, the admins ends up manually testing the node.” Similarly, P26 described that “after configuring the switches, the admin has to ping manually whether the flow is working or not, which makes the task time consuming”.

4.4.2 Desired Improvements

Desired Features

The admins felt there should be options for analysis in their tools so they can measure server performance, delay, etc. P33 said that it is essential to have a feature to know information about the client and server connection. P27 stated that in depth information about “why the network is not connecting is also required”.

Desired Visualizations

P37 stated that visualization is required in network analysis: “how the server would have impact if tools is loaded with many things”. P35 said that network gauging capability and a runtime performance dashboard is required for an enhanced working environment. Maintaining the IP address availability is an important task, as of now it is done manually in industry. All 19 participants with network admin tasks think some sort of informational visualization can help in including a list to show the available and not available IP address.

4.4.3 Implications for Design

We suggest that for the issue of server reaction to a particular command, it would be useful if tools show clips or a picture about how the server might respond if the particular

command is executed. This clip or picture might allow the sys admins to have a choice to implement the change or to avoid a situation that would not provide the expected change required for the system. For the issue too many steps involved in completing a process, we suggest automation in the form of icons should be available. The admin could click to perform the task. However, this suggestion may only be possible for regular routine tasks. For the problem of manual pinging to check whether node is alive or not, we felt that visualization of status of the node or alerts or tracking of the node developments could reduce the work time.

4.5 MONITORING TOOLS

Table 4.9 Interview question about the monitoring tasks related to their routine; after the participant response the prompts were used if necessary.

Question	Prompt
Does monitoring task are part of your routine?	What do you monitor? Which domain of work requires monitoring tools?

When questioned (table 4.9), 21/37 (57%) of participants said that their routine involves monitoring related tasks (table 4.4). Monitoring tasks were completely based on the domain they work. For example the network monitor the network traffic, the admins performing mail server maintenance keep a track of filters and occurrence of spam.

Table 4.10 Interview question about the monitoring related work in their routine; after the participant response the prompts were used if necessary.

Question	Prompt
State of current tools?	
Report any trouble caused with the current monitoring tools?	
Do you think that enhanced visualizations can help in your work routine?	Desired features? Desired Visualizations?

4.5.1 Issues Reported

When questioned (table 4.10), all 21 admins with monitoring tasks reported that current monitoring tool only partially supports only network and security related tasks. The other domains of monitoring tools such as tracking of backup, tracking of filter changes etc., are not prominently available. Fifteen admins said that false alarms in monitoring tool are highly intolerable. Fourteen participants reported that they have had issues with Nagios Core, which is a monitoring tool that lacks configuration management, proper policy management, and patch management. Seven participants reported that, "they are simply not willing to invest time only working with Nagios". Twelve sys admins reported that they had equally bad experiences with Solarwinds, MOM, Zabbix and Zenoss monitoring tools.

P25 states "to know the state of the machine we need to go the logs". Twelve other admins reported similar problems.

4.5.2 Desired Improvements

Desired Features

P28 suggested that the presence of indicators is required in identifying the issues based on the domain specific problem such as network traffic, security breaches etc., providing alerts will improve the quality of work.

Desired Visualizations

In general, every participant felt that there should be a better monitoring tool, certain tools have visualization but the interface is too complicated. P16 stated, "A basic page of visualization were everyone can understand", that is a simple visualized state of the system. Fifteen participants wanted a timeline of the changes made in the system over the course of the day so that they can go and check what major changes occurred. This was particularly important in the case of large networks of complex systems and network traffic.

4.6 TICKETING TOOLS

Table 4.11 Interview question about the ticketing tasks related to their routine; after the participant response the prompts were used if necessary.

Question	Prompt
Do you solve tickets as a part of your routine?	Tools used?

When questioned (table 4.11), 12/37 (32%) participants said that their routine involves solving tickets (table 4.4). Ticketing tools used by most of the admins are RT [7] in organization and Email [5] in the academic institution.

Table 4.12 Interview question about the ticketing related work in their routine; after the participant response the prompts were used if necessary.

Question	Prompt
Report any trouble caused with the current ticketing tools? Do you think that enhanced visualizations can help in your work routine?	Desired features? Desired Visualizations?

4.6.1 Issues Reported

We further questioned (table 4.12) the 12 admins about the current ticketing tools. P30 said one of the major disadvantage in the ticketing tool is “its only a option to attach images when you send a ticket”. P23 states that “it all depends on the input of the users”, and P33 said, “communication is a key feature that is required when you solve a ticket”. P4 added that “continuity of notifications is lost after the ticket is closed”, which leads to poor customer service.

There were issues reported with the priority labeling of tickets. P33 said, “10% of the problem is that tickets come to level1 instead of level2 support”. P26 added that “moving a ticket to a different level alters the time, it ends up in delay in response to the customers which affects the quality of service”.

4.6.2 Desired Improvements

Desired Features

When asked about desired features, P1 said that "the source of the error should be known" and P15 expressed that "live chat with the clients might help" in solving an issue. Ten sys admins feel that a clustering feature should be provided to identify what type of problem that the particular ticket falls into. As P4 said, "Efficient automatic clusters will help in classifying problem to a specialists".

P24 said, "Automation is required in the ticketing process as we solve at least 60 – 100 tickets per day, out of which 20% are spam and 30% are common issues". In such cases, reducing the steps to perform the task will help. All 12 admins with ticket solving tasks felt the presence of icons or drop down lists can help in answering common issues. In addition, drag and drop options to add issues into the common issues list would be helpful.

4.7 TROUBLESHOOTING TOOLS

Table 4.13 Interview question about the troubleshooting related to their routine; after the participant response the prompts were used if necessary.

Question	Prompt
Do you perform troubleshooting as a part of your routine?	Steps you follow?

When questioned (table 4.13), 32/37 participants said that troubleshooting is a part of their routine (table 4.4). All participants agreed they follow a step-by-step process to troubleshoot and their main focus is to understand the problem and later focus on solving it. Five sys admins felt troubleshooting also depends on the experience, problem solving capacity, intuition, and learning interest of the sys admin.

Table 4.14 Interview question about the troubleshooting related work in their routine; after the participant response the prompts were used if necessary.

Question	Prompt
State a common issue while troubleshooting? Do you think that enhanced visualizations can help in your work routine?	Desired features? Desired Visualizations?

4.7.1 Issues Reported

When questioned (table 4.14), all 32 participants agreed that the current tools offer only a very high level of visualization and they are not able to drill down into the data. For example the tools should not only highlight the occurrence of the problem but also help in root cause analysis and finding solution.

4.7.2 Desired Improvements

Desired Features

Ten sys admins felt that integration of monitoring tool and a ticketing tool could help in the troubleshooting process. As P12 stated, “Coupling of the monitoring tool with ticketing tool will help in solving the problem”. Eight sys admins felt that integration of a documentation tool and ticketing tool could help with troubleshooting process and P15 stated, “If ticketing tool is coupled with documentation software will be helpful in solving the problem”. Twelve participants felt that integration of a documentation tool and monitoring tool could help in troubleshooting process and P37 said, “For efficient troubleshooting we require the involvement of both documentation and monitoring in it”. Eight participants suggested that they wanted to select a particular host to look back how many connections were in the host when the problem triggered.

P29 stated understanding the client plays a key factor in implementing the solution with ease and stated any feature “that provides the client background information is needed to know the level of explanation is required”. This is important to ensure that the client understands the problem or the solution to the problem that occurred.

Desired Visualizations

The twelve-tech support sys admins reported that a description of the problem is based on the input of the user. P15 stated that "without proper knowledge visualization or system visualization it is hard to solve any issue". P28 said "visualization on the history of client reporting and background details will help in providing better response". All 32 sys admins involved in troubleshooting tasks felt that visualizations are highly required in this domain, as maintenance is the key to hold onto the client.

4.7.3 Implications for Design

As we found effective troubleshooting depends on information about the source of the error information, details about the state of the system, and knowledge of the admin. This could be an opportunity for system visualization and knowledge visualization to make performing the troubleshooting task efficient. For example, state of system might be helpful in knowing what has triggered the problem and knowledge visualization of heuristic analysis might assist in solving the problem.

4.8 DATA MANAGEMENT TOOLS

Table 4.15 Interview question about the database related to their routine; after the participant response the prompts were used if necessary.

Question	Prompt
Do you maintain databases as a part of your routine?	They use database software or word document or text files?

When questioned (table 4.15), 7/37 participants said that their routine involves database admin tasks (table 4.4). These include managing and maintaining databases, word documents, and text files.

Table 4.16 Interview question about the database related work in their routine; after the participant response the prompts were used if necessary.

Question	Prompt
Report any trouble caused in the current tools and any data loss experience? Do you think that enhanced visualizations can help in your work routine?	Desired features? Desired Visualizations?

4.8.1 Issues Reported

When questioned (table 4.16), all 7 participants with the data management tasks reported that data loss is a critical issue to be addressed in this domain. P36 stated, “Particularly if the clients are the banking organization”. P20 states that, “slow performance when handling large archives” is an issue and that “renowned software doesn’t support all the platforms”. Five participants highlighted that visualization of big data is difficult and P16 said, “The current tools couldn’t scale when they deal with more hosts”.

4.8.2 Desired Improvements

Desired Features

Six participants noted that their daily routine involves allocating resources to the client, checking the status of availability, and checking whether the system is compatible. For instance bill payments, allocation of IP address, allocation of systems in research labs all are maintained. 86% of participants an excel file or word document or a table is used. They felt the presence of overall status of the product or the resource will make a huge difference when they handle a huge database. Basically it might reduce the workload, increase the speed and efficiency of work.

Desired Visualizations

P27 states “visualization of the cube (representation of data) is essential as it is one of the data visualization whose presence would be much appreciated”. P20 points out that “customize options should be present to allow only appropriate visualization to be presented”.

4.8.3 Implications for Design

In general participants felt that data visualization is required in places where the entire details of the individuals and resources are present. For example, just a tick mark that summarizes the information near the client's identification number will help the admin know whether the client is eligible for a the benefit or not with just a glance and if required for explanation options to drill down the data should be present.

4.9 BACKUP TOOLS

Table 4.17 Interview question about the backup tasks related to their routine; after the participant response the prompts were used if necessary.

Question	Prompt
Do you maintain backup as a part of your routine?	What do you backup?

When questioned (table 4.17) to admins, 6/37 participants said that their routine involves backup related tasks (table 4.4). P19, P31, and P36 said that they keep a backup of the current configuration of the system before implementing the changes. P32 and P37 said that they keep a backup of the databases that contain client information. P22 said, "they maintain a backup for important information like employee details and project details".

Table 4.18 Interview question about the database related work in their routine; after the participant response the prompts were used if necessary.

Question	Prompt
Report any trouble caused in the current tools and any data loss experience? Do you think that enhanced visualizations can help in your work routine?	Desired features? Desired Visualizations?

4.9.1 Issues Reported

When questioned (table 4.18), all 6 participants said that the reliability of backup system is not satisfactory in the current tools. P37 said, "Reliability of the backup system are questionable - Systweak Advanced System Optimizer 3, Paragon Backup & Recovery 12 Home are a few software's which I had bad experience". Three participants raised a

concern for check their ability to check the state of the backup and said that none of the tools available effectively supports the process. As P22 stated, " The status of the backup is unknown".

4.9.2 Desired Improvements

Desired Visualizations

P22 desired that any tool that provide status of the backup. P31 also said that "system visualization or process visualization" might help in the work. For example visualization about the capacity of the system or the state of the backup, whether the backup is done or not.

4.10 MANAGEMENT TOOLS

Table 4.19 Interview question to know whether the participant is a team lead; after the participant response the prompts were used if necessary.

Question	Prompt
Are you a team lead?	Tasks?

When questioned (table 4.19), 4/37 participants said that they lead a team of sys admins (table 4.4). In general all four participants said they keep a track of deployment and the resources utilized and required. P17 said the main role is to, "connect the team with the upper hierarchy people".

Table 4.20 Interview question about the management related work in their routine; after the participant response the prompts were used if necessary.

Question	Prompt
Does any tool help in keeping a track of the team developments? How does the presence of visualization can make a difference in your work routine?	Desired features? Desired Visualizations?

4.10.1 Issues Reported

When questioned (table 4.20) about the current state of tracking tools, the participants responded that reporting is a duty of every sys admin as they belong to the lower layer in the hierarchy of the industry. There is a huge difference of how and what to report to each

level of staff and participants expressed that many loops need to be considered to do a simple task of reporting. P13 said, “False reporting and forgetting to report is a common issue”.

4.10.2 Desired Improvements

Desired Visualizations

Team leads felt that tracking the development for trainees as well as current employees could have a visual analytic approach. P11 said that “it would be easy to be track their development and lag” and “it would be more easy to produce the reports in simple data visualizations to the higher level”. In addition, P13 stated that “work status; the difficulty level of the problem solved; and the domain of the problem solved of each employee should be presented in graphs to the team head”. P17 said that “If the database of the employee is visualized it would be easy to point to one to handle a particular issue”. P8 suggested, “Customer feedback towards their service should be represented in visual analytic way”. This was felt to speed up the analysis process of the data collected.

4.10.3 Implications for Design

We believe the presence of automation in reporting will help in solving the problem of false reporting and forgetting to report.

Table 4.21 Interview question about the management vs sys admin; after the participant response the prompts were used if necessary.

Question	Prompt
Describe a scenario were you faced an issue due to the management decision?	Any suggestions to avoid it?

4.10.4 Management Vs Sys Admin

When questioned (table 4.21), 20 of the 33 sys admins who were not the team leads felt that management should be aware of the resources available. They thought that on inventory system should be present and it should have a dependency check with simple visualizations to avoid situations like accepting a project without knowing the whereabouts of the state of the employee. As P10 said, “all the check exist but it all exist in .doc format but there is no visualizations”.

4.11 DOCUMENTATION TOOLS

Table 4.22 Interview question about the documentation related work in their routine; after the participant response the prompts were used if necessary.

Question	Prompt
Do you perform **documentation** as a part of your work routine?	Type of Documentation? Tools Used?

When questioned (table 4.22) 34 out 37 sys admin do documentation as a part of their daily routine (table 4.4). Those 3 sys admins who do not do documentation expressed regrets for not doing it.

There are two major classification of documentation: professional documentation and personal documentation. Typically, sys admins do two types of professional documentation as part of their daily routine. The first type of professional documentation is to regularly update details about their general work routine and how they handled issues with it. The second type is to briefly explain how they solved a particular issue. The tools used are wiki, word documents, text files, and templates designed by the management. Personal documentation refers to keeping a record or information about how the sys admins handled a particular problem. In essence, they keep a personal technical journal. 30 out of 34 participants only did professional documentation; only 4 participants did both personal and professional documentation.

Table 4.23 Interview question about the documentation process; after the participant response the prompts were used if necessary.

Question	Prompt
What are the drawbacks with the current tools used for documentation? Do you think that enhanced visualizations can help in your work routine?	Desired features? Desired Visualizations?

4.11.1 Issues Reported

When questioned about issues with the current documentation tools (table 4.23). The time taken to document and work with documentation was felt to be an issue. As P16 said that the “Documentation process is avoided in most scenarios just because it is time

consuming. P2 said, “searching for a solution in documentation is time consuming and most times you end up with zero help inspite of documentation containing the solution”. The above statement clearly describes that the search feature and the representation of data are not adequate, hence the advantage of the resource is not seen by the sys admins. P5 stated, “documentation is a huge resource to train new hires, but as of now, only the routine documentation is used by new hires”.

The 30 participants who did only professional documentation, out of which 26 sys admins wanted to do personal documentation as well, but do not have time to do it. The four participants who did both professional and personal used a text doc, journal, wiki, or notepad for personal documentation but stated that they don’t document regularly as it is not part of their routine and it is not compulsory to do.

4.11.2 Desired Improvements

Desired Features

Twenty-seven sys admins felt that documentation is not efficiently used in industry. P34 said, “If documentation involves clustering of data collected and proper search features it can be of greater use”. Most participants felt that a tool that looks into the documentation and recommends a solution to the problem would be helpful. At a minimum, the keyword matching should be present to suggest particular set solutions.

Desired Visualizations

The presence of visualization in the general documentation could help the management and team leads to monitor the updates and issues about their team with ease. P10 said, “If there is any visualization for the undone work in their routine, it can be indicated; so that would be of help to focus and guide the employee to complete that particular task”. Every sys admin, irrespective of domain expressed that presence of visualization can bring in valuable improvement to the work routine.

4.11.3 Implication for Design

Twenty-four sys admins said that personnel documentation is prohibited; they cannot record any data from the workplace for their personal reference. To be consistent with the

policy of many organizations, a feature to replace the data or hide the private data of the company can help in addressing the above issue.

The data and knowledge visualization could play a vital role in helping the sys admins in solving the problems with documentation. For example if the existing solutions act as a guide for solving similar problems that is currently occurring.

From observing the sys admins in contextual inquiry, it we saw that the journals are not within reach and writing notes depends on the availability of time. The presence of icons and a click and drag options can encourage sys admins to keep a record of new problems that they encounter.

4.12 INFRASTRUCTURE & CONFIGURATION MANAGEMENT TOOLS

Table 4.24 Interview question about the infrastructure and configuration management related work in their routine; after the participant response the prompts were used if necessary.

Question	Prompt
Do you perform infrastructure and configuration management tasks as a part of your routine?	Tasks?

When questioned (table 4.24), 3/37 participants said that their routine involves infrastructure and configuration management related work (table 4.4). The admins keep track of the resources utilized and available and the deployment configurations.

Table 4.25 Interview question about infrastructure and configuration management related work in their routine; after the participant response the prompts were used if necessary.

Question	Prompt
Report any trouble caused with the current tools? Do you think that enhanced visualizations can help in your work routine?	Desired features? Desired Visualizations?

4.12.1 Issues Reported

When questioned (table 4.25), the sys admins felt that there is no proper tool that can help them in keeping track of the resources deployment and the availability of the resources in their work routine.

4.12.2 Desired Improvements

Desired Features

The sys admins wanted to have tools that keep track of repair frequency, machine warranties, and resource management. P20 stated, “Resources available should be tracked to avoid clash in completing a project”.

Desired Visualizations

The participants in general felt that visual analytics could help in the maintenance of the devices. Three participants felt that there should be system dependency checks so that the work between employees will not clash. In general they felt simple visualizations with work flow diagrams can help in solving the issue.

4.12.3 Implications for Design

P20 stated that there is a “need to check whether the software can work on particular device, as it saves a lot of time and also helps in assisting the customers”. To add to this, P7 stated, “compatibility check requires visualization instead of providing a detailed summary or logs”. In both the cases mentioned, a lot of textual data is present, which can lead to false interpretation of the data. Simple checkboxes and flowcharts could solve the issue.

4.13 VIRTUALIZATION TOOLS

Table 4.26 Interview question about the virtualization related work in their routine; after the participant response the prompts were used if necessary.

Question	Prompt
Do you perform virtualization related tasks as a part of your routine?	Domain?

When questioned (table 4.26), 3/37 participants said that their routine involves virtualization related tasks (table 4.4). Two sys admins performs network virtualization and storage virtualization; the other works with distributed file system.

Table 4.27 Interview question about the ticketing related work in their routine; after the participant response the prompts were used if necessary.

Question	Prompt
Report any trouble caused with the current ticketing tools? Do you think that enhanced visualizations can help in your work routine?	Desired features? Desired Visualizations?

4.13.1 Issues Reported

When questioned (table 4.27), all 3 sys admins with virtualization tasks said that the available tools lack in deployment checks and support to all applications. P8 stated, "The available software doesn't allow all the applications – licensing issue".

4.13.2 Desired Improvements

Desired Visualizations

P8 stated, "Switching the machine due to traffic should be done automatically". At present keeping track of traffic and switching involves both machine as well as human, which in turn can lead to error. But if any alert is provided regarding the increase and decrease of traffic in a visual analytic way the work can be done efficiently. P32 stated, "if automation is done and the switch can be done with click on the icon would help in performing the task quickly".

4.14 WEB ADMIN - MAIL SERVERS SUPPORT TOOLS

Table 4.28 Interview question about the web service related work in their routine; after the participant response the prompts were used if necessary.

Question	Prompt
Do you perform web service related tasks as a part of your routine?	Tasks

When questioned (table 4.28) only 2/37 participants said that their routine involves web service, mainly mail server support (table 4.4). Handling mail servers is a core work of every organization as communication is one of the basic necessities in today's technical world.

Table 4.29 Interview question about the ticketing related work in their routine; after the participant response the prompts were used if necessary.

Question	Prompt
What are the key challenges in your domain of work? Do you think that enhanced visualizations can help in your work routine?	Desired features? Desired Visualizations?

4.14.1 Issues Reported

When questioned (table 4.29), P29 stated that in most of the mail maintenance software the interface is complicated. Both P6 and P29 have used is roundcube tool; and felt the interface of the tool is one of its major drawbacks; organization of the tabs and availability of features are not easily accessible to the users.

4.14.2 Desired Improvements

Desired Visualizations

In general, the admins suggested software visualization might enhance the working environment. Prediction represented in simple visualization about the act to be performed in the server is required to avoid errors. P29 described an incident about when the server was mishandled and it ended up altering the filter properties, specifically the spam blocks. As a result all the clients' mailboxes were buzzed with spam emails. The key issue the mail server maintenance team is to handle the spam emails, but the procedures are lengthy. Simple automation features and text mining can help in solving the issue of spam and time span to solve efficiently.

4.15 REMOTE SYSTEM SUPPORT TOOLS

Table 4.30 Interview question about the remote system support related work in their routine; after the participant response the prompts were used if necessary.

Question	Prompt
Do you support remote systems as a part of your routine?	Issues Faced

When questioned (table 4.30) only 2 participants said that their routine involves remote system support (table 4.4).

4.15.1 Issues Reported

The two remote sys admin reported speed and the quality of service is a major issue faced in this field. For example connectivity and speed in responding to the issues occurred.

Table 4.31 Interview question about visualization in their routine; after the participant response the prompts were used if necessary.

Question	Prompt
Do you think that enhanced visualizations can help in your work routine?	Desired features? Desired Visualizations?

4.15.2 Desired Improvements

Desired Features

When questioned (table 4.31), the sys admin said that it would be helpful if monitoring tools were integrated to their system. This would allow them to keep track of the state of the system that they support.

Desired Visualizations

The admins indicated their concern about whether the presence of visualization could negatively affect their quality of work. P33 stated, “the presence of visualization should not reduce the speed of the service”.

4.16 PRIORITIZATION OF WORK

Table 4.32 Interview question about prioritization at work; after the participant response the prompts were used if necessary.

Question	Prompt
Does any tools support in prioritizing your work?	What are your priorities at work?

When questioned about the prioritization of work (table 4.32) all 37 participants felt that prioritization plays an important role to schedule the work for the day. All 37 sys admins strongly agreed that the maximum priority goes to the work that stops the most people from being able to perform their regular routine.

However, other prioritization schemes were also discussed. According to 8admins, priority was based on from whom the request comes; six sys admins argued that their maximum priority goes to their domain of work or the work that they are in-charge of; while three admins stated that security audits might grab their maximum attention.

Table 4.33 Interview question about prioritizing their work; after the participant response the prompts were used if necessary.

Question	**Prompt**
Does any tool help in prioritization? Do you think that enhanced visualizations can help in your work routine?	Desired features? Desired Visualizations?

4.16.1 Issues Reported

When questioned (table 4.33), in general the admins felt most of the tools does not help in prioritization of work. P21 stated, “the ticketing tools has prioritization option but not effective enough”.

4.16.2Desired Improvements

Desired Features

Seven participants felt that based on the description provided in the tickets or emails, the portal can automatically raise or reduce the level of the ticket or an email.

Desired Visualizations

The clusters can be shown in graphs to indicate which domain of problem is triggered. On the basis of priority, the problems can be solved in order. Clustering and presence of icons can help in the in the prioritization approach.

4.17 CHOICE OF TOOL

Table 4.34 Interview question about choosing a tool; after the participant response the prompts were used if necessary.

Question	Prompt
Are you involved in the process of choosing tool?	If no, who does? Any problem has happened because of the choice?

When questioned about the choice of tool in their organization (table 4.34), 15/37 participants said that they are involved in the process. The rest stated that it is completely a management decision. P3 sarcastically stated, “their money, their organization, they deal with it” and P5 stated, “they purchase, we deal with it”.

Table 4.35 Interview question about the ticketing related work in their routine; after the participant response the prompts were used if necessary.

Question	Prompt
How do choose a tool? Does any support is available? Do you think that enhanced visualizations can help in your work routine?	Desired features? Desired Visualizations?

4.17.1 Issues Reported

When questioned (table 4.35), the four team leads stated that they would ask the opinion of the admins before making a choice. The rest of the admins stated that they look for tools based on the purpose. They would finalize a report about advantages and disadvantages and get feedback from a few known sources. All reported that none of the online inventory lists is reliable. They said that the tool company influenced most of them.

4.17.2 Desired Improvements

Desired Features

The admins felt the inventory available doesn’t provide any information regarding how the problem will be approached. For example description about the steps how the tools solves the particular problem, would help in deciding whether to purchase a tool or not.

Desired Visualizations

P19 suggested visualization for decision making that is “polling for choice of tool would make an interesting visualization” and further stated that the management can see this as well. It was felt that this would avoid the documentation process to get the tool approved.

4.17.3 Implications for design

Based on the findings visualization of features or how the tool works might help sys admin relying on the tool inventory list. In addition, if any videos or a clip about how the specific problem will be solved should be present, it would make it easier for the admins to finalize a tool purchase.

4.18 MODELS

Table 4.36 Interview question about usage of models; after the participant response the prompts were used if necessary

Question	Prompt
Do you use models? How do create your models?	Name the models? Tools Used

When questioned about the use of models (table 4.36), all 37 participants said that they use models. P34 stated that “ they use for general procedure” and P27 stated, “guide to use the particular tool”. When questioned about the tools used to create models (table 4.36), 24/37 (65%) of participants used paper, whiteboard, and charts. The rest used Mindmaps, Calligra Flow, Graphviz, Open/Libre Office,Visio, Omnigraffle.

Table 4.37 Interview question about the models used in their routine; after the participant response the prompts were used if necessary.

Question	Prompt
What lacks in your current models? Which domain would benefit more with the presence of models? Do you think that enhanced visualizations can help in your work routine?	Desired features? Desired Visualizations?

4.18.1 Issues Reported

When questioned about the current models in use (table 4.37), the 37 participants said that current models lack interactivity. Mostly the models uses a paper based or just a screen shot, no features to drill into the details.

4.18.2 Desired Models

One of the models that 15 participants wished to have included in their future tools is the physical location of a machine so that if any machine indicates a problem it would be easy for them to locate it in large machine rooms.

Six participants felt that connectivity models are necessary because they help the sys admins to know which systems are connected or dependent on each other. The connectivity model should provide information about which system or clients work will be affected if a particular system shuts down. This type of model will also help in identifying the catastrophic effects in a system due to the occurrence of a particular issue.

Five network sys admins felt that network diagrams could make their work much easier. A flow diagram of their network, including the presence of switches, and routers could make huge difference in their routine. Three admins suggested a checklist for every server configuration procedure can help in avoid missing a step in the process.

Five database admins complained that no data flow diagrams are available. Four admins reported that at times they need to know from where the source of information comes and where the data is lost. When a huge database is to be managed the data flow diagrams could help in analyzing the data efficiently.

Troubleshooting was another task where it was felt that models would be useful. P8 stated that models briefly explaining about the step-by-step procedure to be followed in troubleshooting could help the trainee or new hire learn how to handle a particular problem. Team leads felt models about how to report an issue (i.e. the hierarchy to be followed) would be useful in order to strictly follow the policy of the organization. Six sys admins suggested that prioritization models are required to help tech support admins to classify the level of the issue.

4.19 State of Visualization in Current Tools

During contextual inquiry, we saw instances of how might the presence of visualizations make a difference in the sys admins' work routine and what are the hindrances in the current state.

Scenario 1

P1 is a person who prefers CLI for work and doesn't use any GUI tools. When we suggested "Cacti" **(**an open-source, web-based network monitoring tool) to monitor the network traffic. Despite using the tool for the first time, the participant was able to perform the task with more speed as compared to checking the log files, in their normal fashion.

Scenario 2

P19 is a network admin disclosed the differences of doing the same job with CLI and GUI based tools. The admin used an inbuilt tool designed by them to monitor the network traffic. The admin was quick enough to identify that some error is happening at a particular port, but wasn't able to drill down the data in GUI based tool. Instead the admin logged into CLI based tool to know the details and solve the issue.

Scenario 3

P36 is a monitoring admin who disclosed a major issue with the available monitoring tool. The sys admin said that "couldn't understand initially the features and require sound knowledge to play with the color combination to view a proper visualization", and also added "sys admin should not be given so much options for colors, that should be taken care by the UI people when they design the tool".

4.20 Summary

Our results reveal that every sys admin domain might benefit from improvements in visualization. We have also identified many issues to be considered while designing a tool for this particular population. Our study allowed us to identify the areas where interactive visualizations and system models could assist the sys admins in their daily routine and provided findings from which recommendations for designing interactive features could be generated.

Before generating guidelines, we wanted to obtain more data from a greater number of sys admins to see if our findings generalize. We did this through the survey phase 2 described in Section 3.5. We present the results of the survey in the next chapter.

4.21 LIMITATIONS

In this study, we collected data through conducting contextual inquiries and semi-structured interview. It was difficult to recruit this critical population, especially for a contextual inquiry. Due to the confidentiality of the sys admins organization policy and often-shared workspaces, we could only conduct contextual inquiries with 24% of participants; the rest were semi-structured interviews. Participants often require permission from the organization and the process can take a lot of time. Additionally despite receiving permission, some sys admins were not comfortable enough to reveal the name of the tools as that might identify corporate details and most sys admins corporate policies about disclosure were strict.

CHAPTER 5 PHASE 2 RESULTS AND DISCUSSION

In this chapter we will discuss in detail the results obtained from the phase 2 online survey study. The upcoming sections showcase in detail the sys admins' need for visualization in each domain and the recommendations of participants regarding the improvement of visualization in future tools conducted in phase 2 of our research. Initially we present the answers to the general section of the survey (Section 5.1) which includes choosing between a CLI and a GUI interface (Section 5.1.1), prioritization at work (Section 5.1.2); and choice of tools (Section 5.1.3); We then investigate the desired features and visualizations expected on a domain by domain basis for the domain of security tools (Section 5.2); networking tools (Section 5.3), monitoring tools (Section 5.4), tech support tools (Section 5.5), troubleshooting tools (Section 5.6), data management tools (Section 5.7), backup tools (Section 5.8), management tools (Section 5.9), documentation tools (Section 5.10), infrastructure and configuration management tools (Section 5.11), virtualization tools (Section 5.12), web administration tools (Section 5.13), and remote system support (Section 5.14); usage of models (Section 5.15) and we conclude with the limitations (Section 5.16) and summary section (Section 5.17). The tools used by each participant are categorized under the domain of work (see Appendix M).

In phase 2, we conducted the survey with 331 participants. Of 331 participants, 194 were male, 59 were female, and 78 did not want to disclose their gender.

Table 5.1 provides detailed information on how many participants participated in each section of the survey. Participation is based upon whether the participant performs work of that type and whether they opted to complete that section of the survey. (Yes – the given description of work is performed by the participant; No - the given description of work is not performed by the participant; Not Applicable - the given description of work is not applicable for the participant's work domain; skipped – participants who skipped the section).

Survey Section	Yes	No	Not Applicable	Skipped
General	290	0	0	41
Documentation	181	26	6	118
Troubleshooting	172	44	2	113
Monitoring	162	47	4	118
Security	132	71	24	104
Network	116	99	7	109
Model	78	60	3	190
Tech Support	71	142	3	115
Backup	70	135	5	121
Data Management	62	120	7	142
Management	31	174	1	125
Web Administration	31	80	7	213
Infrastructure and Configuration Management	27	135	10	159
Remote Systems Support	16	170	1	144
Virtualization	9	90	58	174

5.1 GENERAL SECTION

The first section of survey consists of general questions regarding the choice of interface, the reason for their choice; the drawbacks that they find in each interface, and the

improvements required (Section 5.1.1). Later we questioned participants regarding the prioritization of work (5.1.2) and the choice of tool (5.1.3). Out of 331 participants, 290 participants participated in this section of study.

5.1.1 CLI vs. GUI

Initially we focused on answering the preference of the system administrators for CLI and GUI and their reason for the choice.

Table5.2 Survey question about the preference of the participant

Question: What do you **prefer – GUI or CLI or Both**?

When questioned (table 5.2) 49/290 (17%)of participants opted for CLI, 20/290 (7%) opted for GUI, and the others 221 (76%) opted for both CLI & GUI.

Table 5.3 Survey question about the reason to choose CLI over GUI

Question: Why do you **prefer CLI over GUI?** ***Options:*** *Accuracy, Less resource usage, Reliability, Automation, Comfortability, Speed, All of the above, Others, None*

Participants were then questioned about the reason behind their preference (table 5.3). Out of 290 participants who answered this question, 60 participants opted for speed, 52 participants opted for all of the above, 50 participants opted for automation, 41participants opted for reliability, 32 participants opted for accuracy, 27 participants opted for comfortability, 20 participants opted for less resource usage and 8 participants opted for others (see figure 5.1)

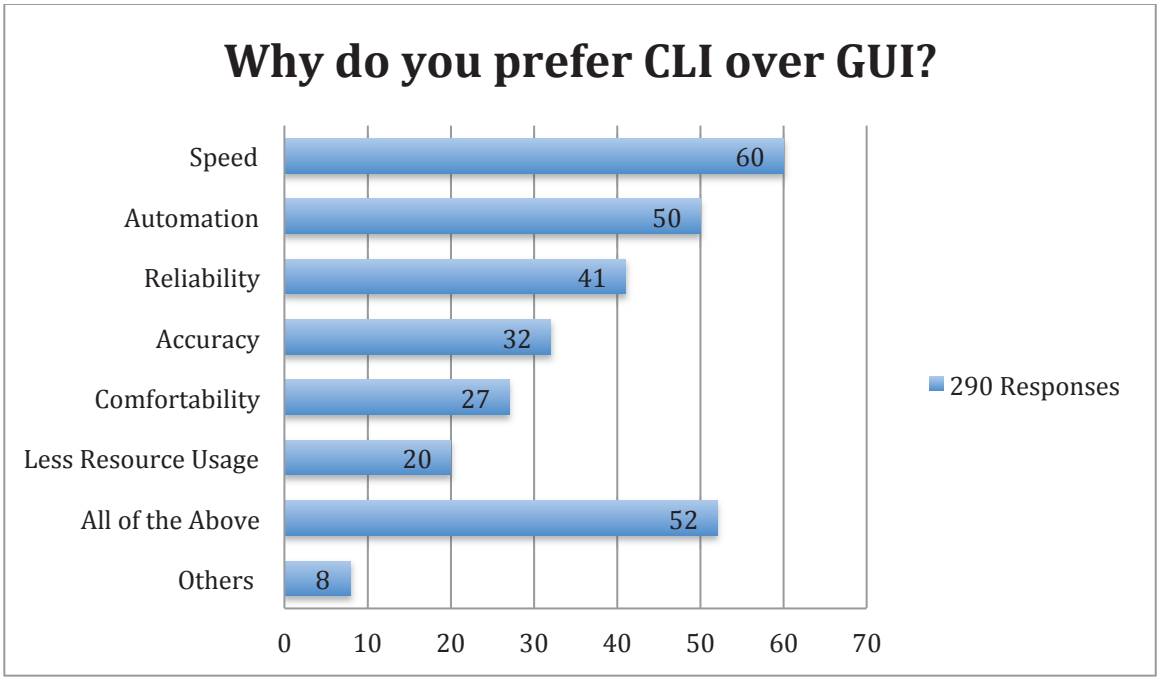

Figure 5.1 Displays the information about how many participants opted for each option given

All participants selected one of the provided responses, with none of them choosing the "none of the above option". Eight participants selected "others" and provided varied answers and explanation as to why. These included "more accurate than a mouse"; "fast grasp of issues"; "Multiple tools/subsystems can be 'joined' or 'chained' together to provide a more powerful tool"; "Scale - We have individual websites running on over 300 servers, and not always the resources we'd like to because we live in reality"; "Good luck trying to for-loop through thousands of servers in an emergency using RDP. I'm not saying this should be how changes are made, but it happens when other options are scarce and keeps things alive"; "Often you can do far more with a well written script and some functions are CLI only"; "Ease of documentation and training"; "Consistency- particularly when needing to communicate a method to someone else. A command is the same whoever runs it. When you have a GUI, there's always a chance that either a) the GUI changes in the interim or b) the person following cannot follow exactly what you mean or c) there may be implicit steps that are not give (e.g. nothing about leaving something checked or unchecked) and someone following may decide to do the opposite for a setting that was originally intended"; "CLI is almost entirely unambiguous".

Table5.4 Survey question about the drawback of CLI

Question: What is the major drawback in CLI? ***Options:*** *Absence of GUI Output, Experience to handle errors, Interaction, Lack of visualization, All of the above, Others, None*

When questioned about the major drawbacks to CLI (table 5.4). The most popular responses was 115/290 opted for absence of GUI output, 76 opted for lack of interaction, 46 opted for lack of visualization, 33 opted for need experience to handle errors, 10 opted for none, 6 opted for all of the above, and 4 opted for others (see figure 5.2).

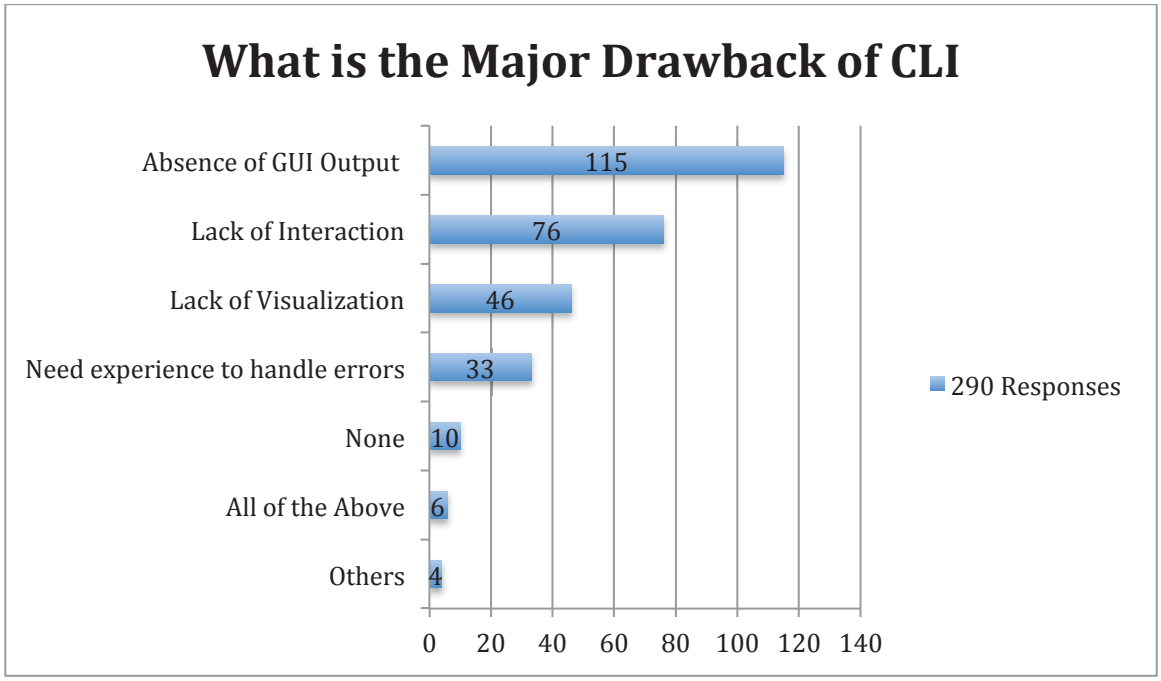

Figure 5.2 Displays the information about how many participants opted for CLI drawback

All participants selected one of the provided responses. Four participants selected "others" and provided varied answers and explanation as to why. These included "Harder to learn as you have to know what you are doing vs. a GUI where you can poke around and look for the command"; "Along the lines of visualization, some complex reporting best represented via GUI. I don't see any advantage for GUI input, only GUI output"; "Training is required to handle the data - Difficult to aggregate and drill down status of activities/errors/etc."; "Poorly specified error messages – leads to trouble in identifying the errors".

Table5.5 Survey question about the reason to choose GUI over CLI

Question: Why do you **prefer GUI over CLI?** ***Options:*** *Visualization, Interaction, Ease of use, All of the above, Others, None*

Participants were questioned about the reason behind their preference (table 5.5) 101/290 participants opted for visualization, 81 participants opted for interaction, 63 participants opted for ease of use, 40 participants opted for all of the above, and 10 participants opted for others (see figure 5.3).

All participants selected one of the provided responses, none of them chose the "none of the above option". Five participants selected "others" and provided varied answers and explanation as to why. These included"Less training / reading needed"; "Should be very careful in designing interactive features or else it might turn as an disadvantage, Requires well-designed GUIs"; "Ability to see the most commonly used options without have to remember them"; "Understanding a problem is far easy compared to finding patterns in CLI"; "Potential for aggregation and drill down (but often not implemented)".

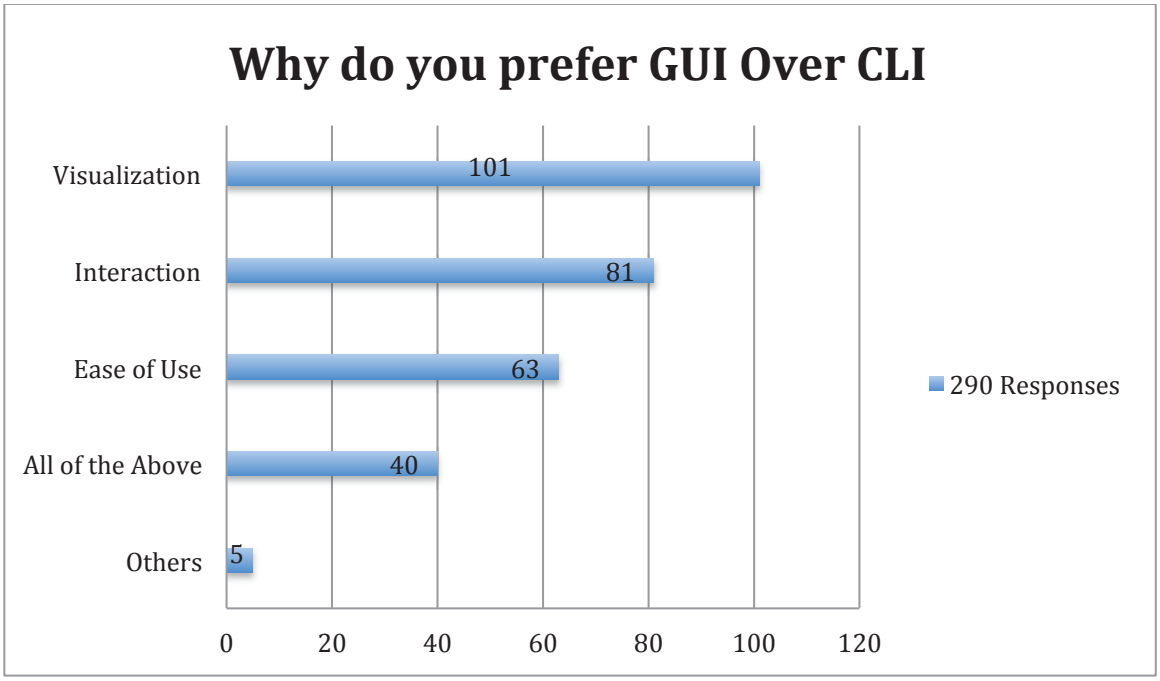

Figure5.3 Displays the information about how many participants preferred

Table5.6 Survey question about the major drawback in GUI

Question: What is the major drawback in GUI? ***Options:*** *Time delay, Inefficiency, Too much interaction, All of the above, Others, None*

When questioned about the major drawbacks of GUI (table 5.6), 101/290 participants opted for time delay, 86 participants opted for inefficiency, 50 participants opted for all of the above, 42 participants opted for too much interaction, and 11 participants opted for others (see figure 5.4).

All participants selected one of the provided responses, none of them chose the "none of the above option". Ten participants selected "others" and provided varied answers and explanation as to why. These included "Allowing people to use a GUI can hide complexity - if it breaks, they may not know how to recover"; " GUIs work well for frontends to home-build automation systems"; "Menu options sometimes hard to find"; "lack of API"; "10 pointy clicky steps to do simple things"; "interfaces designed without due care and attention"; "requirement to use mouse when keyboard would be more efficient"; "Very hard to document standard procedures or to automate. Oftentimes, there is little documentation of what the visual representations mean, so we are left guessing as to exactly what we are being told"; "Hard to automate"; "not flexible enough to meet complex needs, inconsistency".

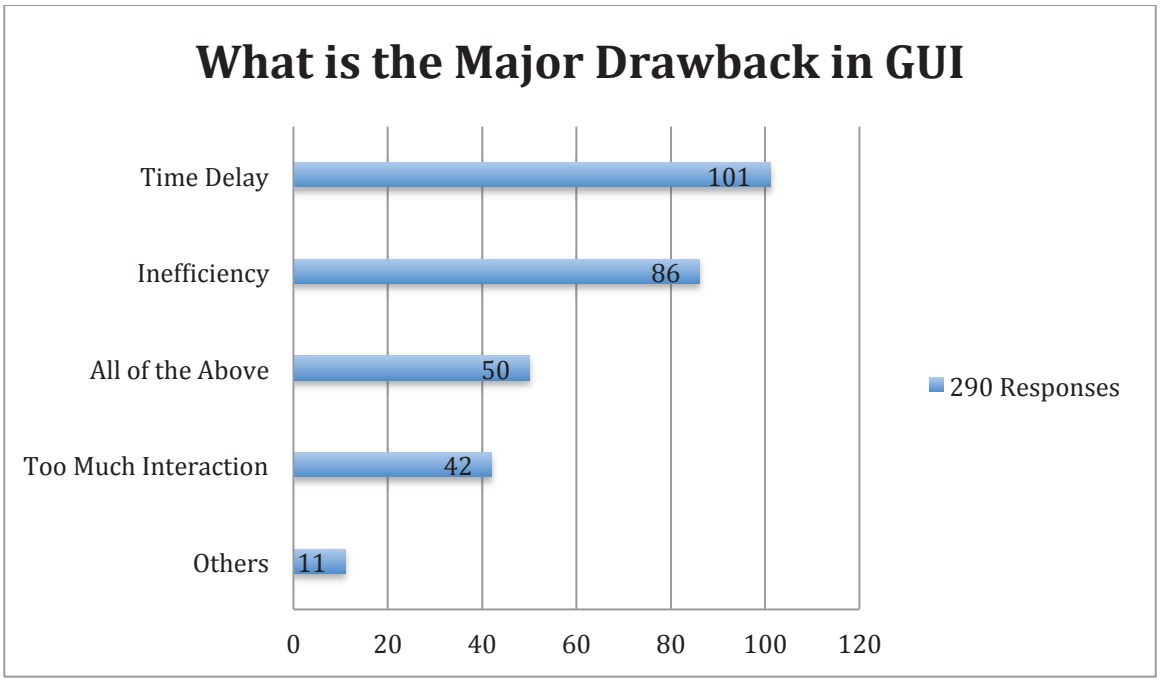

Figure5.4.Displays the information about the major drawbacks in GUI

Table5.7 Survey question about the improvements required in CLI based tools

Question: What are the improvements you want to see in CLI based tools?

When questioned what are the improvements that they like to have in CLI based tools (table 5.7). The 40 participants provided varied answers and explanation as to why. After categoring them we have included few examples of results. These included“More tools should have an option format the output so importing in other software is easier. (E.g. to plot graphs.)”;“There are good CLIs, and good visualization tools. There are rarely good 'glue' between them”; “Where appropriate, progress indicators so you have a reasonable estimate of when the process will complete”; “Provide more feedback and interaction”; “More CLI tools should use color to encode more information (positive examples: git, vim syntax highlighting)”;“simple way to send any metric off to a reporting system”; “Standard ways of interactions, consistent format and semantics”; “Better help/Man pages”; “better error messages”; “Just better way for presentation/formatting is a problem”; “The only time that I find GUI tools useful is when there's a complex model that's hard to convey by text alone. For example, I it is easier to show various RAID configuration options with a GUI”; “Command spell check”.

Table5.8 Survey question about the improvements required in GUI based tools

Question: What are the improvements you want to see in GUI based tools?

When questioned about what are the improvements that they like to have in GUI based tools (table 5.8). The 46 participants provided varied answers and explanation as to why. After categoring them we have included few examples of results. These included“ease to import data”; “Scriptability (e.g. AppleScript), or a CLI backend to allow for install/updates/settings adjustments without having to dig through potentially obscure menus”; “Better keyboard navigation”; “Better UI design; true cross-platform interfaces which work on Linux desktop, Android tablet/phone, etc.”; “More implementation of aggregation / drill down capabilities”; “Solid and detailed documentation of the visual displays”; “A standard automation mechanism”; “Any tool that can be used as a GUI also needs to have an API so that it can be automated, though. 85% of my work is automation”.

5.1.2 Prioritization at Work

Table 5.9 Survey question about what grabs maximum attention at work

Question: What grabs your maximum attention at work? ***Options:*** *Catastrophic Effects, Domain Specific, Management Issues, Security Issues, Client based problems (service oriented), None of the above, Others, All of the above*

When questioned what grabs the maximum attention at work (table 5.9) 113/290 participants opted for catastrophic effects, 76 opted for domain specific, 30 opted for management issues, 60 opted for security issues, and 11 opted for client based problem. ll participants selected one of the provided responses, none of them chose the “none of the above option”, “others”, “all of the above”.

Table 5.10 Survey question about does any tool help in prioritization

Question: Does any tools help in prioritization? ***Options:*** *Yes, if yes, provide the tool name (optional); No; Others*

When questioned does any help in prioritization of work (table 5.10), 40/290 participants opted for yes, 201 opted for no, and 49 opted for others.
All participants selected one of the provided responses. The fourty participants who opted for “yes” provided varied answers. After categoring them we have included few examples of results. These included “ticketing tools – but not effective”; “scripting can be done”. Fourty nine participants selected “others” and provided varied answers and explanation as to why. In general every participant said “need to be scripted” ; “certain amount of priortization is the time management tools”, “certain ticketing tools has provided prioritization but it completely client based and not effective”.

Table 5.11Survey question about visualization can help in prioritization

Question: Do you think visualization can help in the process? ***Options:*** *Yes, if yes, provide example (optional); No*

When questioned whether visualization can help in their work routine (table 5.11) 270/290 participants opted for yes, and 20 opted for no.
All participants selected one of the provided responses. The 270 participants who opted for “yes”, out of which 96 only provided answers. After categoring them, we have included few examples of results. These included “clustering features”; “data visualization”; “information visualization”; “knowledge visualization” and “visual analytics”.

5.1.3 Choice of Tool

Table 5.12 Survey question about are you a part of tool selection process

Question: Do you participate in the tool selection process? ***Options:*** *Yes; No; Not Applicable*

When questioned whether they participate in the tool selection process (table 5.12) 130/290 participants opted for yes, and 120 opted for no, and 40 opted for not applicable.
When questioned who chooses the tool (table 5.13), 11 participants opted for management and sys admin together, and 109 participants opted for ultimate decision by management but you are allowed to give suggestion, 49 participants opted for

management only and 18 participants opted for team lead decision, 91 participants opted for team lead decision and management decision, and 12 participants opted for others. All participants selected one of the provided responses, none of them choosed the “none of the above option”. Twelve participants selected “others” and provided varied answers and explanation as to why. After categoring them we have included few examples of results. These included “small tools we buy and for costly tool we get the management approval”; “small tools we purchase with team leads permission and costly tools the management purchases”; “we don’t purchase tools we develop scripts”; and “we mostly use free online tools”.

Table 5.13 Survey question about are you a part of tool selection process

Question: Who takes the decision regarding the choice of tool? ***Options:*** *Management only; Management and Sys Admin combined together; Ultimate Decision by Management but you are allowed to give suggestion; Team Lead Decision and Management decision; Others; Team Lead Decision; None of the above; Others*.

Table 5.14 Survey question about how do you choose a tool over the other

Question: How do you choose a tool over the other? ***Options:*** *Based on Need; Cost; Based on recommendations; Based of reviews; Brand of tool (renowned tool or the organization); None of the above; Others; All of the above*

When questioned how do they choose a tool over the other (table 5.14) 142/290 participants opted for all of the above, 40 participants opted for based on cost, 39 participants opted based on reviews, 31 participants opted for based on recommendations, 20 participants opted for need, and 18 participants opted for brand of the tool .All participants selected one of the provided responses, none of them chose the “none of the above option” and “others”.

Table 5.15 Survey question about available online inventory list

Question: Does any online inventory list helps in decision making? ***Options:*** *Yes, if yes specify; No; Others*

When questioned do they use any online inventory list (table 5.15) 80 participants opted for yes, 50 opted for based on cost, and 160 opted for others. All participants who opted for “yes”, out of which 62 answered provided varied answers and explanation as to why. After categoring them we have included few examples of results. These included “google”, “blogs”, “sys admin groups” and participants who opted for “others”, out of which 88 answered provided varied answers and explanation as to why. After categoring them we have included few examples of results. These included“not reliable completely”, “mostly influenced”, “can’t have a clear picture about the features in the tools”, and “none of the inventory list provides video clips or picture”.

Table 5.16 Showcases the number of participant participated in each section of the study

Task Performed	**Phase2 (N=331)**
Documentation	**181 (55%)**
Troubleshooting	**172 (52%)**
Monitoring	**162 (49%)**
Security	**132 (40%)**
Network	**116 (35%)**
Model	**78 (25%)**
Tech Support	**71 (21%)**
Backup	**70 (21%)**
Data Management	**62 (19%)**
Management (Team Lead)	**31 (9%)**
Web	**31 (9%)**
Infrastructure & Configuration Management	**27 (8%)**
Remote Systems Support	**16(5%)**
Virtualization	**9 (3%)**

5.2 SECURITY

When questioned do they perform security related tasks (table 5.17) 331 participants, 227 participants participated in this section of study. In which 132 participants performed security as part of their routine (see table 5.16).

Table 5.17 Survey question whether they perform security related tasks

Question: Do perform security related task as a part of your routine?
Options: *Yes, No, Not Applicable, Skip*

When enquired about the separate security team 45 said they have a separate security team, 80 said they don't, and the rest 7 opted 'prefer not to answer'. When questioned whether you are one among the security team 28 said 'yes', 85 said 'no', and 19 said 'prefer not to answer'.

We mainly focused on to check the acceptance of visualization in security tools. When we questioned do you think visualizations might help you in performing your security tasks 78 out of 132 agreed and 54 disagreed.

When questioned about what are the features and visualizations that they like to have in future tools. Out of 132 partcipants only 76 provided varied answers and explanation as to why. After categoring them we have included few examples of results. These included "alerts, for example when an error occurs or virus attacked", and "visualization of logs". The admins also cautioned that the presence of visualization in security domain such as "should not lead to security leaks".

Table 5.18 Survey question what security tasks they perform

Question: Which of the following security tasks you perform?
Options: *Perform and respond to security audits, Design services incorporating security requirements, Solve IT security issues of end-users, Implement security controls, Mitigate vulnerabilities, Administer security devices, Respond to security incidents, Others, All of the above, None of the above, Skip*

When we questioned about what security tasks they perform (table 5.18) 132 participants, 64 participants opted for mitigate vulnerabilities, 59 opted for implement security controls, 54 opted for respond to security incidents, 53 opted for design services incorporating security requirements, 52 opted for perform and respond to security audits, 51 opted for solve IT security issues of end-users, and 42 opted for administer security devices, Fifteen participants selected "others" and provided varied answers and explanation as to why. After categoring them we have included few examples of results.

These included “stress analysis”, “damage assessment”, “threat evaluation”, and “risk analysis”. None of them chose the “all of the above” and “none of the above” options.

5.3 NETWORK

When questioned do they perform network related tasks (table 5.19) 331 participants, 222 participants participated in this section of study. In which 116 participants performed network related tasks as a part of their daily routine (see table 5.16).

Table 5.19 Survey question whether they perform network related tasks

Question: Do perform network related task as a part of your routine? ***Options:*** *Yes, No, Not Applicable, Skip*

We mainly focused on to check the acceptance of visualization in networking tools. When we questioned do you think visualizations might help you in performing your networking tasks 113 out of 116 agreed and 3 disagreed.
When questioned about what are the features and visualizations that they like to have in future tools. Out of 116 partcipants only 61 provided varied answers and explanation as to why. After categoring them we have included few examples of results. These included “IpV6 support”; “detect bottleneck traffic "and “flexible access lists in firewalls (the ability to define URL or domain names instead of IP)”.

5.4 MONITORING

When questioned do they perform monitoring related tasks (table 5.20) 331 participants, 213 participants participated in this section of study. In which 162 participants performed network related tasks as a part of their daily routine (see table 5.16).

Table 5.20 Survey question whether they perform monitoring related tasks

Question: Do perform monitoring related task as a part of your routine? ***Options:*** *Yes, No, Not Applicable, Skip*

We mainly focused on to check the acceptance of visualization in monitoring tools. When we questioned do you think visualizations might help you in performing your monitoring tasks 162 out of 162 agreed.

When questioned about what are the features and visualizations that they like to have in future tools. Out of 162 partcipants only 81 provided varied answers and explanation as to why. After categoring them we have included few examples of results. These included “monitoring tools lacks in integration between alerting and graphing”; “ability to automatically repair certain types of problems”; and "ease in configuration and implementation”.

5.5 TECH SUPPORT

When questioned do they perform tech support related tasks (table 5.21) 331 participants, 216 participants participated in this section of study. In which 71 participants performed tech support related tasks as a part of their daily routine (see table 5.16).

Table 5.21 Survey question whether they perform tech support related tasks

Question: Do perform tech support related task as a part of your routine? ***Options:*** *Yes, No, Not Applicable, Skip*

We mainly focused on to check the acceptance of visualization in tech support tools. When we questioned do you think visualizations might help you in performing your monitoring tasks 70 out of 71 agreed.

When questioned about what are the features and visualizations that they like to have in future tools. Out of 71 partcipants only 30 provided varied answers and explanation as to why. After categoring them we have included few examples of results. These included “improvement of UI”; “interactivity with the client”; and “the workflow is invariably clunky and difficult to use”; “involves too many clicks and keystrokes”. Also, 15 felt most of their reporting options lack creative insight into data analytics and business or operational intelligence. One of the participant reported, “Perldesk lacks ability to CC multiple people in a ticket for email”.

5.6 TROUBLESHOOTING

When questioned do they perform troubleshooting related tasks (table 5.22) 331 participants, 218 participants participated in this section of study. In which 172 participants performed troubleshooting related tasks as a part of their daily routine (see table 5.16).

Table 5.22 Survey question whether they perform troubleshooting related tasks

Question: Do perform troubleshooting related task as a part of your routine? ***Options :*** *Yes, No, Not Applicable, Skip*

We mainly focused on to check the acceptance of visualization in troubleshooting tools. When we questioned do you think visualizations might help you in performing your troubleshooting tasks 168 out of 172 agreed.

When questioned about what are the features and visualizations that they like to have in future tools. Out of 171 partcipants only 42 provided varied answers and explanation as to why. After categoring them we have included few examples of results. These included "desire for a tool that understands the model of their system and could help standardize/encapsulate standard chunks of our troubleshooting process"; "a tool to create troubleshooting charts with powerful search capabilities and pattern recognition"; "a bug tracking system that scanned updates & error messages to compare them to previously logged bugs".

5.7 DATA MANAGEMENT

When questioned do they perform data management related tasks (table 5.23) 331 participants, 189 participants participated in this section of study. In which 62 participants performed data management related tasks as a part of their daily routine (see table 5.16).

Table 5.23 Survey question whether they perform data management related tasks

Question: Do perform data management related task as a part of your routine? ***Options:*** *Yes, No, Not Applicable, Skip*

We mainly focused on to check the acceptance of visualization in database tools. When we questioned do you think visualizations might help you in performing your data management tasks 61out of 62 agreed.

When questioned about what are the features and visualizations that they like to have in future tools. Out of 62 partcipants only 18 provided varied answers and explanation as to why. After categoring them we have included few examples of results. These included "visualization to keep track of the status of the data capacity"; "simple data visualizations"; and "visual analytics".

5.8 BACKUP

When questioned do they perform backup related tasks (table 5.24) 331 participants, 222 participants participated in this section of study. In which 70 participants performed backup related tasks as a part of their daily routine (see table 5.16)

Table 5.24 Survey question whether they perform backup related tasks

Question: Do perform backup related task as a part of your routine? ***Options:*** *Yes, No, Not Applicable, Skip*

We mainly focused on to check the acceptance of visualization in backup support tools. When we questioned do you think visualizations might help you in performing your backup tasks 68 out of 70 agreed.

When questioned about what are the features and visualizations that they like to have in future tools. Out of 70 partcipants only 32 provided varied answers and explanation as to why. After categoring them we have included few examples of results. These included"centralized web interface to see backups across many hosts"; "alert sys admins to know whether or not backup failed or was otherwise not performed"; and "integrity checks for backup"; "simple visualization such as how my backups are progressing, covering multiple machines".

5.9 MANAGEMENT – TEAM LEAD

When questioned do they perform management related tasks (table 5.25) 331 participants, 206 participants participated in this section of study. In which 31 participants performed management related tasks as a part of their daily routine (see table 5.16).

Table 5.25 Survey question whether they perform management related tasks

Question: Do perform management related task as a part of your routine? ***Options:*** *Yes, No, Not Applicable, Skip*

We mainly focused on to check the acceptance of visualization in management tools. When we questioned do you think visualizations might help you in performing your management tasks 31 out of 31 agreed.

When questioned about what are the features and visualizations that they like to have in future tools. Out of 31 partcipants only 21 provided varied answers and explanation as to

why. After categoring them we have included few examples of results. These included " a tool to track the team advancement in a project"; "a tool to keep track of employee updates"; and " a tool to categorize the skill level of each employee based on the task done or problems solved".

5.10 DOCUMENTATION

When questioned do they perform documentation related tasks (table 5.26) 331 participants, 213 participants participated in this section of study. In which 181 participants performed management related tasks as a part of their daily routine (see table 5.16).

Table 5.26 Survey question whether they perform documentation tasks

Question: Do perform documentation as a part of your routine? ***Options:*** *Yes, No, Not Applicable, Skip*

We mainly focused on to check the acceptance of visualization in documentation tools. When we questioned do you think visualizations might help you in performing your documentation tasks 175 out of 181 agreed.

When questioned about what are the features and visualizations that they like to have in future tools. Out of 181 partcipants only 59 provided varied answers and explanation as to why. After categoring them we have included few examples of results. These included "good indexing"; "search features"; " heuristic analysis" and "knowledge visualization".

5.11 INFRASTRUCTURE AND CONFIGURATION MANAGEMENT

When questioned do they perform infrastructure and configuration management related tasks (table 5.27) 331 participants, 172 participants participated in this section of study. In which 27 participants performed infrastructure and configuration management related tasks as a part of their daily routine (see table 5.16).

Table 5.27 Survey question whether they perform infrastructure and configuration management tasks

Question: Do perform infrastructure and configuration management as a part of your routine? ***Options:*** *Yes, No, Not Applicable, Skip*

We mainly focused on to check the acceptance of visualization in infrastructure and configuration management tools. When we questioned do you think visualizations might

help you in performing your infrastructure and configuration management tasks 27 out of 27 agreed.

When questioned about what are the features and visualizations that they like to have in future tools. Out of 27 partcipants only 11 provided varied answers and explanation as to why. After categoring them we have included few examples of results. These included "simple data visualization to keep track of the deployments done in the organization"; and "visual analytics to know the keep track of the available resources in the organization".

5.12 VIRTUALIZATION

When questioned do they perform virtualization related tasks (table 5.28) 331 participants, 157 participants participated in this section of study. In which 9 participants performed virtualization related tasks as a part of their daily routine (see table 5.16).

Table 5.28 Survey question whether they perform virtualization tasks

Question: Do perform virtualization related task as a part of your routine? ***Options:*** *Yes, No, Not Applicable, Skip*

We mainly focused on to check the acceptance of visualization in virtualization tools. When we questioned do you think visualizations might help you in performing your virtualization tasks 7 out of 9 agreed.

Table 5.29 Survey question what type of virtualization they perform

Question: Specify the type of virtualization? ***Options:*** *Data, Distributed File System, Memory, Operating System, Storage, Network, Service, Application, None, All of the above and Others*

When we questioned about the type of virtualization used (table 5.29) 4 opted for storage and network virtualization; 3 opted for data, storage and application; 2 opted for all of the above.

When questioned about what are the features and visualizations that they like to have in future tools. Out of 9 partcipants only 7 provided varied answers and explanation as to

why. After categoring them we have included few examples of results. These included “a tool that support all application”; and “visual analytics in deployment maps”.

5.13 WEB ADMINISTRATION

When questioned do they perform virtualization related tasks (table 5.30) 331 participants, 195 participants participated in this section of study. In which 31 participants performed web administration related tasks as a part of their daily routine (see table 5.16).

Table 5.30 Survey question whether they perform web administration tasks

Question: Do perform web administration related task as a part of your routine? ***Options:*** *Yes, No, Not Applicable, Skip*

We mainly focused on to check the acceptance of visualization in web administration tools. When we questioned do you think visualizations might help you in performing your web administration tasks 31 out of 31 agreed.

When questioned about what are the features and visualizations that they like to have in future tools. Out of 31 partcipants only 23 provided varied answers and explanation as to why. After categoring them we have included few examples of results. These included “easy way to automate upgrades of multiple web sites in an automated fashion”; “there's no good open-source alternative to Exchange tool”; “tools like Dreamweaver lack the ability to make clean HTML integration with a version control system”; and “not enough visual detail of queue status and flow web”.

5.14 REMOTE SYSTEM SUPPORT

When questioned do they perform remote system support related tasks (table 5.31) 331 participants, 187 participants participated in this section of study. In which 16 participants performed remote system support related tasks as a part of their daily routine (see table 5.16).

Table 5.31 Survey question whether they perform remote system support tasks

Question: Do perform remote system support related task as a part of your routine? ***Options:*** *Yes, No, Not Applicable, Skip*

We mainly focused on to check the acceptance of visualization in report system support tools. When we questioned do you think visualizations might help you in performing your remote system support tasks 8 out of 16 agreed.
When questioned about what are the features and visualizations that they like to have in future tools. Out of 4 partcipants only 16 provided varied answers and explanation as to why. After categoring them, we have included few examples of results. These included "simple visualization to know the state of the support system", "network traffic"; "connectivity diagrams". The admins also cautioned that the presence of visualization in remote system support domain such as "should not affect the quality of service and speed".

5.15 MODELS

When questioned do they use models (table 5.32) 331 participants, 141 participants participated in this section of study. In which 78 participants used models as a part of their daily routine (see table 5.16).

Table 5.32Survey question whether they use models

Question: Do use models as part of your routine?
Options: *Yes, No, Not Applicable, Skip*

We mainly focused on to check the acceptance of visualization in interactivity and visualization in tools. When we questioned do you think interactivity and visualizations might enhance the models available 78 out of 78 agreed.
When questioned about what are the features and visualizations that they like to have in future tools. Out of 78 partcipants only 61 provided varied answers and explanation as to why. After categoring them we have included few examples of results. These included "interactivity in models"; "guide through the process"; "hardware visualization"; "software visualization"; and "knowledge visualization imparted in models, which might help in decision-making process".

5.16 LIMITATIONS

In this study, we collected the data through, an online survey. The problem with the questionnaire is it takes some time as there were some open-ended questions in the survey and also it depends upon the participants' ability to suggest solution for the problems that they face in their daily routine. Moreover, the participants had some technical difficulties to fill out the survey as the survey software required a Mac or Windows machine, 11 participants reported this problem.

5.17 SUMMARY

This chapter comprised of quantitative results of the study, which we conducted to know the features that they desire and, the need for visualizations that sys admins tools.
The results showed that the overall participants desire enhanced visualizations and would like to use them as a part of their daily routine.
The results also indicate that the participants in every domain of system administration work acceptance rate is more than 90% except for security and remote system support the acceptance rate is less than 60%. Because they feel that enhanced visualization can affect their system performance.

CHAPTER 6 RECOMMENDATIONS OF DESIRED FEATURES AND GUIDELINES

In this chapter we will discuss in detail the need and expectation of sys admin for their tools in future. Based on the recommendations for the findings reported in Chapter 4 and 5, we provide desired features and guidelines to be considered while designing a CLI based tools (Section 6.1), GUI based tools (Section 6.2), security tools (Section 6.3), network tools (Section 6.4), monitoring tools (Section 6.5), tech support tools (Section 6.6), troubleshooting tools (Section 6.7), data management tools (Section 6.8), backup tools (Section 6.9), management tools (Section 6.10), documentation tools (Section 6.11), infrastructure and configuration management tools (Section 6.12), virtualization tools (Section 6.13), web administration tools (Section 6.14), and remote system support tools (Section 6.15). Later, the chapter focuses on the implementation of prioritization in tools (Section 6.16), inventory features to support in the decision making process in choosing a tool (Section 6.17), and interactivity in models (Section 6.18). Finally, we conclude the chapter with a summary of key characteristics and features required in each domain of sys admin tool (Section 6.19). Some of these recommendations and suggestions may seem obvious and most of the tools available in the market partially fulfill these in some way. However, based on our participant's feedback there is a lot of room for improvement in current sys admin tools.

6.1 CLI Based Tools

The results (Section 4.2 & Section 5.1.1) show that a CLI is popular among the sys admin population for its automation, lower resource usage, reliability, speed, and accuracy [31]. However, it lacks in interaction, visualization, and GUI output; and it requires experience to handle the interface.

Based upon the findings, we have recommended few desired features and guidelines to be considered when designing CLI based tools for sys admin:

1) Provide an auto complete option; command spell check can be implemented.
2) Provide ability to visualize log files [49].

3) Provide progress indicators to have a reasonable estimate of when the process will complete.
4) Provide a man or help page; this is available in certain tools, like 'powershell' but it requires enhancements such as up to date solution for recent issues.
5) Provide more interactive features in the tools.
6) Provide search features such as pattern search or information search.
7) Provide a way to input or modify data via CLI and present output in a GUI.
8) Provide efficient usage of color codes and highlighters at the location of errors or other indicators to help sys admins notice the error more quickly [34, 49]

6.2 GUI Based Tools

The results highlight that the GUI is popular among the population for its visualization, ease of use, and interaction, but it is often criticized about its efficiency, time delay, and need for too much interaction (Section 4.2 & Section 5.1.1).
Based upon the findings we have recommended key tool characteristics that should be addressed while designing GUI based tools for sys admins:

1) Compatibility: Requirements to support the tool should be less and mainly the tool should be supported by every platform.
2) Clarity: The interface should be clumsy and it should be simple enough to explore all the features with minimum guidance [31].
3) Accuracy: The data or information provided should be accurate [4, 31].
4) Speed: The presence of the GUI should not affect the speed of the process [31].
5) Automation: Provide the ability for sys admins to implement automation at least for common procedures.
6) Reduce the steps: Avoid too much interaction to complete a procedure or if possible replace too much interaction with simple icons.
7) Scriptability: Provide the ability to script in GUI based tools.
8) Keyboard navigation: Avoid too mouse interaction and use keyboard navigation, which might speed up the process [37].
9) Data analysis: Provide implementation of aggregation / drill down capabilities.

6.3 SECURITY TOOLS

Based upon our findings (Section 4.3 & Section 5.2). We would like to highlight some points to be considered when designing a tool to support an admin in handling security incidents:

1) Provide reasons to rely on the software such as make them feel that their data is secured and the possibility of security threats are less [4].
2) Provide facilities to implement changes uniformly and implement a set of checks against all machines simultaneously.
3) Provide ability to tune the alert engines.
4) Provide features to automate, routine work such as scans.
5) Provide features to automatically update the system on feedback several integrated system and classify what is a problem; what could be a problem, and what is not important [36].
6) Provide dashboard to view the time stamping the access of syslog files.
7) Provide secure storage facilities such as to store an important data within the workstation (like a partitioned disk that doesn't consume much space but can accommodate crucial data and protect it with password security etc.)
8) Provide features to classify the priorities and to provide better dashboard facilities to help narrow down what to work on; what shouldn't get in on their way unless it needs to.
9) Provide features to avoid and identify false positives.
10) Provide ability to correlate different information based on feedback or documentation, which in turn can help in decision-making process.
11) Provide ability to categorize "Emergent" vs. "Cause for Concern" vs. "Might indicate problem" on basis of catastrophic effects.
12) Provide useful color coding, and filtering options etc. [49]
13) Provide ability to group common problems across multiple machines.
14) Provide categorization based on area of responsibility, importance of machines (highlighting high priority machines, low priority machines), importance of this type of problem, etc.
15) Provide ability to instantly point to a root cause of the problem.

6.4 NETWORK TOOLS

Based upon our findings (Section 4.4 & Section 5.3), we would like to highlight some points to be considered when designing a tool to support an admin in handling network related tasks:

1) Provide heuristic analysis from the existing documentation [47].
2) Provide context-based analysis will help in getting the required data through searches.
3) Provide real-time data, to make the work efficient.
4) Provide simple, robust integration with a network management-reporting engine.
5) Provide support to IPv6 address. As the networking tools are not completely updated yet.
6) Provide simple custom metrics, e.g. number of entries in the ARP tables of all routers across the organization, number of DHCP discovers/offers/etc. in the past hour/day/week across the organization (or by subnet, host, site, etc.)
7) Provide tree diagrams for each network object with its current status, priority, and performance.
8) Provide scalability of data [34].
9) Provide useful built-in metrics that help us accurately gauge the state of our network (Charts that show user traffic patterns, error messages, logs in and out, traffic rates, and port utilizations)

6.5 MONITORING TOOLS

Based upon our findings (Section 4.5 & Section 5.4). We would like to highlight some points to be considered when designing a monitoring tool to support sys admin in their work routine:

1) Provide tunable and effective alert options.
2) Provide root cause analysis to identify the cause of the problem.
3) Provide ease in configuration of hosts.
4) Provide ability to automatically repair common problems.
5) Provide effective diagnostic map.

6) Provide useful built-in metrics that help in accurately gauge the state of the system.
7) Provide a time line to showcase the changes (before and after the problem) occurred.
8) Provide the immediate set of solutions that might be helpful to solve the problem popped in (based on the knowledge obtained from past troubleshooting process or from documentation) [36].

6.6 Tech Support Tools

Based upon our findings (Section 4.6 & Section 5.5). We would like to highlight some points to be considered when designing a tool to support an admin in solving tickets:

1) Provide heuristic analysis from the existing documentation [47].
2) Provide integration between ticketing and documentation tools, which will help in solving the problem based on prior documented solution.
3) Provide automation to send the state of the system when the ticket is send to the admin.
4) Provide better communication with the client such as live chat.
5) Provide prioritization to a ticket based on the importance of this type of problem and catastrophic effects.

6.7 Troubleshooting Tools

Based upon our findings (chapter 4.7 & 5.6). We would like to highlight some points to be considered when designing a tool to support an admin in handling troubleshooting related tasks:

1) Provide heuristic analysis from the existing documentation, which might help in solving the problem with ease [47].
2) Provide useful built-in metrics that help in accurately gauge the state of the system.
3) Provide prioritization options.
4) Provide a time line to showcase the changes (before and after the problem) occurred.

5) Provide indications of processes that are affected due to the problem caused.
6) Provide root cause analysis to identify the exact reason for the cause, from which a caution can be raised to avoid similar problem in future.

6.8 Data Management Tools

Based upon our findings (Section 4.8 & Section 5.7). We would like to highlight some points to be considered when designing a database tool to support sys admin in their work routine:

1) Provide ability to secure data from data loss.
2) Provide features to efficiently use the storage capacity of the system.
3) Provide scalability of huge data [34].
4) Provide database updates (capacity, status, storage location).

6.9 Backup Tools

Based upon our findings (Section 4.9 & Section 5.8). We would like to highlight some points to be considered when designing a backup tool to support sys admin in their work routine.

1) Provide alerting for sys admins to know whether or not backup failed or was otherwise not performed.
2) Provide integrity checks.
3) Provide centralized web interface to see backups across many hosts; how my backups are progressing; covering multiple machines.
4) Provide catastrophic restorations.
5) Provide integration between backup and monitoring (dashboard facilities) tools. It might help in tracking the backup updates.

6.10 Management Tools

Based upon our findings (Section 4.10 & Section 5.9). We would like to highlight some points to be considered when designing a tool to support the team lead and as well communication with the team:

1) Provide notification features to convey information effectively and quickly.

2) Provide discussion setup (Google hangouts; Blogs; Email altogether) and more options for effective communication.
3) Provide sharing knowledge and suggestion setup [48].
4) Provide features to support in planning infrastructure deployments or changes.
5) Provide supportive features to allocate resource and perform dependency checks.
6) Provide useful built-in metrics that help in accurately gauge the state of the project.
7) Provide options to classify the jobs on based on their priority.

6.11 Documentation Tools

Based upon our findings (Section 4.11 & Section 5.10). We would like to highlight some points to be considered when designing a documentation tool to support sys admin in their work routine:

1) Provide heuristic analysis from the existing documentation, which might help in solving the problem with ease [47].
2) Provide integration between documentation and troubleshooting process to help in suggesting solutions.
3) Provide integration between documentation and ticketing tools.
4) Provide automatic documentation options such as presence of icons like bookmarks.
5) Provide effective categorization options.
6) Provide efficient search features.

6.12 Infrastructure and Configuration Management Tools

Based upon our findings (Section 4.12 & Section 5.11). We would like to highlight some points to be considered when designing an infrastructure and configuration management tool to support sys admin in their work routine.

1) Provide statistics about deployment details.
2) Provide resource management features.
3) Provide dependency checks.
4) Provide features to track the repair frequency of the system.

5) Provide features to store and alert regarding the system warranties.

6.13 VIRTUALIZATION TOOLS

Based upon our findings (Section 4.13 & Section 5.12). We would like to highlight some points to be considered when designing a virtualization tool to support sys admin in their work routine.

1) Provide visualization of the whole setup after deployment.
2) Provide the presence of GUI without affecting the speed of the system.
3) Provide ability to avoid catastrophic consequences.
4) Provide support to all the applications.
5) Provide suggestion to minimize the impact of an outage after the deployment done.
6) Provide alert when the setup is overloaded.
7) Provide features to support effective capacity planning.

6.14 WEB ADMINISTRATION TOOLS

Based upon our findings (Section 4.14 & Section 5.13). We would like to highlight some points to be considered when designing a web administration and mail server maintenance tool to support sys admin in their work routine:

1) Provide features to alert regarding the queue status and flow web.
2) Provide statistics of hosts from which we can be aware where mails came from (source).
3) Provide statistical information of flow rate and queue sizes - source/destination rates (top talker).
4) Provide statistical breakout of error conditions and delay queues; spam rate, error conditions, delay time.

6.15 Remote System Support Tools

Based upon our findings (Section 4.15 & Section 5.14). We would like to highlight some points to be considered when designing a remote system support tool to support sys admin in their work routine:

1) Provide quality of service to the remote clients.
2) Presence of any feature should not compromise the speed.
3) Provide frequent updates about the supported systems.
4) Provide features to predict catastrophic effects.

6.16 Tool to Support Prioritization

Based upon our findings (Section 4.16 & Section 5.1.2). We would like to highlight some points to be considered when designing a tool to support prioritization in sys admin work:

1) Provide features to script our own priority.
2) Provide prioritization on basis of catastrophic effects, domain specific and security audits.
3) Provide clustering features.
4) Provide automatic prioritization in ticketing tools based on heuristic analysis.

6.17 Tool to Support in Decision Making Process – Choosing a Tool

Based upon our findings (Section 4.17 & Section 5.1.3). We would like to highlight some points to be considered when designing a tool to support in the decision making process of choosing a tool over the other in sys admin work:

1) Provide description about features available in the tool and how the problem will be approached [47].
2) Provide a tool that can is compatible with the existing environment. The clients should not change the whole setup for using the tool.

6.18 Models

Based upon our findings (Section 4.18 & Section 5.15). We would like to highlight some points to be considered when designing a model to support sys admin in their work routine:

1) Provide integration between documentation and training new employee models.
2) Provide connectivity models to know the dependency of each system.
3) Provide model to locate the physical location of the system, which will be usual in a room of more systems.
4) Provide configuration checklists to keep a track of resources.
5) Provide data flow diagrams to know the status of the data.
6) Provide network flow diagrams, which helps understanding connections.
7) Provide hierarchy diagrams for reporting purpose.

6.19 SUMMARY

The chapter provided a summary the characteristics and features that sys admin desired in each domain based on our findings. Table 6.1 gives an overview of the key characteristics and the key features that is required in each domain of sys admin work. In the next chapter, we focus on the opportunities for visualizations.

Table 6.1 Displays Key Characteristics and Key Features required in each Tool Domain of Sys Admin Work

Tool Domain	Key Characteristics	Key Features
CLI Based	Interactivity	GUI Output, Search Options
GUI Based	Clarity, Reliability, Accuracy	Automation, Scripting
Documentation	Anonymity	Clustering, Search Options
Network	Scalability	Support to IPv6
Security	Accountability	Tunable Alert Engines
Data Management	Less resource usage	Alerts, Keep Track of Update
Virtualization	Speed	Avoid Catastrophic Effects
Monitoring	Accuracy	Heuristics Analysis
Remote System Support	Speed, Clarity	Avoid Catastrophic Effects
Web	Speed	Web Traffic
Prioritization	Automation	Based on Catastrophic Effects
Ticketing	Interactivity, Clarity	Integration of Documentation
Infrastructure & Configuration Management	Efficiency	Resources Available, Deployment and Dependency Maps
Backup	Reliability	Alerts
Management	Interactivity	Tracking of Project Status, Process
Models	Interactivity	Integration with Training Process

CHAPTER 7 VISUALIZATION OPPORTUNITY

In this chapter we will showcase the visualization opportunities available in each domain of sys admin work. In table 7.1,visualization applications are mapped to each domain on the basis of the results obtained in each study (Chapters 4 & 5) and the current state of art in tools. The visualizations listed are partially fulfilled in many tools, but there are a lot of areas that need to be improved. Refer back to definitions in Chapter 2. In general, irrespective of the domain, the presence of data and informational visualization will benefit the performance of sys admin tools.

Table 7.1 Displays Tool Domains and Visualization Opportunities available in each domain.

Tool Domain	Visualization Opportunity
CLI Based	**Product, Knowledge, Visual Analytics**
GUI Based	**Visual Analytics, Product**
Security	**Knowledge, Strategy, Visual Analytics**
Network	**Structure, Informational, System, Product**
Monitoring	**System, Product, Process, Knowledge**
Tech Support -Ticketing	**Knowledge, System, Product**
Troubleshooting	**Knowledge, Strategy, Product, Visual Analytics**
Database	**System, Visual Analytics**
Backup	**Structure, System**
Management	**Concept, Strategy, Process, Product**
Documentation	**Knowledge, Visual Analytics**
Infrastructure & Configuration Management	**Structure, Product, System, Visual Analytics**
Virtualization	**System, Structure**
Web Administration – Mail Server Maintenance	**Structure, Process**
Remote System Support	**Structure, System**
Prioritization	**Visual Analytics**
Choice of Tools	**Product**
Models	**Strategy, Process, Product**

7.1 VISUALIZATION OPPORTUNITIES IN CLI BASED TOOLS

The study results reveal that presence of data, informational visualization will benefit the performance of CLI based tools. The applications of visualization like product, knowledge visualization and visual analytics might benefit the sys admin in their work routine.

The output obtained from the CLI based tools can be displayed the output using simple data visualization like charts, and graphs. The large data available in the logs can be implemented as informational visualization for better understanding of data [7]. The informational visualization as well as visual analytics in visualizing the logs can help in the decision making process. The admins stated that help pages are not sufficient in their routine. The presence of knowledge visualization based on the tasks performed and problem solved with the history of data can provide the admins with suggestion, which will help them in solving problems [7, 36]. Scripting is one of the key advantages in CLI based tools but it suffers from experience and learning process [48]. Product visualization – software visualization that involves icons, buttons, labels, drop down list features can make the understanding of the scripting tool easier.

7.2 VISUALIZATION OPPORTUNITIES IN GUI BASED TOOLS

The study results reveal that presence of data, informational visualization will benefit the performance of GUI based tools. The applications of visualization like product visualization, and visual analytics might benefit the sys admin in their work routine.

The results reveal GUI has the capacity to provide better features to drill down the data, but it is lacking currently in the existing tools [4, 31]. Data visualization and informational visualization can be used to achieve more drill down features [7]. The presence of visual analytics will help in the decision making process from the data visualized. In general product visualization – software visualization can be used in documentation to guide the admin through any process [20].

7.3 Visualization Opportunities in Security Tools

The study results reveal that presence of applications of visualization like knowledge, strategy visualization, and visual analytics might benefit the sys admin in their work routine.

The results reveal the presence of knowledge visualization based on the heuristic analysis might help the admins to understand and solve a problem [42, 43, 44, 45, 46, 47]. The strategy visualization can be made for procedures that should be followed as a part of routine. The displays with the checks boxes will help them in understanding whether they have followed the procedure step by step [7]. The visual analytics would be an interesting inclusion which might help the admins in analyzing the data and act accordingly.

7.4 Visualization Opportunities in Network Tools

The study results reveal that presence of applications of visualization like structure, informational, system, and product visualization might benefit the sys admin in their work routine.

Structure visualization might help the understanding the hierarchy and the relationship between the networks and will help in avoiding such scenarios that leads to catastrophic effects. The informational visualization might give a clear picture about the host and the current occurrence in the network. The presence of system visualization will give the entire state of the system, the updates of the software and the available resources. The product visualization – hardware visualization might act as a guide for the admin to understand the peripherals connected to the network [7].

7.5 Visualization Opportunities in Monitoring Tools

The study results reveal that the presence of applications of visualization like process, product, system, and knowledge visualization might benefit the sys admin in their work routine.

Process visualization might help in keeping track of the updates in the project or a process or any developments or changes. The product visualization – hardware and software visualizations presence in monitoring tools will help in understanding the actual state and features of product and then they can track down the changes accordingly. The

system visualization would help when the admin wanted to know the current state of the system such a timeline. It might provide ease in understanding the state of the system. The knowledge visualization will help tracking back whether the particular incidents that is occurring at present has happened in past and how they have been handled.

7.6 Visualization Opportunities in Tech Support - Ticketing Tools

The study results reveal that presence of applications of visualization like product, system, and knowledge visualization might benefit the sys admin in their work routine. The presence of product visualization – software and hardware visualization might benefit the admins in understanding the product well before solving the problem [7]. The system visualization might benefit the admin in understanding the state of the system when the particular problem has occurred. The knowledge visualization might help the admin in the process of problem solving with the information of how the problem has been solved in the past scenarios.

7.7 Visualization Opportunities in Troubleshooting Tools

The study results reveal that presence of applications of visualization like product, strategy, knowledge visualization, and visual analytics might benefit the sys admin in their work routine.

The visualization about the product's hardware and software might help the admin in solving the problem in a better way. The strategy visualization might guide the admin in solving the problem. The general procedures can be visualized which in turn help the admin following the proper steps in approaching a problem. The knowledge visualization obtained from the past solutions might suggest the admins to solve the current problems [47]. The visual analytics will help in the process of decision making from the data or information obtained.

7.8 Visualization Opportunities in Data Management Tools

The study results reveal that presence of applications of visualization like system visualization, and visual analytics might benefit the sys admin in their work routine.

The presence of system visualization might help the understanding the capacity of the system, particularly the storage locations and the status of the data stored etc., The visual analytics might help the admins concluding the information obtained from large sets of data [21, 22, 23].

7.9 Visualization Opportunities in Backup Tools

The study results reveal that presence of applications of visualization like system, and structure visualization might benefit the sys admin in their work routine.
The structure visualization will provide information about the dependency and with the information we can avoid catastrophic effects. The system visualization can provide detail information regarding the capacity, availability of the system from which we can check the status of the backup.

7.10 Visualization Opportunities in Management Tools

The study results reveal that presence of applications of visualization like concept, process, product and strategy visualization might benefit the sys admin in their work routine.
The concept visualization might help in process of visualizing a proposed idea. The process visualization might help tracking the status of project or developments with the employee. The product visualization will assist the management in deciding whether the product fits in their work culture or not. The strategy visualization might provide the ease of conveying the strategy that should be followed by the employees in order to fulfill the management requirements.

7.11 Visualization Opportunities in Documentation Tools

The study results reveal that presence of applications of visualization like knowledge visualization and visual analytics might benefit the sys admin in their work routine.
The documentation process could be benefitted with the inclusion knowledge visualization as the information stored regarding a procedure to be followed or solution might help the admin. The visual analytics based on the data present in documentation

will help in the process of decision making regarding solving or predicting a problem or finding a solution [21, 22, 23].

7.12 Visualization Opportunities in Infrastructure and Configuration Management Tools

The study results reveal that presence of applications of visualization like system, structure, product visualization, and visual analytics might benefit the sys admin in their work routine.

The system visualization might help the admin in understanding the occurrences in the system. The structure visualization might help clearly stating the connectivity of each system, which might result in effective resource usage. The product visualization will help in utilizing the resource effectively. The visual analytics will give a clear picture about the deployment arrangement and might help in configuration process.

7.13 Visualization Opportunities in Virtualization Tools

The study results reveal that presence of applications of visualization like system, and structure visualization might benefit the sys admin in their work routine.

The system visualization will help in understanding of the state of the system and its capacities. The structure visualization will provide the state of the system connected from which the hierarchy and connectivity information of each system in the loop will be known.

7.14 Visualization Opportunities in Web Administration – Mail Server Maintenance Tools

The study results reveal that presence of applications of visualization like process, and structure visualization might benefit the sys admin in their work routine.

The process visualization can be used to automate the regular routine procedures followed for spam emails. The structure visualization can be used to determine the source of the problem.

7.15 Visualization Opportunities in Remote System Support Tools

The study results reveal that presence of applications of visualization like system, and structure visualization might benefit the sys admin in their work routine.
The system visualization might help in knowing the state of the supported system and the structure visualization might help in the process of avoiding catastrophic effects.

7.16 Visualization Opportunities in Prioritization of Tools

The study results reveal that presence of applications of visualization like visual analytics might benefit the sys admin in their work routine.
The visual analytics can be used in the classification of the work loaded. The admin might opt one based on their priority.

7.17 Visualization Opportunities in Choice of Tools

The study results reveal that presence of applications of visualization like product visualization might benefit the sys admin in their work routine.
The product visualization might provide a detailed description about the product, which will help in choosing the product, or not.

7.18 Visualization Opportunities in Models

The study results reveal that presence of applications of visualization like strategy, process, and product visualization might benefit the sys admin in their work routine.
The management rules should be visualized via strategy visualization. The way to approach or complete a process can be briefed via process visualization. The product visualization will describe the features as well showcase the use of each part or a feature in a product, which might act a guide to use the product.

CHAPTER 8 LIMITATIONS AND CHALLENGES

Although our research methods chosen had much strength, we would also like to give a brief overview of some of the challenges faced and the limitations of this research.

8.1 Access to Sys Admins

Getting access to the sys admin for the study purpose was not easy. Even though we got a lot of contacts from the various sources, the percentage of contextual inquiry was just 24% in phase 1. This was a result of various policies followed in the industry. In addition, the shared workspaces of many participants were not conducive to observations.

8.2 Observing Sys Admins at work

Observing sys admin during work is one of the major challenge in this research. Even though nine sys admins gave us access to their workspace, the work processes we observed wasn't in real time. Because the timing of the observation were mostly during the end of the day or when they were the only one in the industry working at late hours, only a fraction of their work routine was observed.

8.3 Gaining sufficient domain knowledge

Due to the low number of contextual inquiries, we weren't able to see much specific domain work in person. This limits our understanding of working the current tools. Instead we rely on the self-reported suggestion and recommendation of features reported to us by the sys admins.

8.4 Instrumenting current tools

We wanted to instrument tools listed in the various inventory lists, in order to investigate whether they actually satisfy the needs and desires of the sys admin. But we could not do it to a greater extend as most of the tools was costly and there is always a list of resources required to support each tool before the work.

8.5 Getting access to actual data

When we did contextual inquiries and semi-structure interviews due to the company policy most of the participants did not reveal the name of the tool. Instead they shared information about the issues and desired features with respect to their work domain or tool domain in general. This limits our ability to understand the tool environment.

8.6 Attaining domain breadth

In both the study we could not get many participants (i.e., virtualization, remote system support) in certain domains. One of the sys admin domains that is currently trending is virtualization and remote system support. However we could not get a large number of participants in these domains (virtualization phase 1 - 2 participants, phase 2 – 9 participants; remote system support phase 1 - 2 participants, phase 2 – 16 participants) during either phase of the research.

8.7 Participants Recruitment in Phase 1

In the phase 1 study 7 of our participants are currently studying in Canada, but had been sys admins prior to undertaking their studies. But at the time of the study they were not currently employed. The participants were relying on memories of their actions, workplace, environment, tools in their past and may not have remembered all details or be aware of some of the changes in technology. But all the participants had 2 years of experience and just started studying in Canada 3 months back.

8.8 Lack of Visualization Exposure

In the phase 1 study, certain participants had limited experience with the visualization tools. The suggestions provided by them, tend to have less sophisticated visualization improvements.

CHAPTER 9 FUTURE WORK AND CONCLUSION

In this chapter, we identify the future work that can be carried on in this domain, which is required to see what changes can bring presence of visualizations in their work environment. Finally we end the chapter with the overview of final conclusions.

9.1 FUTURE WORK

We would like to identify the list of tools currently used and the features they lack. Another student is currently working on finding out the available features in the current tools. Later, we can come to a conclusion with the analysis of both the data; find the gap in each tool with the recommendation listed. We might implement or develop a high fidelity prototype with the enhanced visualization and features according to the outcome of the analysis. Finally, we will conduct a comparative study with the existing tools to know the difference how much enhanced visualization can benefit in each domain of sys admin work.

We are also interested to conduct a study for each sub domain of system administration. We would like to select at least one of the popular tools and recruit participants who use the tools and see how they respond or have them look at and then suggest improvements accordingly.

9.2 CONTRIBUTION

From this research, tool designers can have a better understanding about the desired tool features and visualizations in each domain of system administration. To design a tool, understanding the domain and the need of the client is very essential. Both these aspects are covered in this research.

The subsequent researchers and experts can refer to our results to learn more about sys admin work and the opportunities for visualizations. The visualization experts may be able to suggest more visual based solutions for the problems listed. They can also take a lead from the visualizations mapped to each domain of sys admin work.

The stakeholders within the organization can identify the listed hindrances included in tool purchases in the current choice of tool. They can try to mitigate the chances of future tool purchases not addressing known concerns of sys admins.

9.3 CONCLUSION

Our results reveal that the sys admins who participated in our study would like improved visualizations for many of the task domains that are part of their daily routine. Our participants have given several suggestions of tasks where they feel that enhanced GUIs with visualizations would improve their tools. They also highlighted areas where adding enhanced visualizations may hinder their work. We conclude that our study results will be helpful to fill the gaps with visualizations and interactive models that assist the sys admins in their daily routine.

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APPENDICES

APPENDIX A - ETHICS APPROVAL FOR PHASE 1

DALHOUSIE UNIVERSITY
Inspiring Minds

Social Sciences and Humanities Research Ethics Board
Letter of Approval

Date: September 12,2012.

To: Jeevitha Mahendiran , Computer Science
Kirstie Hawkey, Computer Science

The Social Sciences Research Ethics Board has examined the following application for research involving humans:

Project # 2012-2751 (V2) (R# 1011668)

Title: Understanding the Use of Models and Visualization Tools in System Administration Work

and found the proposed research involving human participants to be in accordance with Dalhousie Guidelines and the Tricouncil Policy Statement on *Ethical Conduct in Research Using Humans.* This approval will be in effect for 12 months from the date indicated below and is subject to the following conditions:

1. Prior to the expiry date of this approval an annual report must be submitted and approved.
2. Any significant changes to either the research methodology, or the consent form used, must be submitted for ethics review and approval *prior to their implementation.*
3. You must also notify Research Ethics when the project is completed or terminated, at which time a final report should be completed.
4. Any adverse events involving study participants are reported immediately to the REB

Effective Date: September 11,2012.
Expiry Date: September 11,2013.

signed: [redacted]

IMPORTANT FUNDING INFORMATION - *Do not ignore*

To ensure that funding for this project is available for use, you must provide the following information and FAX this page to RESEARCH SERVICES at 494-1595

Name of grant /contract holder _____ Dept. _____
Signature of grant / contract holder _____
Funding agency _____
Award Number _____ Dal Account # (if known) _____

Dalhousie Research Services • Research Ethics • 6299 South Street,2nd Floor, Suite 231,PO Box 15000 • Halifax, NS, Canada • B3H 4R2 Tel: 902-494-3423 • Fax: 902-494-1595 • Email: ethics@dal.ca • www.dal.ca/~research

APPENDIX B – ETHICS APPROVAL CONTINUATION OF PHASE 1

Social Sciences & Humanities Research Ethics Board
Annual Renewal - Letter of Approval

September 17, 2013

Ms Jeevitha Mahendiran
Computer Science\Computer Science

Dear Jeevitha,

REB #: 2012-2751
Project Title: Understanding the Use of Models and Visualization Tools in System Administration Work

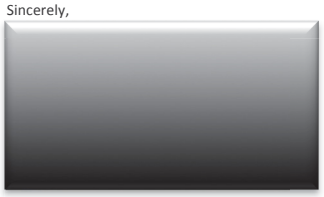
Expiry Date: September 11, 2014

The Social Sciences & Humanities Research Ethics Board has reviewed your annual report and has approved continuing approval of this project up to the expiry date (above).

REB approval is only effective for up to 12 months (as per TCPS article 6.14) after which the research requires additional review and approval for a subsequent period of up to 12 months. Prior to the expiry of this approval, you are responsible for submitting an annual report to further renew REB approval. Forms are available on the Research Ethics website.

I am also including a reminder (below) of your other on-going research ethics responsibilities with respect to this research.

Sincerely,



Dr. Sophie Jacques, Chair

APPENDIX C – ETHICS APPROVAL FOR PHASE 2

DALHOUSIE UNIVERSITY
Inspiring Minds

Social Sciences & Humanities Research Ethics Board
Letter of Approval

April 30, 2013

Ms Jeevitha Mahendiran
Computer Science\Computer Science

Dear Jeevitha,

REB #: 2013-2973
Project Title: Understanding the Use of Models and Visualization Tools in System Administration Work

Effective Date: April 30, 2013
Expiry Date: April 30, 2014

The Social Sciences & Humanities Research Ethics Board has reviewed your application for research involving humans and found the proposed research to be in accordance with the Tri-Council Policy Statement on *Ethical Conduct for Research Involving Humans.* This approval will be in effect for 12 months as indicated above. This approval is subject to the conditions listed below which constitute your on-going responsibilities with respect to the ethical conduct of this research.

Sincerely,

Dr. Sophie Jacques, Chair

APPENDIX D – RECRUITMENT SCRIPTS FOR PHASE 1

RECRUITMENT SCRIPT

Project Title: Understanding the Use of Models and Visualization Tools in System Administration Work

We are seeking participants to take part in a study about the tools used by system administrators. Ideally we would come to your workspace, so that we can interview you and you can show us your tools and any system models and visualizations. However, we would also welcome participation via an interview at the location of your choice, be it your work space, a meeting room at your location, a quiet room at Dalhousie University, or via a telephone conversation or video chat.

You will be asked about your goals, routines, the system models, and visualization tools you work with, and the difficulties faced. The interview will take approximately one hour. Through this study, we hope to understand the concerns of system admins and learn how to better design, tools to assist them in their daily routine.

Any identifying information (e.g. individual or the organization) will be anonymized before data analysis. Participation is voluntary and you can withdraw from participation at any time. If you think that any question would affect the confidentiality agreement of your organization or if you think it would put you in risk in anyway, you can avoid answering the question.

To be eligible to participate, you should be a system administrator. Participants will not receive any honorarium.

If you are interested in participating in this study, please contact Jeevitha Mahendiran by email at Jeevitha@cs.dal.ca.

APPENDIX E – CONSENT FORM PHASE 1

DALHOUSIE UNIVERSITY
Inspiring Minds

Informed Consent Form

Project Title: Understanding the Use of Models and Visualization Tools in System Administration Work

Principal Investigators:

Jeevitha Mahendiran, Master's Student, Faculty of Computer Science

Kirstie Hawkey, Assistant Professor, Faculty of Computer Science

Nur Zincir-Heywood, Professor, Faculty of Computer Science

Ramandeep K. Dhillon, Master's Student, Faculty of Computer Science

Contact Person: Jeevitha Mahendiran, Jeevitha@cs.dal.ca [902-9997763]

We invite you to take part in a research study at Dalhousie University. Your participation in this study is voluntary, and you may withdraw from the study at any time. If you are a student or employee of Dalhousie University, your academic or employment performance evaluation will not be affected by whether or not you participate. This study does not involve any additional risk to you or to others outside of those posed in everyday life. The study is described below. Your participation in the study might not benefit you directly, but we might learn things that will benefit others. You should discuss any questions you have about this study with the principal investigators who will be administering the study.

The purpose of the study is to design a tool or a model to assist a system admin in their daily routine. We want to know about your goals, routines, the system models, and visualization tools you work with, and the challenges you face in your day-to-day work. Your participation consists of an interview conducted at your workplace or a place convenient to you, in which the researcher will ask you about these topics. Optionally you can show us your workspace and the tools you use. You can also participate in the interview by telephone or video chat.

Please do not answer anything that affects the confidentiality agreement of your organization. You should avoid answering any question that makes you think it would be a risk to you in any way.

To be eligible to participate, you should be a system administrator.

The entire session is expected to take about 60 minutes.

The interview will recorded on a digital audio recorder and will be transcribed by a professional transcriber. All personal and corporate identifying data will then be removed from the transcript, and the audio file will be destroyed. The data you provide will be kept and reported under a code name only. The informed consent form and all research data will be kept in a secure location for five years after the end of the study.

In the event that you have any questions, or wish to voice concerns, about any aspect of your participation in this study, you may contact Catherine Connors, Director, Office of Research Ethics Administration at Dalhousie University's Office of Human Research Ethics for assistance: phone: (902) 494-1462, email: Catherine.Connors@dal.ca.

Project Title: Understanding the Use of Models and Visualization Tools in System Administration Work

"I *have read the explanation about this study. I have been given the opportunity to discuss it and my questions have been answered to my satisfaction. I hereby consent to take part in the study. However, I understand that my participation is voluntary and that I am free to withdraw from the study at any time."*

Participant	***Researcher***
Name: _____	Name: _____
Signature: _____	Signature: _____
Date: _____	*Date:* _____

" *I agree that the interview session will be audio recorded. I understand that this is a condition of participation in the study, and I understand that this audio record will not be used in publication or presentation of results."*

Participant	***Researcher***
Name: _____	Name: _____
Signature: _____	Signature: _____
Date: _____	*Date:* _____

☐ *"I agree to let you directly quote, in any written reports, any comments or statements I make while participating in the study, without viewing the quotes prior to their use. I understand that all personal and corporate identifying data will then be removed from the transcript, and the audio file will be destroyed. The data you provide will be kept and reported under a code name only."*

Participant	***Researcher***
Name: _____	Name: _____
Signature: _____	Signature: _____
Date: _____	*Date:* _____

☐ "I *agree to be contacted later if any clarification is required."*

☐ "I *would like to be notified by email when results are available via a publication."*

If either of the above is chosen, please include a contact email address: _____

APPENDIX F – RECRUITMENT NOTICE FOR PHASE 2

RECRUITMENT SCRIPT

Project Title: Understanding the Use of Models and Visualization Tools in System Administration Work

We are seeking participants to take part in a study about the tools used by system administrators. Participants will be asked to complete an anonymous and confidential survey that should take about 20-30 minutes to finish. The study is an online survey.

You will be asked about your goals, routines, the system models, and visualization tools you work with, and the difficulties faced. You will also be asked to provide demographic information about yourself and to characterize your position and your organization. Through this study, we hope to understand the concerns of system admins, generalize our findings and learn how to better design, tools to assist them in their daily routine.

While the survey does not ask for any identifying information (e.g. individual or the organization), if you do provide any such information that could identify you or the organization, it will be anonymized before data analysis. Participation is voluntary and you can withdraw from participation at any time. If you think that any question would affect the confidentiality agreement of your organization or if you think it would put you in risk in anyway, you can avoid answering the question.

To be eligible to participate, you should be a system administrator. Participants will not receive any honorarium.

If you are interested in more information about the study, please contact Jeevitha Mahendiran by email at Jeevitha@cs.dal.ca or proceed to the survey website at https://surveys.dal.ca/opinio/s?s=19556

APPENDIX G – CONSENT FORM FOR PHASE 2

DALHOUSIE UNIVERSITY
Inspiring Minds

Informed Consent Form

Project Title: Understanding the Use of Models and Visualization Tools in System Administration Work

Principal Investigators:

Jeevitha Mahendiran, Master's Student, Faculty of Computer Science

Kirstie Hawkey, Assistant Professor, Faculty of Computer Science

Nur Zincir-Heywood, Professor, Faculty of Computer Science

Ramandeep K. Dhillon, Master's Student, Faculty of Computer Science

Contact Person: Jeevitha Mahendiran, Jeevitha@cs.dal.ca [902-9997763]

We invite you to take part in a online survey. Your participation in this study is voluntary, and you may withdraw from the study at any time. If you are a student or employee of Dalhousie University, your academic or employment performance evaluation will not be affected by whether or not you participate. This study does not involve any additional risk to you or to others outside of those posed in everyday life. The study is described below. Your participation in the study might not benefit you directly, but we might learn things that will benefit others. You should discuss any questions you have about this study with the principal investigators who will be administering the study.

The purpose of the study is to design a tool or a model to assist a system admin in their daily routine. We want to know about your goals, routines, the system models, and visualization tools you work with, and the challenges you face in your day-to-day work. Your participation consists of an online survey, in which the researcher will ask you about these topics.

Please do not answer anything that affects the confidentiality agreement of your organization. You should avoid answering any question that makes you think it would be a risk to you in any way.

To be eligible to participate, you should be a system administrator.

The entire session is expected to take about 15-20 minutes.

All personal and corporate identifying data will then be removed from the document. The data you provide will be kept and reported under a code name only. The informed consent form and all research data will be kept in a secure location for five years after the end of the study.

In the event that you have any questions, or wish to voice concerns, about any aspect of your participation in this study, you may contact Catherine Connors, Director, Office of Research Ethics Administration at Dalhousie University's Office of Human Research Ethics for assistance: phone: (902) 494-1462, email: Catherine.Connors@dal.ca.

Project Title: Understanding the Use of Models and Visualization Tools in System Administration Work

"I *have read the explanation about this study. I have been given the opportunity to discuss it and my questions have been answered to my satisfaction. I hereby consent to take part in the study. However, I understand that my participation is voluntary and that I am free to withdraw from the study at any time."*

Participant	***Researcher***
Name: _____	Name: _____
Signature: _____	Signature: _____
Date: _____	*Date:* _____

☐ *"I agree to let you directly quote, in any written reports, any comments or statements I make while participating in the study, without viewing the quotes prior to their use. I understand that all personal and corporate identifying data will then be removed from the transcript, and the audio file will be destroyed. The data you provide will be kept and reported under a code name only."*

Participant	***Researcher***
Name: _____	Name: _____
Signature: _____	Signature: _____
Date: _____	*Date:* _____

☐ "I *agree to be contacted later if any clarification is required."*

☐ "I *would like to be notified by email when results are available via a publication."*

If either of the above is chosen, please include a contact email address: _____

APPENDIX H – TIME SHEET

TIME SHEET

Domain	Types	Issues	Tools	Desired Features	Desired Visualization
General					
CLI					
GUI					
Security					
Network					
Monitoring					
Tech Support					
Troubleshooting					
Data Management					
Backup					
Management					
Documentation					
Infrastructure and Configuration Management					
Virtualization					
Web Administration					
Remote System Support					
Models					
Choice of Tools					
Prioritization					

APPENDIX I – CODING SHEET

CODING SHEET

Domain	Types	Issues	Tools	Desired Features	Desired Visualization
General	☐	☐	☐	☐	☐
CLI	☐	☐	☐	☐	☐
GUi	☐	☐	☐	☐	☐
Security	☐	☐	☐	☐	☐
Network	☐	☐	☐	☐	☐
Monitoring	☐	☐	☐	☐	☐
Tech Support	☐	☐	☐	☐	☐
Troubleshooting	☐	☐	☐	☐	☐
Data Management	☐	☐	☐	☐	☐
Backup	☐	☐	☐	☐	☐
Management	☐	☐	☐	☐	☐
Documentation	☐	☐	☐	☐	☐
Infrastructure and Configuration Management	☐	☐	☐	☐	☐
Virtualization	☐	☐	☐	☐	☐
Web Administration	☐	☐	☐	☐	☐
Remote System Support	☐	☐	☐	☐	☐
Models	☐	☐	☐	☐	☐
Choice of Tools	☐	☐	☐	☐	☐
Prioritization	☐	☐	☐	☐	☐

APPENDIX J – INTERVIEW GUIDE FOR PHASE 1

Type of Organization

Domain of work

- What is y**our role within the organization**?
    - **Actual duties/ official duties**
    - Implement controls
    - Solve end user Issues
- What do you **prefer – GUI or CLI or Both**?
    - Reason for Choice?
- **Partial** Towards CLI?
    - *Influence? Familiar? Prominent?*

Security

- Does your organization have a **separate** security team?
- Are you a **part of the security team**?
    - Security Vs Sys Admin
- Is security a **part of your routine**?
    - Tasks? Policies? Incidents? Tools? Visualization?
- **Improvements** in future tool
    - Desired **Features**
    - Desired **Characteristics**
    - Desired **Visualization**

Network (Similar questions repeat to all domains except documentation and virtualization)

- Duties
- **Tools Used**
- **Issues** faced in the current tools

- **Improvements** in future tool
    - Desired **Features**
    - Desired **Characteristics**
    - Desired **Visualization**

Documentation (Similar question to virtualization and models)

- Types
- Duties
- **Tools Used**
- **Issues** faced in the current tools
- **Improvements** in future tool
    - Desired **Features**
    - Desired **Characteristics**
    - Desired **Visualization**

Choice of Tool

- **Decision Making**
    - Clash
- Any online tool support
- **Influence**
- **Suggestions** to support in choosing a tool

Prioritization

- Any **tool support**
- What grabs your **maximum attention**?
- **Suggestions** to help in prioritization

APPENDIX K – SURVEY QUESTIONS (PHASE 2)

Q1 What is your sex?

Options:

Male

Female

Prefer not to answer

Q2 What sector is your organization in?

Options:

Advertising

Internet Services

Government

Insurance

Financial

Health Services

Research Labs

Manufacturing

Telecommunication

Educational Institution

Software

IT Consulting

Others

Prefer not to answer

Q3 Where is your workplace located?

Options:

Asia

North America

South America

Africa

Europe

Australia

Prefer to answer

Q4 How many employees are in your workplace?

Options:

<10

10-49

50-99

100-499

500-999

1000-4999

Q5 How many members are in your team?

Options:

1

2 – 4

5 – 7

8 – 10

11 – 14

15 – 19

20 – 49

Q4. What do you prefer?

Options: CLI, GUI, Both

Q5. Why do you prefer CLI over GUI?

Options: Accuracy, Less resource usage, Reliability, Automation, Comfortability, Speed, All of the above, Others, None

Q6. What is the major drawback in CLI?

Options: Absence of GUI Output, Experience to handle errors, Interaction, Lack of visualization, All of the above, Others, None

Q7. Why do you prefer GUI over CLI?

Options: Visualization, Interaction, Ease of use, All of the above, Others, None

Q8. What is the major drawback in GUI?

Options: Time delay, Inefficiency, Too much interaction, All of the above, Others, None

Q9. What are the improvements you want to see in CLI based tools?

Q10. What are the improvements you want to see in GUI based tools?

Q11. What grabs your maximum attention at work?

Options: Catastrophic Effects, Domain Specific, Management Issues, Security Issues, Client based problems (service oriented), None of the above, Others, All of the above

Q12. Does any tools help in prioritization?

Options: Yes, if yes, provide the tool name (optional); No; Others

Q13. Do you think visualization can help in the process?

Options: Yes, if yes, provide example (optional); No

Q14. Do you participate in the tool selection process?

Options: Yes; No; Not Applicable

Q15. Who takes the decision regarding the choice of tool?

Options: Management only; Management and Sys Admin combined together; Ultimate Decision by Management but you are allowed to give suggestion; Team Lead Decision and Management decision; Others; Team Lead Decision; None of the above; Others;

Q16. How do you choose a tool over the other?

Options: Based on Need; Cost; Based on recommendations; Based of reviews; Brand of tool (renowned tool or the organization); None of the above; Others; All of the above

Q17. Does any online inventory list helps in decision making?

Options: Yes, if yes specify; No; Others

Q18. Do you perform security related task as a part of your routine?

Options: Yes, No, Not Applicable, Skip

Q19. Which of the following security tasks you perform?

Options: Perform and respond to security audits, Design services incorporating security requirements, Solve IT security issues of end-users, Implement security controls, Mitigate vulnerabilities, Administer security devices, Respond to security incidents, Others, All of the above, None of the above, Skip

Q20. List the tools used?

Q21. What are the features and visualizations that they like to have in future tools?

Q22. Do you perform network related task as a part of your routine?

Options: Yes, No, Not Applicable, Skip

Q23. List the tools used?

Q24. What are the features and visualizations that you like to have in future tools?

Q25. Do you perform monitoring related task as a part of your routine?

Options: Yes, No, Not Applicable, Skip

Q26. List the tools used?

Q27. What are the features and visualizations that you like to have in future tools?

Q28. Do you perform tech support related task as a part of your routine?

Options: Yes, No, Not Applicable, Skip

Q29. List the tools used?

Q30. What are the features and visualizations that you like to have in future tools?

Q31. Do you perform troubleshooting related task as a part of your routine?

Options: Yes, No, Not Applicable, Skip

Q32. What are the features and visualizations that you like to have in future tools?

Q33. Do you perform data management related task as a part of your routine?

Options: Yes, No, Not Applicable, Skip

Q34. List the tools used?

Q35. What are the features and visualizations that you like to have in future tools?

Q36. Do you perform backup related task as a part of your routine?

Options: Yes, No, Not Applicable, Skip

Q37. List the tools used?

Q38. What are the features and visualizations that you like to have in future tools?

Q39. Do you perform management related task as a part of your routine?

Options: Yes, No, Not Applicable, Skip

Q40. List the tools used?

Q41. What are the features and visualizations that you like to have in future tools?

Q42. Do you perform documentation as a part of your routine?

Options: Yes, No, Not Applicable, Skip

Q43. List the tools used?

Q44. What are the features and visualizations that you like to have in future tools?

Q45. Do you perform infrastructure and configuration management as a part of your routine?

Options: Yes, No, Not Applicable, Skip

Q46. List the tools used?

Q47. What are the features and visualizations that you like to have in future tools?

Q48. Do you perform virtualization related task as a part of your routine?

Options: Yes, No, Not Applicable, Skip

Q49. Specify the type of virtualization?

Options: Data, Distributed File System, Memory, Operating System, Storage, Network, Service, Application, None, All of the above and Others

Q50. List the tools used?

Q51. What are the features and visualizations that you like to have in future tools?

Q52. Do you perform web administration related task as a part of your routine?

Options: Yes, No, Not Applicable, Skip

Q53. List the tools used?

Q54. What are the features and visualizations that you like to have in future tools?

Q55. Do you perform remote system support related task as a part of your routine?

Options: Yes, No, Not Applicable, Skip

Q56. List the tools used?

Q57. What are the features and visualizations that you like to have in future tools?

Q58. Do you use models as part of your routine?

Options: Yes, No, Not Applicable, Skip

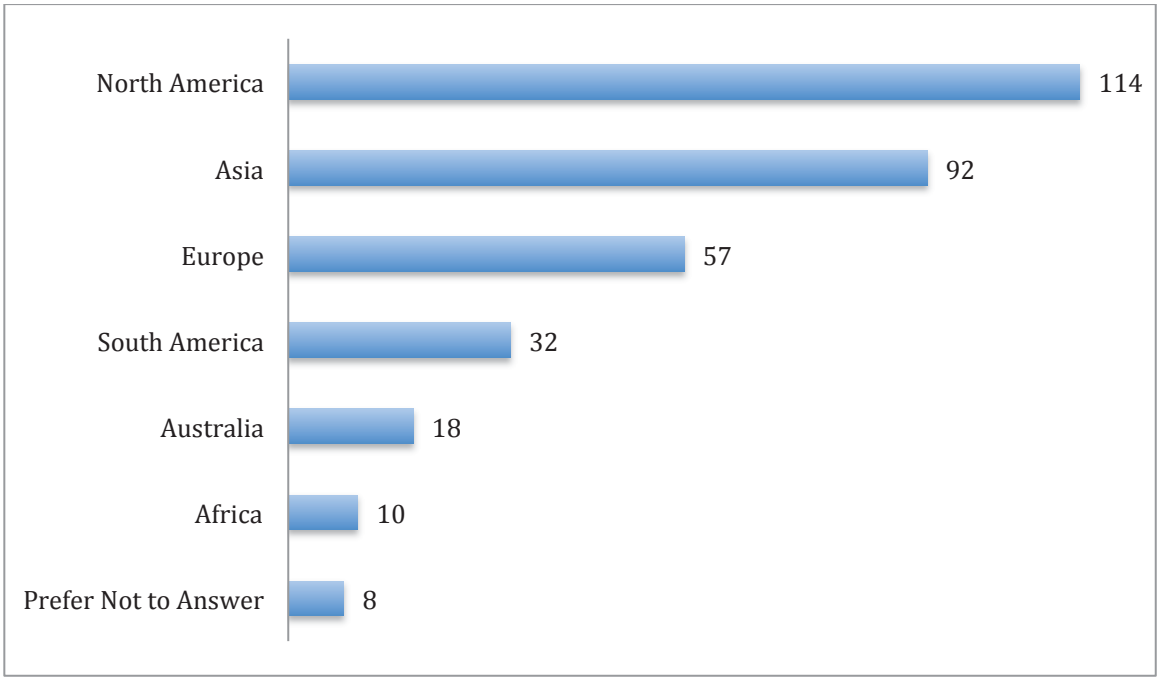
Q59. List the tools used to create models?

Q60. What are the features and visualizations that you like to have in future tools?

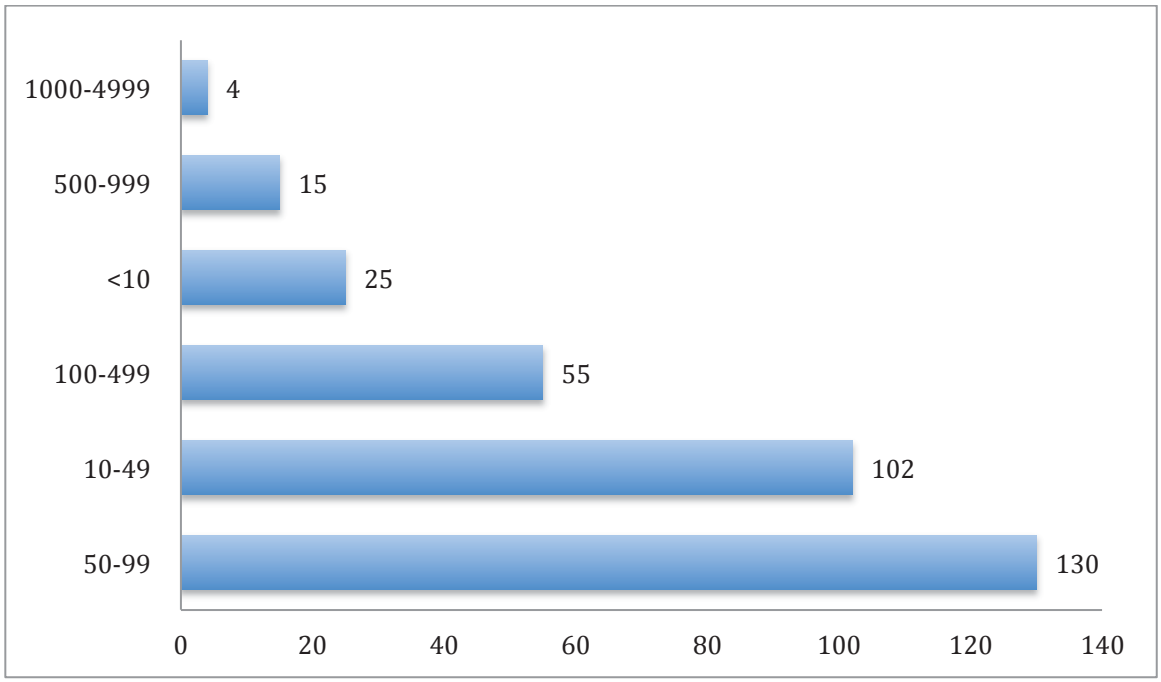
APPENDIX L – PHASE 2 DEMOGRAPHIC RESULTS

Survey Demographic Question and Answers – Phase 2

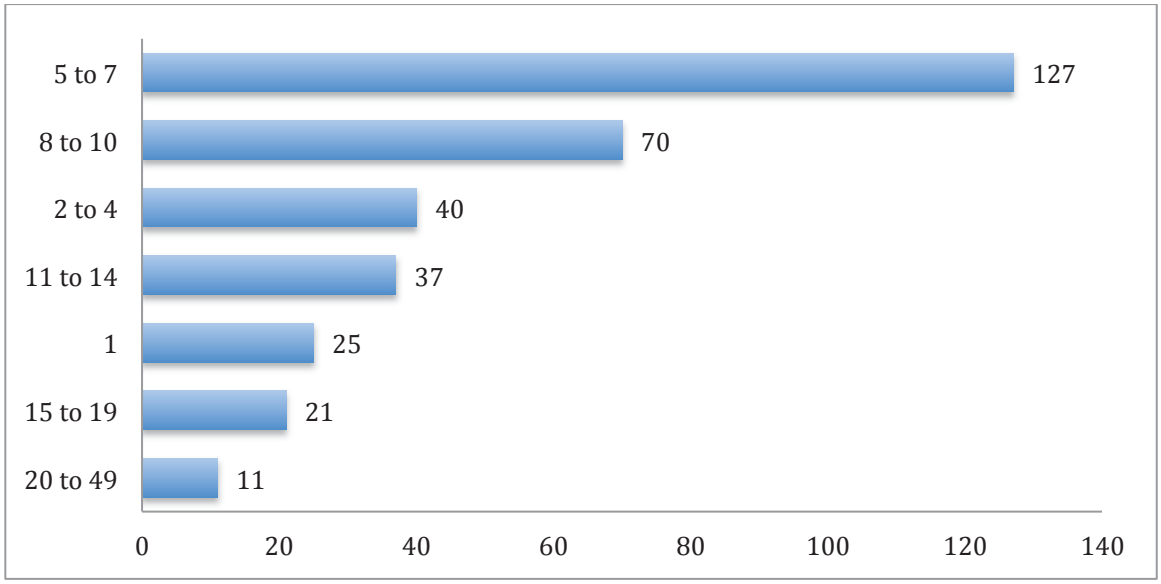
Where is your workplace located?



How many employees are in your workplace?



How many members are in your team?



APPENDIX M – TOOLS LISTED IN PHASE 2 STUDY

Security

1) Solera
2) Stealthwatch
3) Sourcefire
4) BlueCoat
5) Nessus Scanner
6) AIDE
7) Puppet
8) Qualys
9) Puppet
10) Ansible
11) Chef
12) Saltstack
13) VSphere

Network

1) OpenTSDB
2) Linux KVM
3) Nagios
4) Hotsanic
5) Observium
6) Command prompt, IPCONFIG, PING, etc
7) Solarwinds
8) Microsoft system Center Operations Manager
9) Cisco network Assitant
10) Zabbix
11) Opsview
12) Microsoft System Center Orchestrator
13) Foreman
14) Microsoft Configurations Manager
15) VQmanager
16) VCenter
17) Wireshark
18) GMER
19) Cacti
20) BigBrother

Management

1) MS service manager
2) MS Project
3) JIRA
4) GLPI
5) Confluence

Monitoring

1) Zenoss
2) Nagios
3) SpyAgent
4) WebWatcher
5) Pc Pandora
6) Spector Pro
7) Argus
8) Zabbix
9) Ganglia
10) Amazon
11) CF Engine
12) Munin

Virtualization

1) Amazon Web Services/EC2
2) KVM
3) Solaris Zones
4) VMware
5) Citrix Xen Server

Backup

1) CloneZilla
2) Rsync
3) BakBone Netvault
4) Networker
5) Tivoli Storage manager
6) BackupPC

7) Amanda
8) SyncToy
9) VeeAm
10) DataProtector

Web Administration

1) Perl
2) Shell
3) Cron jobs
4) Directory services
5) Ssh
6) TextWrangler
7) Nano
8) WebMin
9) Munin,
10) Postsuper
11) Zimbra
12) Postfix
13) Dovecot
14) Apache
15) Wordpress
16) Drupal
17) Joomla
18) Mail server
19) Dovecot2
20) Apache2
21) Nginx
22) Lighttpd
23) Chef
24) Splunk

Remote System Access

1) Apple Remote Desktop
2) Munin
3) RemoteDesktop
4) Lync
5) Ssh
6) MS RemoteDesktop
7) OpenVPN
8) DameWare
9) PuTTY

10) RDp

Data Management

1) Oracle
2) DB2
3) SQL Server
4) Informix
5) Sybase
6) MYSQL
7) Microsoft Access
8) File Maker Pro
9) Alpha Five

Documentation

1) Apple Pages
2) Vi/vim
3) Emacs
4) RT
5) MS Project
6) OmniPlan
7) Evernote
8) OmniFocus
9) Todo
10) Wiki
11) Textmaker
12) Notepad
13) Ms Word
14) Viso
15) Tex
16) StarUML
17) Sandcastle
18) GhostDoc
19) AgroUML

Tech Support

1) Tivoli
2) Perldesk
3) BMC Patrol
4) WHMCS

5) RT
6) Radix
7) Remedy
8) OTRS
9) OVSD
10) OVSC
11) Perlgreen
12) IT-Serelog

Tools used to Create Models

1) Google Docs
2) Dia,
3) Calligra Flow
4) Graphviz
5) Open/Libre Office
6) Visio
7) Omnigraffle
8) VMM
9) Mindmaps