MOBILE VISUALIZATION: A FRAMEWORK TO ASSIST DECISION-MAKING IN FINANCIAL MANAGEMENT

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FACULTY OF COMPUTING AND INFORMATICS
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I hereby declare that the material in this thesis is my own except for quotations, excerpts, equations, summaries and references, which have been duly acknowledged.

12 July 2017

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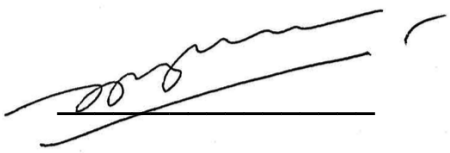

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ABSTRACT

Nowadays, every organization has their own management process, and equipped with information systems to assist them. With the continuous data generation from the system, it is overwhelming for the users to make use of all this information in their process of decision-making. Information visualizations offered the advantageous data exploration by visualizing the relevant information for the user to retrieve and understand promptly. However, only few researches were found regarding information visualization in mobile platform especially in context of decision-making process for financial management. This research developed a framework through the uses of mobile visualization as a concept tool to assist the decision-making in financial management. An action case research strategy, including observation and interview were used to procure results for analysis and to answer the research questions and final conclusion. The latest statistics presented by technology observant such as Morgan Stanley Research have proven the increase of mobile application usage and development that led the research to perceive that mobile visualization will be used in the future context.

Keywords: Information visualization, mobile visualization, decision-making process, financial management.

ABSTRAK

VISUALIZASI MUDAH ALIH: RANGKA KERJA UNTUK MEMBANTU MEMBUAT KEPUTUSAN DALAM PENGURUSAN PERUNTUKAN

Penulisan berkenaan penggunaan visualisasi maklumat dalam teknologi mudah alih bagi membantu proses membuat keputusan dalam pengurusan peruntukan di sector awam di Malaysia. Zaman kini, setiap organisasi mempunyai proses pengurusan tersendiri serta dimantapkan lagi oleh penggunaan teknologi maklumat. Namun, dengan setiap data yang terhasil dari penggunaan teknologi tersebut, pengguna masih belum dapat memanfaatkan data terkumpul dengan sepenuhnya, terutamanya dalam proses membuat keputusan. Visualiasi maklumat dapat memberi kelebihan dalam mendalami maklumat yang relevan dengan bantuan visual agar pengguna mudah mencari dan memahami maklumat tersebut untuk proses membuat keputusan. Namun begitu, hanya beberapa penyelidikan yang mendalami penggunaan visualisasi maklumat di dalam platform mudah alih, terutamanya dalam konteks pengurusan peruntukan. Penyelidikan ini dijalankan bertujuan untuk mereka rangka kerja untuk memanfaatkan visualisasi maklumat mudah alih sebagai alat bantuan untuk proses membuat keputusan. Sebuah penyelidikan dengan strategi action case, menggunakan kaedah pemantauan dan temuduga untuk memperoleh maklumat untuk analisis dan membantu menjawab persoalan serta membuat kesimpulan. Statistik terkini dari institusi pemantau teknologi seperti Morgan Stanley Research menunjukkan bukti peningkatan penggunaan dan penghasilan aplikasi mudah alih, mencadangkan visualisasi mudah alih pasti akan digunakan secara besaran pada masa hadapan.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter introduces the information visualization on both traditional and mobile platform, along with the discussion of the current state of decision-making process particularly in financial management and the problems within the field from the academic perspective. Details on the research objectives and questions were explained throughout the chapter.

1.2 Motivation

This research is about the idea of how visualization concept in decision-support system can be implemented to help decision making process particularly in the public sector, and how mobile visualization can be designed to specifically assist the requirement and task involved in the decision making process. Information visualization has proven of being able to provide the advantage in many contexts such as medical (Lavrač, et al., 2007) (West, Borland, & Hammond, 2015), software engineering (Gansner & North, 2000), collaborative software development (Chen, Chen, Liu, & Zhang, 2014), aerospace (JoelEdgar, et al., 2016) and even the economy (Ng & Qu, 2014). However, as technology progressed along with the hardware capabilities, there were significant changes in term of desktop and mobile usage throughout the years (Chaffey, 2016) as shown in Figure 1.1.

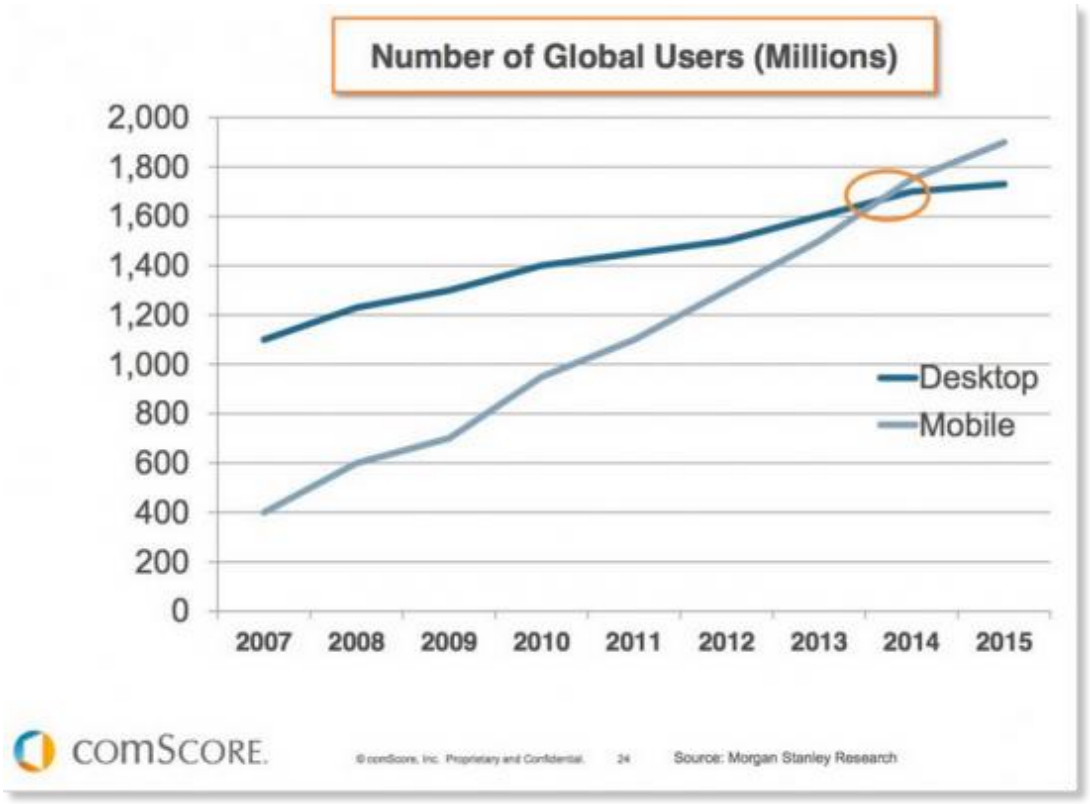

Figure 1.1: Number of Global Users on Desktop vs. Mobile

Source : http://www.smartinsights.com/wp-content/uploads/2014/03/Mobile stats-vs-desktop-users-global-550x405.png

The increased number of mobile users in the technology trend indicated the behavioral changes of consumers and the push for company adoption of mobile. Mobility and simplicity were the key factors that were sought out by users nowadays, with the assimilation of application and technology into their daily life process. Software and application developer also driven to use multi-platform or mobile due to declining of web and desktop-only retails (Chaffey, 2016) as shown in Figure 1.2 below.

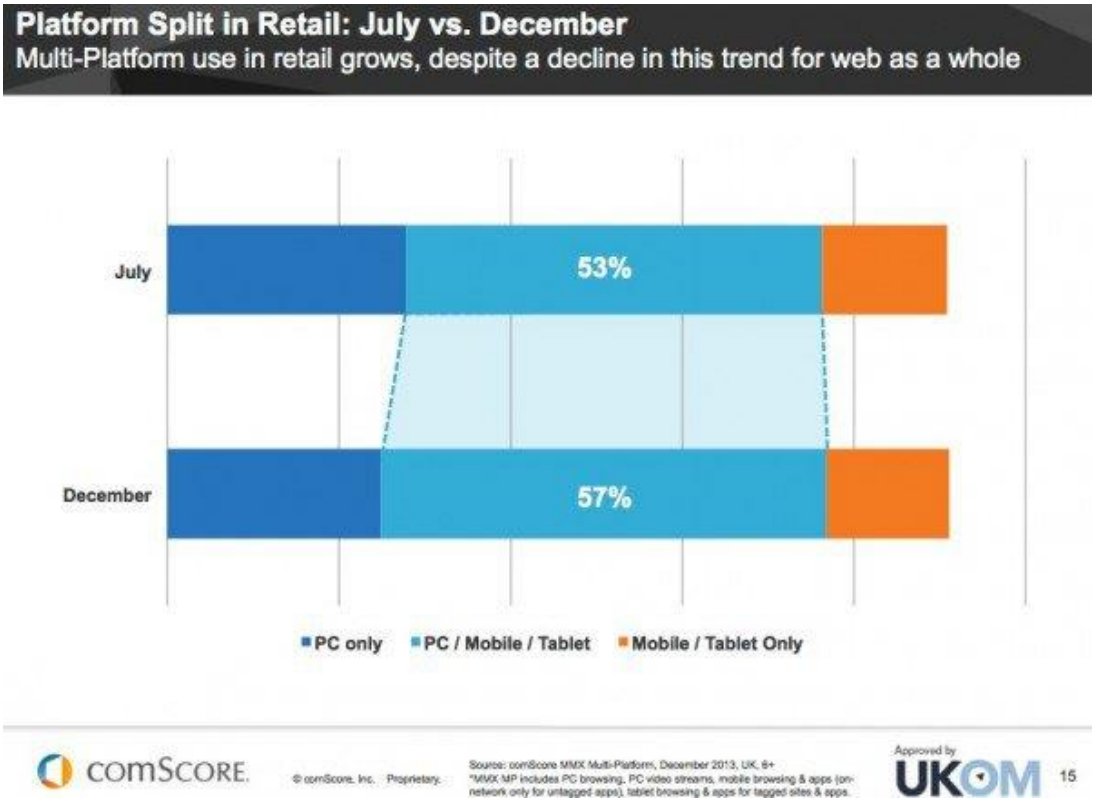

Figure 1.2: Platform Split in Retail for Software and Application

Source : http://www.smartinsights.com/wp-content/uploads/2013/06/Split mobile-desktop-retail.jpg

The public sector generally comprised of various governance agencies and enterprises such as Malaysia's Ministry of Higher Education and Inland Revenue Board of Malaysia to administer and deliver public services with the public funding allocated by national yearly budget (The Institute of Internal Auditors, 2011). The public servants, officials, employed by the government (Merriam-Webster, 2015), operated these agencies. The public sector was chosen as the context of this research due to lack of implementation of visualization to assist their officials in their work procedure. Although the agencies within the public sector already established their financial management system through vote management and accounting, the data kept in the records were not sufficiently utilized for decision-making, and in a complex state for the project leaders to even make sense out of it.

1.3 Problem Statement

Ever since within the time of massive usage of information technology, it results in the accumulation of growing and expansion of complicated data with multiple usage that created complex relationships, only limited until the stage of user's understanding due to ineffective data representation (Zhang & Whinston, 1995). The problem was no longer about computational power, but concerned on data warehousing to gather integrated data, analyze the relationship and utilize it for problem solving (Vetterli, Vaduva, & Staudt, 2000). This research targets on the problem faced by public sector management in their decision-making process particularly in financial management. The research was conducted on the group of project leaders within the Ministry of Higher Education, Malaysia. The community already established the system capable of housing generated data, but unable to properly utilize the stored data to help problem solving in decision-making process for financial management (Hamzah & Asli, 2015). The research intended to utilize mobile visualization as an assisting tool for the project leaders in financial management. A visualization application deployed in desktop devices provided the sufficient function required for the task, however with the extension of platform towards mobile devices, it brings new value for the application in terms of mobility and frequent assistance.

1.4 Introduction to Information Visualization

The definition of visualization is the representation of an object, situation, or set of information in the form of visual such as chart or graph ((Oxford University Press, 2017). Recent addition made to describe visualization as "a tool or method for interpreting image data fed into a computer and for generating images from complex multi-dimensional data sets" (Owen, 1999).

The term Information Visualization is a study of visual representations of abstract information to amplify human cognitive activity (Nagel, 2006). The researchers of Xerox PARC coined the expression information visualization at the end of 1980s to discern a new study concerned with the creation of visual representation to better amplify human cognition capability (Mazza, 2009).

1.5 Research Questions & Objectives

This research investigates three questions in the context of public sector management where cooperative style of decision-making is used:

1. How does mobile visualization can assist decision-making in financial management?
2. What are the appropriate mobile visualization techniques that can assist the decision-making in financial management?
3. What are the relevant data required to be visualized to assist decision-making in financial management?

These questions cover the key areas of this research and will serve as a means to evaluate the outcome of the research. Based from the research questions above, the aim of this research is to utilize mobile visualization to assist the decision-making in financial management that consists of the objectives as below:

1. To investigate the mobile visualization techniques that can assist decision-making in financial management.
2. To propose a theoretical framework for mobile visualization in assisting decision-making for financial management.
3. To empirically prove the development of the theoretical framework for mobile visualization in assisting decision-making for financial management.

1.6 Chapter Structure

The thesis was written with chronological structure.

"Chapter 1: Introduction" introduced the research and why it was conducted. This chapter covers the research details on the problem statement, research questions and how information visualization may assist the implementation.

"Chapter 2: Review of Literature" entails the process of reviewing and referring to the past research work. This chapter started with the introduction of Information Visualization with examples of its implementation for decision-making

support in various practical domains. Referring back to the research problem context, the chapter included reviews of difference between information visualization and mobile visualization, along with the challenges of mobile visualization implementation particularly in the domain of decision-making in financial management for the public sector in Malaysia.

"Chapter 3: Research Methodology" describes the methodology used for this research along with the data generation and analysis method. This chapter started with the reviews of action case research and the qualitative approach. Research context and scope were defined in this chapter along with the description of the research process and field studies.

"Chapter 4: Results and Analysis" consists of the results from First cycle and second cycle interviews. First cycle results were analyzed to understand the decision-making and financial management process along with defining the requirement and design of the prototype development. Second cycle results then analyzed to discover the effect of mobile visualization implementation to the domains along with finding the appropriate visualization techniques for the domain users.

Finally, "Chapter 5: Discussion and Conclusion" entails the discussion of the findings from the previous results analysis. This chapter consists of supporting evidence and verification of the proposed theoretical framework. Limitation and challenges of the implementation were stated along with the possible future work and approach towards other domains.

1.7 Summary

This chapter introduced the information visualization and how it can be utilized in assisting decision-making process for financial management. The problem stated with examples and current situation. Three research questions in the context of public sector management have been stated. The next chapter consisted of literature review from the previous work in regards to the research topic and context.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discusses about the information visualization and how it was implemented into various context. The chapter then explores the viability of information visualization to be implemented in decision-making support, along with the difference between traditional and mobile visualization. Along the progression, the chapter explores on the context of decision-making styles in Malaysia, targeting the public sector in financial management domain. Following the context and target end users, the appropriate visualization techniques have to be explored to support for the user experience factor. Finally, the conceptual framework is shown and explained as the basis of this research.

2.2 What is Information Visualization?

Information visualization is the study of visual representations of abstract information to amplify the human cognition. When human are engaged through interaction with visual (what they see with their eyes), there is an activity that is internal construction of processing information in our mind. Generally, visualization is a cognitive activity that is facilitated by external visual representations where human build an internal mental representation of it. Visual representations such as pictorial, graph, chart, help us to understand the external data thus producing better information understanding (Mazza, 2009). The visualization process starts with refining or filtering the raw data, which then classified into data tables. The data then undergo visual structuring and then presented in the appropriate views (Card, Mackinlay, & Shneiderman, 1999). The whole process was shown in the Figure 2.1.

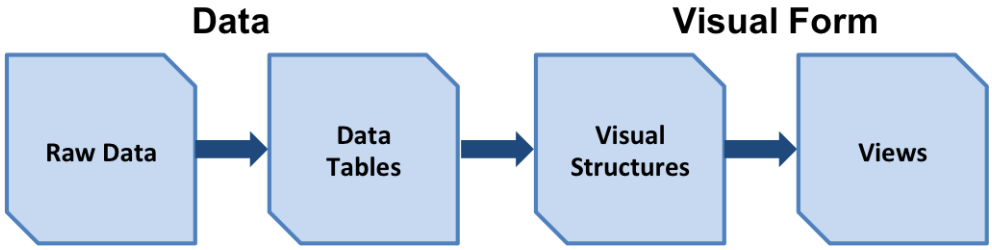

Figure 2.1: Visualization model (Card, Mackinlay, & Shneiderman, 1999)

Information visualization was different from scientific visualization. Previous research (Nagel, 2006) state that while scientific visualization procure accurate visualization of the real world, information visualization was intended to make it possible for data analysts to obtain internal mental models of the information content in datasets, frequently used as models for characterization, prediction and decision making. There was classification of information visualization as stated by (Keim & Ankerst, 2001), exploratory analysis, confirmatory analysis, and presentation. This research focused on utilizing mobile visualization as assisting presentation tool for decision-making in the financial management.

However, with emergence of information technology where there are abundant of information and data, especially in current time to the certain point of overload, causing disruption on information exploration (Wurman, 1989). Visual language research and user-interface designers have long working on inventing and improving information visualization methods to provide smoother integration of technology with task. Currently, information visualization and graphical interfaces are likely to have more critical role as computing speed and display resolution increase. Visual displays proven to become more attractive thanks to its capability to provide orientation or context, enabling selection of regions and provide dynamic feedback for any changes identified. Information presentation has shown potential higher bandwidth in the visual domain than other senses (Shneiderman, 1996).

This research was designed and conducted by implementing the visual design guidelines summarized as the Visual Information Seeking Mantra: Overview first, zooms and filters, then details-on-demand (Shneiderman, 1996). The task started with Overview, by gaining an overview of the entire collection of data. Once the user grasped on what information they have, then Zoom on items of interests,

or Filter to hide the uninteresting items. The information exploration continues on Details-on-demand, by selecting the items and get the details inside.

2.3 Traditional Versus Mobile Visualization

Visualization has simplified human understanding information towards the mean of using visual tools such as maps, chart and graph to help solve problems. With the continuous improvement of computer technology capability, visualization also improved parallel with it; able to be incorporated in most computing application domains such as business, medical, engineering and management (Chittaro, 2006). Adaptation of this concept has been implemented towards mobile device so that it can be used in mobile means. However, there are limitations that made it impossible to make the tools accessible the way it can be used from computers as shown in Table 2.1. The mobility context has introduced further complications as mobile devices required to remain compact in order to be practical of usage. Data presentation in a mobile devices would be different from the computer version, but both data represented need to have equal value and important for the user.

Table 2.1: Mobile versus Traditional Visualization Development Factors.

Mobile visualization	Factors	Traditional visualization (Computer)
Limited due smaller size, lower resolution, fewer colors	*Displays*	Available for bigger display but lack of mobility
Mobile devices have less power in terms of hardware performance, memory thus lead to instability	*Onboard hardware*	Most computers nowadays equipped with sufficient performance
Limited input peripheral such as tiny keypad, touch onscreen keypad	*Input peripheral*	Wide variety of input peripherals available
Different input techniques such as handwriting and pattern recognition on small surface	*Input techniques*	Keyboard, navigating screen and comfortable large surface
Slower interactivity due to hardware performance and remote database	*Connectivity*	Faster due to hardware performance and network stability
Form-factor, performance and input peripherals among different mobile device models vary greatly	*Device Performance*	Most computer have the capacity to perform the system