

Data Warehouse Design for Mobile Environment

Muhamad Shahbani Abu Bakar¹ and Azman Ta'a²

School of Computing, College of Arts and Sciences, Universiti Utara Malaysia, shahbani@uum.edu.my
School of Computing, College of Arts and Sciences, Universiti Utara Malaysia, azman@uum.edu.my

ABSTRACT

Analysis and design are very important roles in Data Warehouse (DW) system development and forms as a backbone of any successful or failure of the DW project. The emergence trends of ubiquitous-based application required DW system to be implemented in the mobile environment. However, current analysis and design approaches are based on existing DW environments that focusing on the deployment of DW system in static client-based applications. This will create the limitations on user accessed and reduced the used of analytical information by the decision makers. Consequently, this will prolong the adoption of business intelligence (BI) applications to the users and organisations. This research is to suggest an approach for designing the DW and implement the DW system on the mobile environments. A variant dimension modeling technique will be used to enhance the DW modeling in order to accommodate the requirements of mobile characteristics in the DW design.

Keywords: Requirement Analysis, Data Warehouse, Mobile Environment, Information Science

I INTRODUCTION

Nowadays, mobile technology is rapidly utilized in various computer systems, including data warehouse (DW) and Business Intelligence (BI) system. As reported by Borg and White (2010), the BI usage among organisations with mobile BI increased double as compared to immobilized users as shown in Figure 1.

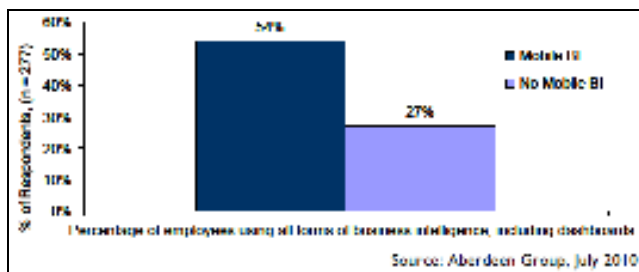


Figure 1. Mobility in BI usage

At the beginning, DW for BI is design for operational-based information to support strategic decisions making in the organisation. However, the information requirements in the organizations today need to support customer satisfaction, enhance administration, improve

financial management, increase business activities, and assist human resources tasks. Decisions making in these areas must be made quickly based on the historical and current data through the implementation of the latest technologies that enable to store, retrieve, manipulate, analyze, produce report and communicate with the captured data of the organisation. The decision makers such as Chief Executive Officer (CEO), General Manager (GM), and Directors of agencies are seeking to synthesize and analyze data as well as information in a real-time manner for implementing good strategies.

This scenario is based on the current economic situation that needs faster and effective management of the available resources in order to achieve the organisations, clients, and communities requirements. The requirements of meaningful and analytical information in real-time is essential for organisations to provide better services, which enable better decision-making. However, in order to provide the real-time DW-based application, the organization needs to develop centralize mobile DW system that systematically collects and analyzes the heterogeneous data sources in seamlessly accessed and processed. Therefore, the challenge to build DW system is to model and design the DW system according to the mobile technology environment. Nowadays, several methods for designing mobile applications have been used by developers. However, most of the methods are focused on the operational-based applications. Thus, a new proper and systematic method is required in modeling and designing the mobile DW system according to the users and organisation requirements. The method should be able to accommodate with the mobility characteristics, which is concerned with the availability of DW at any place, any time, and any device. Moreover, the method must be able to extend for other kinds of mobile applications.

II PROBLEM STATEMENT

DW systems have been used mainly to support decision making. Nowadays, the decision-support systems (DSS) are developed based on DW to provide strategic information for analysis, behold trends, and monitoring performance (Ponniah, 2010; Shahbani & Shiratuddin, 2011). However, traditional DW is passive, historical-based data, batch-processing, and not real-time. The current trend for DSS is faced new system environment is required DW to be designed for analytical decision making. It needs to extract from heterogeneous data sources for providing online and real-time information. Indeed, the attention given to the DW systems is focused on the mobile-based application that supports the new system environment.

In the new report by Forrester, a mobile DW-based application will be the norm in most organisations (Evelson & Yakkundi, 2012). Knowledge workers will

make decisions at any places and any times. Furthermore, vendors will respond with more features for multiple visual query methods such as GPS analytics and integration with enterprise mobile ERP applications. Meantime, various platforms, portal, social functionality and other tools will be increasingly and integrated into a user friendly system called information workplaces. As anticipated by Information Systems Audit and Control Association (ISACA), the use of mobile devices to access and deal with data is increased for the coming year. Moreover, this was a top trend in the information technology (IT) field: the consumerization of IT and the proliferation of mobile BI (Kern, 2012). Clearly, the DW-based system is required to be equipped by the mobile-based characteristics.

III LITERATURE REVIEW

Since 1999, several methods and approaches have been suggested to develop and implement the mobile DW due to the emergence of mobile technology. Most of the suggestions are interested in the method to implement the DW system in mobile environments. However, we argued, a new method is required in order to design and implement a mobile DW-based application due to the current DW system always depended on the success of the DW design process (Inmon, 1992; Kimball, 1996; Lujan-Mora, 2005; Rizzi, 2007). Existing methods were not focused on the design process, and neglected the important roles of mobile functionalities. Generally, a review for various methods and approaches used in design and implement mobile DW system is shown in the Table 1.

Table 1. Methods and Approaches Used in Mobile DW System

Researcher/Developer	Methods and Approaches for Mobile DW	Description
Ken (1999)	Mobile Warehousing System (MoWS)	Propose a framework to investigate issue for improving the performance of query processing.
Stanoiet al. (1999)	Data Warehousing Alternatives for Mobile Environments	Propose technique for managing data warehouse in mobile environment.
Weipplet al. (2000)	Mobile Database Agents for Building Data Warehouses	Propose a pragmatic approach for applying mobile agent technology within distributed database management systems (DBMSs).
Choy et al. (2000)	Distributed Database Design for Mobile Geographical	Investigate GIS-based system and propose system architecture for

	Applications	ATIS that based on GIS and distributed database (e.g., data warehouse) technology
Chi et al. (2002)	Agent Warehouse - A New Paradigm for Mobile Agent Deployment	Describes a novel concept of agent warehouse. The intermediate <i>proxy-like</i> agent warehouse is proposed to address the mobility issues.
Huang et al. (2005)	Intelligent Cache Management for Mobile Data Warehouse Systems	Proposes an intelligent cache mechanism for a data warehouse system in a mobile environment
Oueslati & Akaichi (2010)	Mobile Information Collectors' Trajectory Data Warehouse	To analyse complex phenomena which involve moving objects, Trajectory Data Warehouse (TDW) for many recent decision problems related to various professions that concerned with mobility
Gaspar et al. (2011)	Design and implementation of a client warehouse application over an enterprise resource planning system for mobile devices	Proposes a client warehouse application over Microsoft Dynamics Navision 5.0 Enterprise Resource Planning system
Motskinet al. (2011)	Network Warehouses: Efficient Information Distribution to Mobile Users	Propose a strategy to distribute select a set of well-placed nodes (warehouses) to act as intermediaries between the information sources and clusters of users

As on Table 1, the focuses on mobile DW can be classified as query processing (Ken, 1999), management (Stanoiet *al.*, 1999; Weipplet *al.*, 2000), Architecture/Framework (Ken, 1999; Choy *et al.*, 2000), Agent-Based (Weipplet *al.*, 2000; Chi *et al.*, 2002), Hardware-Based (Huang *et al.*, 2005; Oueslati&Akaichi, 2010; Motskinet *al.*, 2011), Trajectory Data (Oueslati&Akaichi, 2010), and Application (Gaspar *et al.*, 2011). Clearly, the systematic method for modeling and designing the mobile DW was not given attention by the researchers. Thus, existing methods such as Dimension Modeling (DM) (Kimball, 1996), Entity-Relationship Modeling (ERM) (Inmon, 2002), Dimension Fact Model (DFM) (Golfarelli, 1998), Unified Modeling Language (UML) (Lujan-Mora, 2005), and Goal-Oriented Model (Giorgini *et al.*, 2008) were not carefully delved into the mobility requirements of the DW systems. Thus, the motivation of this research is to explore and investigate the method to model and design the DW systems for mobile environments.

Generally, current methods used in mobile DW system development were focused on the implementation issues of DW systems. The methods are concerned with the deployment of DW systems and feed the big amount of DW to the limited spaces and power of mobile devices. However, the outstanding issues in DW development are regarding to the design-related problem of DW structure (Giorgini, Rizzi&Garzetti, 2008). Indeed, the problems are prolonging to the modeling and designing the DW for mobile environments (Huang, Lin & Deng, 2008). Therefore, this research will tackle the modeling and designing issues of the mobile DW, which was not treated properly by researchers.

IV METHODOLOGY

The research methodology used in this project is based on the general research methodology proposed by Vaishnavi and Kuechler (2008) and the Information System (IS) framework presented by Hevner and Salvatore (2003). The methodology has emphasized the combination of behavioral and design science in understanding, executing and evaluating IS research as illustrated in Figure 2. This research focuses on building and evaluating the new method to design the mobile DW, which is:

- 1- Construct (the use of modeling language)
- 2- Models (to present the problems and solutions in the real-world)
- 3- Methods (to define solution processes)

4- Instantiations (to demonstrate how to implement constructs, models or methods in a real environments) in the IS research framework.

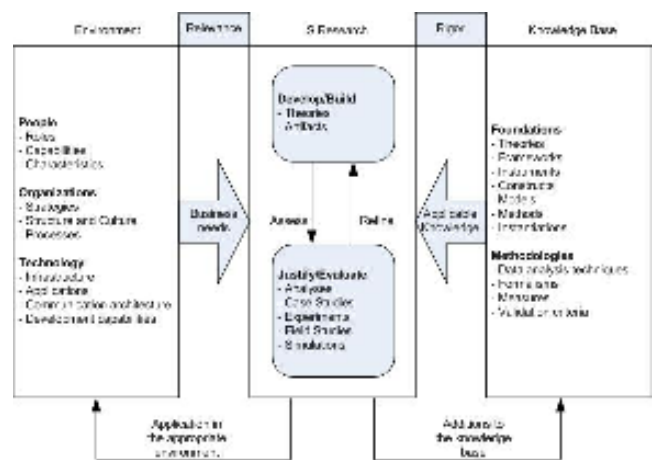


Figure 2. IS Research Framework (Hevner & Salvatore, 2003)

These research activities drive the achievement of the research goal that comprises of the objectives from each of the phases. The achievement of phase I objective will drive the objective of phase II. The success of objective in phase II will contribute to the achievement of phase III objectives and finally confirm the mobile DW architecture for implementation in the real organization. Therefore, the method for mobile DW system development needs to be validated and evaluated after designing the mobile application prototyping. Furthermore, a specific modeling language and requirement analysis tasks will be used to construct the proposed method for designing the mobile DW systems. A specific domain will be identified to be applied in development of the mobile DW applications.

V MOBILE DATA WAREHOUSE APPROACH

The question is whether the DW systems can be modeled and designed from the perspectives of mobile environments need to be delved deeply, and presented the design process for mobile DW systematically. Importantly, the design method will be based on the existing DW modeling (i.e. Dimension Modeling (DM)) in order to maintain the consistency of the model throughout the design process. Moreover, the DM was proven to be successful used in building DW systems since 1996 (Kimball, 1996; Rizzi, 2007), and most of the new methods are based on the DM paradigm. The concepts of fact, dimension, and measure in DM paradigm will be organized with mobile characteristics in introducing the method for DW design.

Generally, any software systems that support mobility are orchestrated into two distinct types of hosts: mobile and fixed hosts (i.e., base stations) (Pitoura and Bhargava, 1994). Mobile hosts have limited computing power, memory, hard disk, and display screen due to their small size and weight (e.g., iPhone, Palm Top, Tablet). The characteristics of the mobile hosts that normally operate in wireless connectivity are identified

as low bandwidth, always disconnected, still expensive, small size, small display, limited battery power, easy to lost, so on. In DW system, these mobile characteristics should be taken into DW design and implementation. For example, to access and analyze the heterogeneous data sources, disconnectivity scenario will be aroused. This will cause an error-prone in the results and produced inconsistency information to the users. Instead of resolved on a physical part (e.g., increase wireless signal or bandwidth size), the design of the DW structure should be able to capture the intermediate results, and finally consolidated or migrated at the available connection. This will be explored and proposed the workable design method to overcome these problems.

Mobile DW is made sense in the most specific scenarios such as sale representatives want to promote their business to the prospect client. In the competitive business rival, the sale representatives need to meet client face-to-face and presented the real information at the real-time. With the minimal processing capabilities of the mobile devices (e.g., mobile phone) and prevent to perform deep analytics, a simple set of extracted data from mobile DW is enough to provide the required information. Importantly, the consistency and reliability of the information are controlled by DW structured. A mobile DW is designed to meet business needs that consistent and reliable as accessed by the desktop PC or fixed hosts. Moreover, by supporting the appropriate mobile tools or platforms, the development of the mobile DW applications is going to be demanding for the DW developer.

This research is to define user requirements for mobile DW systems and propose a method to design the system in mobile environments. The designing of a system will be translated into a prototype of mobile DW system, which is developed within the telecommunication domain. To ensure the good performances of the mobile DW systems, feedbacks from the users will be evaluated. Adjustment will be made for mobile DW design that fits into the requirements of the users.

The proposed architecture for mobile DW implementation is shown in Figure 3, which is comprised of the relationships between eight main activities in mobile DW system development. The alignment of the development activities with the general research methodology (Figure 2) are presented in Table 2, which shows how the steps correspond to the research methodology.

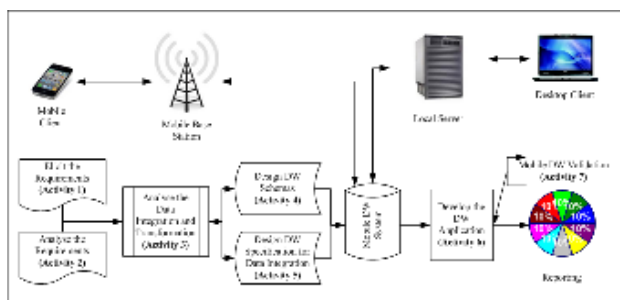


Figure 3. Mobile DW Architecture

All the relationships represent the process within the development, which is started from identifying requirements, building DW schemas and ETL specifications, process, transform and loading the data, and produce the data for user's utilization. The ETL specifications as series of a process for data transformation (Ta'a, Abdullah, &Norwawi, 2011) will be defined according to the mobile application requirements.

Table 2. Activities in the Mobile DW System development

No	Activities	Phases	Process in Development
1.	Gather and elicit mobile DW requirements	Requirement gathering and elicitation.	Data gathering and elicitation based on user and organization perspectives
2.	Analyze mobile DW requirements	Requirement Analysis	User and organizational-based analysis on facts, dimension and attributes.
3.	Analyze mobile DW integration, transformation requirements		
4.	Design mobile DW schemas with mobile characteristics	Modeling and Designing	Modeling and designing the DW structure for mobile
5.	Design mobile DW specification for data Integration, transformation		Modeling and Designing the ETL processes
6.	Develop a Mobile DW Application	Implementation	Prototype Development
7.	Validate and Evaluate the Mobile DW Application	Validation and Evaluation	Validation and Evaluation

VI CONCLUSION

This research aims to suggest an approach for modeling and designing the DW and implement the DW system on the mobile environments. A variant dimension modeling technique is suggested to enhance the DW modeling for accommodating the mobile characteristics of the DW design. Knowledge in mobile computing is required to understand the process involved in the mobile DW design. This is important to ensure the DW design will fulfill the requirements of mobile characteristics and support the implementation of the DW system in mobile environment.

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