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Data Warehouse Model For Mobile-Based Applications

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ABSTRACT
Analysis and design are very important roles in the Data Warehouse (DW) system development and forms as a backbone of any successful or failure of the DW project. The emerging trends of analytic-based application required the 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 the DW system in traditional web-based applications. This will create the limitations on user accessed and the used of analytical information by the decision makers. Consequently, this will prolong the adoption of analytic-based applications to the users and organizations. This research aims to suggest an approach for modeling the DW and design the DW system on the mobile environments. A variant dimension of modeling techniques was used to enhance the DW schemas in order to accommodate the requirements of mobile characteristics in the DW design. A proposed mobile DW system was evaluated by expert review, and support the success of mobile DW-based application implementation.
Keywords: Requirement Analysis, Data Warehouse, Mobile Application, Information Science

I. INTRODUCTION

Nowadays, mobile phones and smart phones have become very popular for a large number of users (Ketmaneechairat, 2014). Current information and communication technologies (ICT) allow users to get important information instantly. Smart phones are mainstream in this area with active iOS and Android devices surpassing 700 million globally (Smirnov, Kashevnik, Shilov, Teslya, & Shabaev, 2014). Moreover, mobile technology is rapidly utilized in various computer systems, including Data Warehouse (DW), Business Intelligence (BI) system, and Data Analytic (DA). As reported by Borg and White (2010), the BI usage among organizations with mobile BI has increased double as compared to immobilized users as shown in Figure 1.

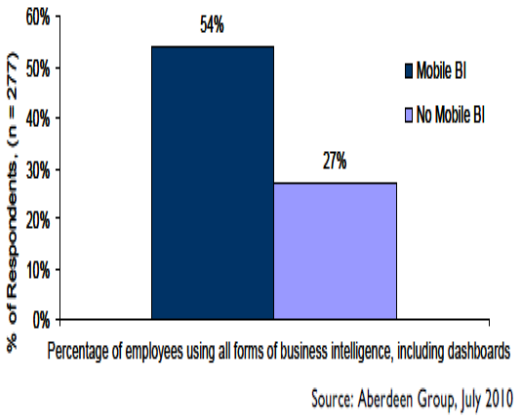

Fig. 1: Mobility in BI Usage

At the beginning, DW is designed for operational-based information to support strategic decisions making in the organization. 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. Making decisions 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 reports and communicate with the captured data of the organization. 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 better 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 organizations, clients, and community's requirements. The requirements of meaningful and analytical information in real-time is essential for organizations 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 focus 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 organization requirements. The method should be able to accommodate with the mobility characteristics, which is concerned about the availability of DW at any place, any time, and any device. Moreover, the method must be able to extend to other kinds of mobile applications.

I. THE PROBLEM

DW systems have been used mainly to support decision making. These days, the decision-support systems (DSS) were 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 required new DW model to support analytical decision making. It needs to extract from heterogeneous data sources for providing online and real-time data analytics. 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 organizations (Evelson & Yakkundi, 2012). Knowledge workers will make decisions at any places and anytime. 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 increased and integrated into a user friendly system called information workplaces. As anticipated by Information Systems Audit and Control Association (ISACA), the uses of mobile devices are to access and deal with data is increased for the coming year. Moreover, this was a top trend in the Information Technology (IT) field, which is the consumerization of IT and the proliferation of mobile BI (Kern, 2012). One of the major problems that need to consider is how to spread and share the analytical information from the related agencies to the farmers and support the farmers with the right and accurate information for decision making. This paper aims to model and design the mobile DW system to support the implementation of portable Paddy Management System (PMS) for benefiting the farmers.

II. MOBILE DATA WAREHOUSE

The question is whether the DW systems can be modeled and designed from the perspectives of mobile environments need to be explored, 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) in order to maintain the consistency of the model throughout the design process. Moreover, the Dimension Modeling (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 is 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 lose, and so on. These mobile characteristics should be taken into DW design and implementation.

For example, to access and analyze the heterogeneous data sources, disconnected scenario will be aroused. This will cause an error-prone in the results and produced inconsistent information to the users. Instead of resolving 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 made sense in the most specific scenarios such as sales representatives want to promote their business to the prospect client. In the competitive business rival, the sales 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 extracting 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 mobile DW system, which is developed within the telecommunication domain. To ensure best performances of the mobile DW systems, feedbacks from the users will be evaluated. The adjustment will be made for a mobile DW design that fits into the requirements of the users.

The proposed architecture for mobile DW implementation is shown in Figure 2, which is comprised of the relationships between eight main activities in mobile DW system development.

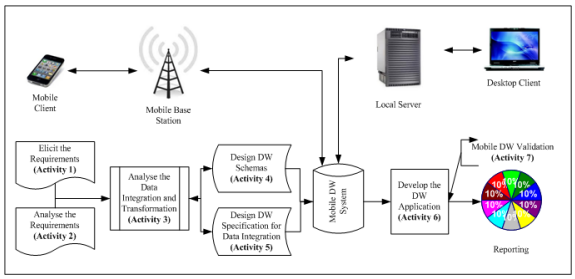

Fig. 2: Mobile DW Architecture

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 of data transformation (Ta'a, Abdullah, & Norwawi, 2011) will be defined according to the mobile application requirements. The alignment of the development activities with the general research methodology is presented in Table 1, which shows how the steps correspond to the research methodology.

Table 1. Mobile DW System Development

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

III. CASE STUDY: PADDY MANAGEMENT IN YAN, KEDAH

Currently, the only effective mechanism for informing farmers about agriculture activities is through television. However, only few farmers, managers and agents were receiving the updated information about the paddy farming activity schedule, paddy crop information, manual procedures and guidelines, government policies and more. The limited distribution of information to the farmers has been studied by researchers and finding that the information sharing using the television is effective, but with the limited air time frame for agriculture segments, the user can't have enough information about the agriculture activities (Hassan, Mohamed Shaffril, Abu Samah, Shahkat Ali, and Ramli, 2010).

Mobile technology is the technology that can be used anywhere, any devices and anytime. Therefore, the development of the Paddy Management System (PMS) must be suited to the concept of the portable PMS, which can be accessed from anywhere and anytime. The PMS is delivering the information to the users in order to guide farmers to increase the productivity and income by using the right information for planning, farming, and harvesting the paddy plantation. The case study for PMS will be based on the paddy management in Kedah state.

Requirement elicitation and analysis

The information about paddy management is handled by the related agencies such as Muda Agriculture Development Authority (MADA), Padi Beras Nasional Berhad (BERNAS), Department of Irrigation and Drainage Malaysia (JPS), Malaysian Agricultural Research and Development Institute (MARDI) and several more was not integrated to be

one "database" that can be shared by the farmers, managers and agents, especially in helping farmers for farming their paddy plantation.

The Paddy Management System includes the process of gathering, processing, storing and distributing of data to carry out the operation functions of the farm in the form of the information needed (Sorensen et al., 2010). In order to collect and process data, interviews have been conducted with the farmers to identify the requirement of the system. In addition, we also carry out a literature reading to get more information about the requirement of paddy management. The results from the interview sessions and literature reading can be formulated into the system requirement as Figure 3.

Fig. 3: Paddy Planting Practices

Mobile DW in PMS consist of data that developed from several databases that supply the information to the system as shown in Figure 3. Each of the databases comes from a different location and combined as the DW system for integration and data analysis. The requirements collected and analysts will be used to design the DW according the mobile elements. Each data is analysis to the specific user level and location. The data provided to the DW system will display the information for the PMS users, including the important information or announcement from the information provider. Indeed, the information can be shared among farmers by using mobile devices and can be accessed anywhere, any devices and anytime with the availability of the internet connection.

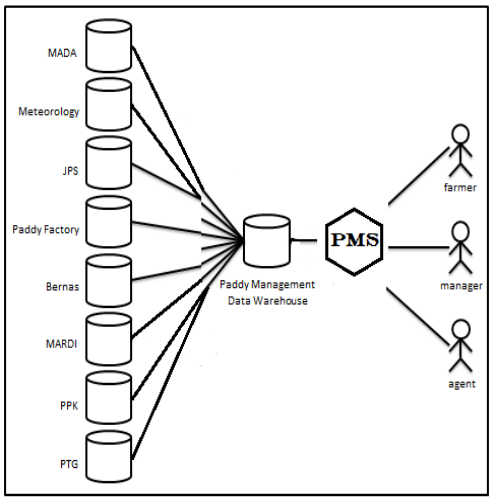

Fig. 4: The User Domain for PMS

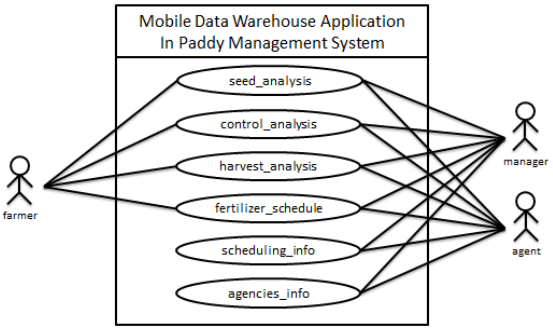

Fig. 5. The Use Case of the PMS

Based on the Figure 4, the various data sources are collected from several related agencies in different locations. Each of the agencies supplied the data to the DW and performs the analysis and integration to load the required data into the DW. The information produced from the analysis is ready to access by the farmers, managers and agents as shown in use case model in Figure 5. The functions showed in Figure 5 are used to design the mobile DW structure for portable PMS. The main information provided by the DW comprises of seed analysis, fertilizer analysis, farming scheduling analysis, and control analysis. The evaluation will determine the correctness of the DW model through expert review. The result of the DW model is used to develop the prototype for PMS it will simulate the functionality of PMS to deliver the information as requested by the farmers or agencies.

Mobile Data Warehouse Design

The mobile DW is designed based on the dimensional modeling that contains fact, dimension and measure components in the table schema. Based on the requirement analysis presented in Figure 5, the components of DW model are listed in Table 2.

Table 2: Components of DW Model for PMS

DW Components	Description
Fact	Paddy Farming
Dimensions	Season, Farmer, Seed, Crop, Lot
Measures	Size, Yield, Farming Cost, Profit Cost, Seed Cost, Plough Cost, Fertilizer Cost, Poison Cost, Harvest Cost, Subsidies Cost, Other Cost, Percent Profit

The measures defined the information required by the users, which are comprised of total cost of farming such as seeds, plough, fertilizer, and poison. Other information is size area, yield, cost profit, subsidies cost, harvest cost, and percent profit. All these components are presented in DW modeling as shown in Figure 6.

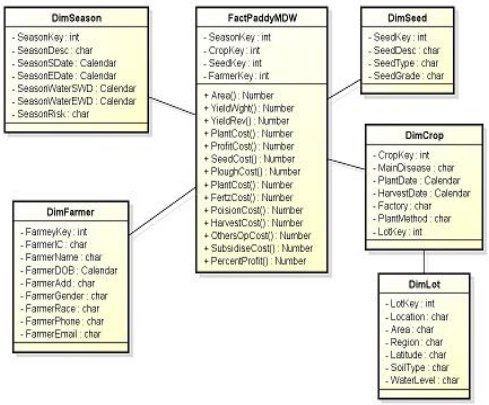

Fig. 6. Mobile DW Model for the PMS

Prototype for PMS

The PMS prototype consists of the six functions of seed analysis, control analysis, harvest analysis, fertilizer schedule, scheduling info, and agency info stated in the use case. All of these functions developed based on the data stored in the DW for PMS. The prototype is developed using the Microsoft Visual Studio 2010 based on the Microsoft ASP.NET MVC framework and Microsoft.NET 4.5 framework that connected to the DW system that build on the Microsoft SQL Server 2008.

The interfaces are designed for mobile characteristics and all of the functions can be accessed by mobile devices and personal computer. It is important to make sure the user of the mobile devices can access, read and use the system smoothly. The system also can be accessed from the computer with the web browser interface. An example of the interfaces designed for PMS is shown in Figure 7 and Figure 8.

Fig. 7: Main Menu

Fig. 8: Seed Analysis Page.

Figure 7 shows the main menu of the PMS, and Figure 8 shows one of the analysis functions provided by the prototype system that is the seed analysis system. This function is for determining the suitable seed for the planting process of the paddy field. The attributes such as field size, water level, type of soil and decease are shown in the area. The entire attribute insert to the system or by collecting the information for the personal user information, the system will determine the suitable seed for the planting process.

IV. EVALUATION

The model evaluation was done by using expert review technique. Two focus group sessions were conducted. The purposed of the session is to get feedback from the experts (nine experts) on the DW mobile model and developed prototype. The sessions involved two rounds; the first was open discussion where they were asked eight of quality model dimensions that are visibility, complexity, compatibility, flexibility, clarity, effectiveness, manageability, and evolutionary of the model. The second round required the respondents to go through the prototype of PMS. The respondents were asked to complete an instrument measuring eight dimensions indicates in the research. The result shows the proposed model generally has moderate strength of five dimensions and high strength in

three dimensions that are visibility, clarity, and effectiveness. The strength of the model can be illustrated in Figure 9.

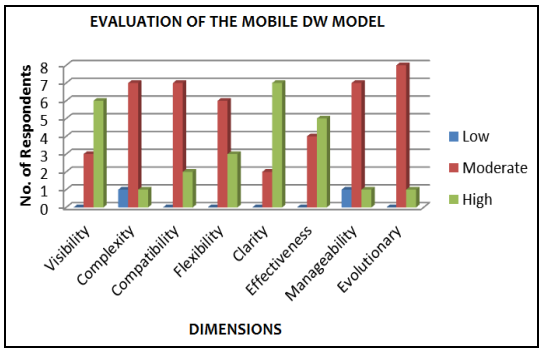

Fig. 9: Evaluation of the Mobile DW Model

V. RESEARCH WORKS

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 of various methods and approaches used in the design and implement mobile DW system is shown in the Table 3.

Table 3: Methods Used in Mobile DW System

Researcher/Developer	**Methods Used for Mobile DW**	**Description**
Ken (1999)	Mobile Warehousing System (MoWS)	Propose a framework to investigate issues for improving the performance of query processing.
Stanoi *et al.* (1999)	Data Warehousing Alternatives for Mobile Environments	Propose technique for managing DW in mobile environment
Weippl *et 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 Applications	Investigate GIS-based system and propose system architecture for ATIS that based on GIS and distributed database (e.g., DW) technology
Chi *et al.* (2002)	Agent Warehouse - A New Paradigm for Mobile Agent Deployment	Describes a novel concept of agent's warehouse.
Huang *et al.* (2008)	Intelligent Cache Management for Mobile Data Warehouse Systems	Proposes an intelligent cache mechanism for a DW system in a mobile environment
Oueslati & Akaichi (2010)	Mobile Information Collectors' Trajectory Data Warehouse	Analyze complex phenomena involve moving objects, Trajectory DW for decision problems 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 ERP
Motskin *et al.* (2011)	Network Warehouses: Efficient Information Distribution to Mobile Users	Propose a strategy to distribute select a set of well-placed nodes (warehous e)

VI. CONCLUSION

This research aims to model and design the DW system for mobile environments. A variant dimension modeling technique is suggested to enhance the DW modeling for accommodating the mobility characteristics of the DW design. Indeed, 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 a mobile environment. The information about Paddy Management System (PMS) is used for testing the proposed mobile DW modeling. The farmers, managers and agencies of MADA, MARDI, JPS and other related agencies will be provided the mobile technology that can use the PMS anywhere, any devices and anytime. The PMS shares the valuable information on the agriculture, specifically for paddy plantation to be useful for the users and make their farming activity easy, direct and successful regardless location, devices and time. By using the PMS, it is encouraging the farmers, managers and agencies in paddy planting activity make better decision, and keep informed about their planting activities instantly.

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