A selection model of ERP system in mobile ERP design science research

Case study: mobile ERP usability

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***Abstract*— Nowadays, mobile apps penetrate in every aspect of our daily life, due to the proliferation of mobile devices, the constant advances in mobile computing, and the enormous leaps of mobile HCI. Thus, these factors have increased the demands to adopt the mobile ERP as a working model in enterprises. Regardless of these demands, mobile ERP has several challenges and issues that need to be addressed through a problem the design science research paradigm, since this paradigm is considered a problem-solving paradigm and it has its roots in engineering and the sciences of the artificial. Accordingly, this paper aims to propose a model for selecting an appropriate ERP system within the mobile ERP's design science research domain. The proposed model was applied to a set of ERP systems that are provided by the dominant ERP vendors. In addition, an integrated overview of the selected ERP system for the proposed use case will be presented in this paper.**

Keywords—mobile ERP; design science research; mobile ERP usability

I. INTRODUCTION

The past two decades have witnessed a plethora of research in information systems (IS) that examined ERP systems in several research areas, due to the tangible and intangible benefits that can be realized in case these systems have been implemented correctly within the enterprises.

The proliferation of mobile devices, the constant advances in mobile computing, and the huge leaps in mobile HCI increased the desired demands to access ERP systems via mobile devices (mobile ERP) such as smartphones, tablet computers, and mobile handheld computers.

However, mobile ERP has areas of research that are not covered yet, and it has knowledge gaps that need to be bridged, because it's considered a young topic in practice and research [1],[2]. For instance, the usability of mobile ERP's user interfaces (UIs) can be considered one of those research areas [3], especially, the mobile ERP's ancestor (i.e. ERP system) suffers from usability issues due to their complex, rigid, and bloated UIs. These results were revealed in several research works such as [4]–[8].

Two complementary but distinct research paradigms characterize much of the research in IS discipline namely: behavioural science and design science [9]. The behavioural science paradigm has its roots in natural science research methods; it seeks to develop and verify theories that explain or predict human or organizational behaviour [9]. Whereas design science paradigm is considered a problem-solving paradigm, and it has its roots in engineering and the sciences of the artificial [9]. The latter is accepted as a valid and valuable research methodology by the engineering research culture, due to its effective applicable problem solutions [9], [10]. In addition, it seeks to extend the boundaries of human and organizational capabilities by creating new and innovative artifacts in terms of constructs (vocabulary and symbols), models (abstractions and representations), methods (algorithms and practices), and instantiations (implemented and prototype systems) [9].

Consequently, mobile ERP research is considered the latest research trend of ERP systems. Thus, this trend needs to be polished by further IS innovations through employing the design science research paradigm as a problem-solving paradigm. Usability is one of the problems that hinders the mobile ERP working model [3], and thus, design science research paradigm can be employed to address this problem.

Nowadays, many products of ERP systems can be found in the ERP software market, which only make the selection of one of these products is difficult in order to be researched. In addition, there is a lack of the existence of a specific scientific approach that can be followed to select an appropriate ERP system in order to be researched by following the design science research paradigm. Therefore, this paper aims to propose a model to select an ERP system for the experimental purposes within the design science research area of mobile ERP.

The remainder of this paper is structured as follow: Section 2 discusses the mobile ERP concept. The problem definition of this research will be described in Section 3. The selection criteria in the proposed model will be discussed in Section 4. Section 5 presents the case study which discusses how the proposed model was verified and the results that have been achieved after employing this model. An integrated overview

978-1-5090-4320-0/16/$31.00 ©2016 IEEE

of the selected ERP system will be presented in Section 6. This is followed by the conclusion in Section 7, the acknowledgment, and the list of references.

II. MOBILE ERP

Mobile computing has improved the way of doing today's businesses. Therefore, numerous enterprises have adopted the mobile strategy in order to meet the new requirements and expectations of their customers and business partners [11]. The wide acceptance of using mobile devices at various levels has attracted the attention of many businesses, thus, an increased focus on incorporating and capitalizing on mobility, in order to extend and expand the use of their designated ERPs [12].

Nowadays, a significant number of enterprises employ a strategy of "best of breed" for their ERP systems to strive for a competitive advantage. Thus, ERP vendors are struggling to improve and extend their products features [13]. Therefore, the mobile ERP concept emerged and has been implemented cautiously, due to the challenges that surround this working model such as the usability [3].

The term mobile ERP was coined by Willis and Willis-Brown as an extension of ERP Systems that helps to solve the data capture problem; This extension permits its user to access the ERP system anywhere [14], due to the rapid technological advances in mobile computing and mobile HCI. Mobile ERP enables a mobile device (portable computer, phone, tablet PC, PDA) to be connected to the back-end ERP system of an enterprise through a mobile net of communications and transmission of data GPRS/UMTS [15]. Figure 1 depicts the proposed architecture of mobile ERP by Dabkowski and Jankowska [11].

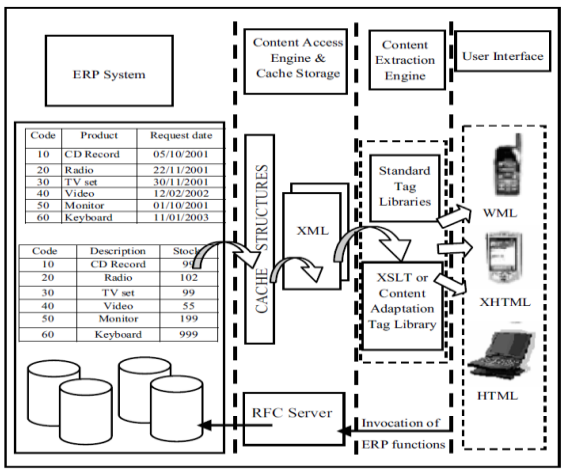

Fig. 1. Architecture for mobile ERP [11]

Mobile ERP system consists of three main components namely: the mobile application (mobile app) that access the back-end ERP system and it is installed on the mobile device, the mobile net communication, and the backend ERP system.

Mobile ERP has become a key requirement for enterprises, due to the benefits that can be reaped from its adoption such as an increase in productivity, achieving high efficiencies and effectiveness in the operational processes in enterprise, some reduction in costs, provides a real-time visibility and traceability, better decisions making, deepen customer engagement, an increase in the qualifications of employees and empower them, leverage existing skills, streamlined supply chain, and an improvement of the users' quality of life [1], [13], [16]. Furthermore, the current evaluation and selection process for ERP systems need to consider the importance of the mobile apps role in its overall business solution [17]. Figure 2 depicts the systems components of mobile ERP systems.

III. PROBLEM DEFINITION

This paper aims to propose a model that aims to support the researchers who are employing the design science research in order to select an appropriate ERP system in mobile ERP research.

Fig. 2. Mobile ERP system components [13]

IV. SELECTION CRITERIA

The ERP system is the core component of the mobile ERP system, thus, several challenges that need to be addressed by the researcher in the selection process of this component for experimental purposes within the design science research paradigm. Therefore, these challenges were extracted from the mobile ERP research's realm and will be presented as criteria that need to be fulfilled by the researcher, in order to select an appropriate ERP system for his/her mobile ERP research. These criteria are as follow:

Criterion one (C1): the selected ERP system must have the ability to support the integration of the most core functional modules and activities that can be found in the conventional ERP systems. This criterion aims to maintain the concept of ERP system, and thus, after applying this criterion, the resulted artifact from any mobile ERP research would be applicable for the most ERP systems.

According to Dahlén and Elfsson, the software system must integrate three of the following core modules in order to belong traditionally to the ERP group namely: manufacturing, distribution, finance and human resources [18]. However, the traditional core modules that can be found in the most of the successful ERP systems are: accounting management, financial management, manufacturing management, production management, transportation management, sales & distribution

management, human resources management, supply chain management, customer relationship management, and e-Business [19].

Criterion two (C2): the selected ERP system must be flexible in the source code. The open source model enables further development and customization for the selected ERP's functionalities and modules after its deployment. Thus, this will support the researcher in case he/she needs to develop a prototype that will act as a proof of concept that he/she wants to achieve.

Criterion three (C3): the selected ERP must have the ability to allow the access to the most of its core modules via one of the mobile apps types namely: mobile web app, mobile native app, or mobile hybrid app.

Criterion four (C4): the selected ERP must have the ability to accommodate different sizes of enterprises. Thus, the resulted artifacts and concepts from the mobile ERP research can be exploited from different sizes of enterprises.

Criterion five (C5): the selected ERP must be utilized in a variety of industry sectors. Thus, the resulted artifacts and concepts from mobile ERP research can be exploited in a wide range of industries.

Criterion six (C6): the selected ERP system must be supported by the developers and practitioners' community, in order to support the researcher through addressing the emergence of any potential issues, or in case he/she needs to perform a customization at the programming level.

Criterion seven (C7): the selected ERP system must be applicable, this means the researcher or the organization who intend to conduct mobile ERP research must be able to bear the infrastructure cost and any hidden cost of the selected ERP system.

Criterion eight (C8): the selected ERP system must be appropriate for the context of the research. The appropriateness means that the researcher must have a sufficient experience in the practicing of the selected ERP system. Furthermore, the selected ERP system must be compatible with the programming experience of the researcher in case he/she needs to perform a customization at the programming level.

V. Evaluation and Results

ERP systems suffer from poor usability [4]–[8], due to their complex, and bloated UIs. This complexity and rigidity stem from the nature of the functions that are carried out by these systems, because these systems are integrating and processing large amounts of data [5].

On the other hand, there are distinctive aspects of mobile ERP interaction that pose usability challenges, these aspects could be classified based on mobile device specifications (i.e. screen size, processing and power capabilities, data entry methods, diversity of mobile operating systems), mobile context, mobile data connection, user heterogeneity, and social issues [3]. According to those challenges and aspects, mobile ERP suffers from the usability challenges. Furthermore, this research area has not been given an adequate attention from the research community. Therefore, the authors of this paper have engaged in this field of research, and an ERP system was selected for the experimental purposes in their research, and this selection was based on the selection criteria that were presented in section four to a set of ERP systems. The ERP systems that were involved in the selection process are the most prominent products in the ERP systems market. These products are provided by the dominant ERP vendors of the worldwide ERP software market in the year 2013 [20]. These vendors have been reported by the Gartner Group report as can be seen from Figure 3.

However, as can be seen from Figure 3, the classification of others vendors represent a large share of thirty-seven percent of all ERP vendors' market share, therefore, this share has been considered in the selection process.

Odoo company is one of the ERP vendors that is considered from the others class, and its ERP system is called Odoo. This ERP system has a significant rate of interest in the searching of its name by using Google search engine as can be seen from Figure 4. Accordingly, Odoo ERP system was selected to be involved in the selection process.

Table 1 presents the results of the comparisons analysis among the selected ERP systems after applying the proposed criteria in section 4.

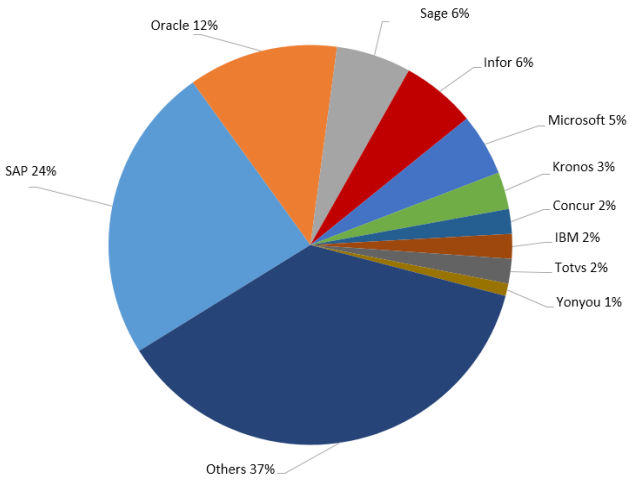

Fig. 3. Worldwide ERP software market share for 2013 [21]

VI. Odoo ERP System

This section presents an integrated overview of the selected ERP system from the comparison analysis.

A. Historical background

Odoo ERP system was founded by Fabian Pinckaers whose dream was to lead the enterprise management market with a fully open source software. Based on this dream, the enterprise software giant SAP was selected as a competitor to fuel Pinckaers in his motivation. This was his strategy from the beginning [22].

In 2005, the TinyERP product was developed under GNU General Public License (GPL) for micro, small and medium size enterprises in the sectors trade, distribution and services.

The TinyERP included modules such as accounting, CRM, sales and purchases (delivery, purchase, sales management, point of sale), human resources, marketing, MRP, MRP II, inventory control, project management, and e-Commerce (EzPubish integration module http://ez.no). This ERP system supported the operating system (OS) independence and followed the client-server architecture; Where the client operating systems (OS) could be Linux, Windows, or MAC OS X, while the server side could be Linux or Windows. TinyERP was programmed by Python programming language and its data was stored in PostgreSQL the object-relational database managements system (ORDBMS) [23]. TinyERP released versions are 1.0,2.0,3.0, and 4.0 [24].

In 2008, the TinyERP was renamed to OpenERP due to marketing reasons, with a notably increased in its adoption rate, where the number of downloads reached to more than one thousand downloads per day [25]. In addition, OpenERP supported eighteen languages and had a large world network of partners and contributors [26]. The software was available under the AGPL license version three, and its released versions are 5.0,6.0, 6.1 and 7.0 [24]. OpenERP included sales, CRM, project management, warehouse management, manufacturing, financial management, and human resources. In addition, more than one thousand OpenERP's modules were available from the OpenERP Apps marketplace [25]. OpenERP was continued in evolving with a constant increasing in its community and the following accomplishments were achieved [22]:

- More than one thousand installations per day, thus, it became the most installed management software in the world;
- OpenERP was analysed by researchers who have years of experience in the ERP world, and it was evaluated with SAP. The analysis results were published in a book titled "Openerp Evaluation with SAP as Reference" [27];
- OpenERP is now being taught to the students at universities.
- An average of sixty new modules was released every month; and
- In 2013, OpenERP had two million users worldwide.

OpenERP moved beyond the conventional concept of ERP system by extending this model, this extension believes that the integration of business activities is not restricted to the conventional ERP modules such as sales, accounting, inventory, and procurements. Therefore, OpenERP v 8.0 was released in June 2014 under AGPL license version 3 with a CMS and e-Commerce, a Point of Sales, an integrated Business Intelligence engine, and more than three thousand modules. In May of 2014, OpenERP has raised ten million dollars in funding to support its R&D efforts and commercial growth. This funding was jointly provided by leading venture capital firms XAnge (France), SRIW (Belgium), Sofinnova Partners (France), and the management team. Accordingly, and as part of OpenERP company growth strategy, the company and product were renamed to Odoo to better reflect its expanded areas that exceeded beyond the core ERP function. [22]. The last released version of Odoo is version 9.0.

Nowadays, Odoo penetrates rapidly in the ERP software market as can be seen in Figure 4 which contains comparative graphs that were created by using Google Trends exploration tool. The colour curved lines show the number of Google searches for the associated keywords (i.e. between Odoo and the other ERP system name) during the years of 2013 to 2016. This metric shows the relative searcher's interest for each ERP system has been selected for the conducted comparisons analysis.

TABLE 1. The results of the comparisons analysis

ERP System	C1	C2	C3	C4	C5	C6	C7	C8
SAP Business One	✓	✓	x	x	✓	✓	x	x
SAP ERP	✓	✓	x	✓	✓	✓	x	x
Oracle E-Business Suite	✓	✓	x	✓	✓	✓	x	x
PeopleSoft Applications	✓	✓	x	✓	✓	✓	x	x
JD Edwards Enterpriseone	✓	✓	x	x	✓	✓	x	x
JD Edwards World	✓	✓	x	✓	✓	✓	x	x
Oracle Fusion Applications	✓	✓	x	✓	✓	✓	x	x
Sage 100c	✓	✓	x	x	x	✓	x	x
Sage 300c	✓	✓	x	x	✓	✓	x	x
Sage X3	✓	✓	x	✓	x	✓	x	x
Microsoft Dynamics AX	✓	✓	x	✓	x	✓	x	x
Microsoft Dynamics GP	✓	✓	x	x	✓	✓	x	x
Microsoft Dynamics NAV	✓	✓	✓	x	✓	✓	x	x
Microsoft Dynamics SL	✓	✓	x	x	x	x	x	x
Odoo ERP system	✓	✓	✓	✓	✓	✓	✓	✓

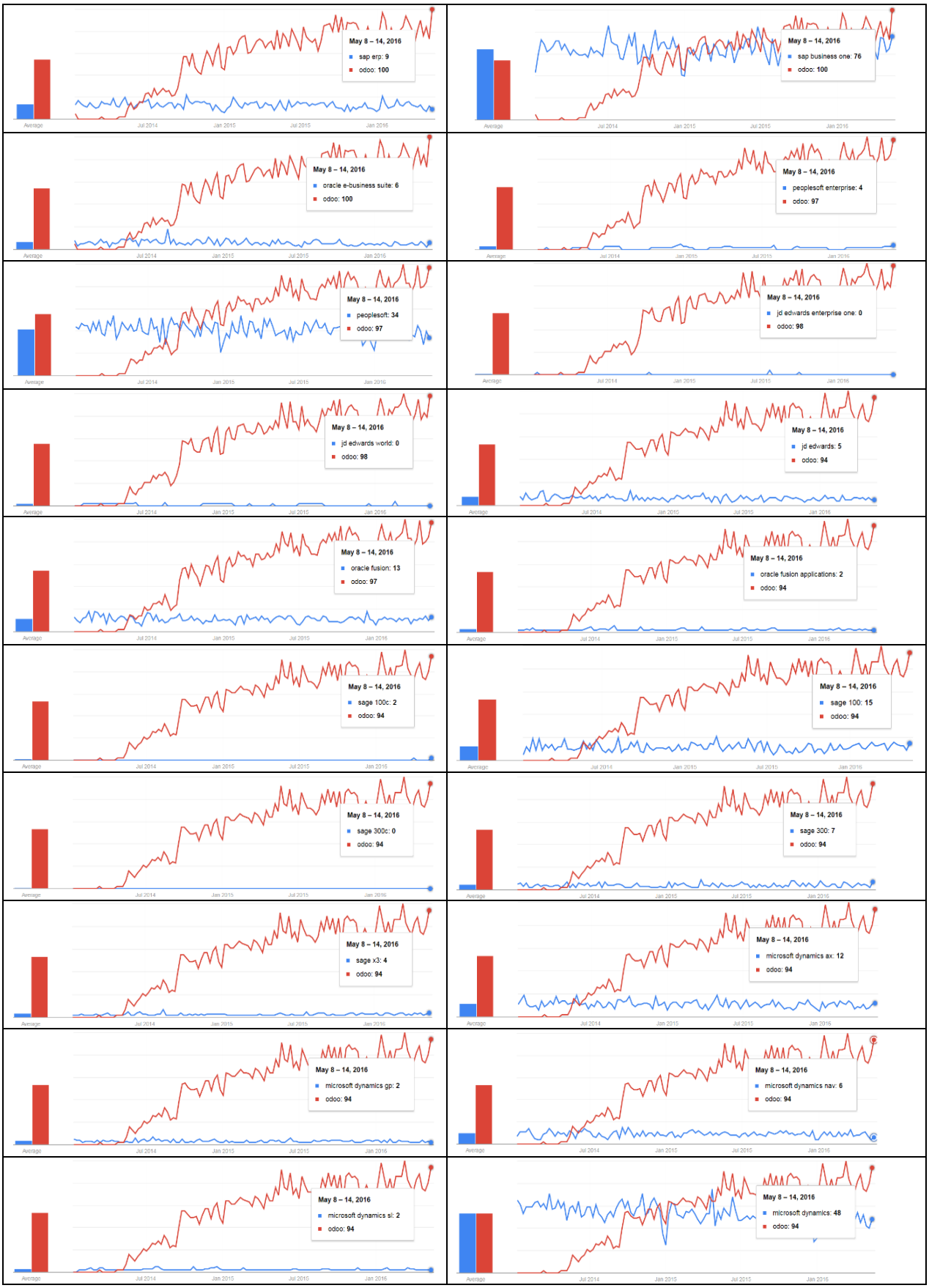

Fig. 4. The relative number of Google searches for the associated keywords for Odoo (the red line) and the other ERP system name (the blue line) during the years of 2013 to 2016.

B. *Odoo Core Modules*

Odoo ERP system consists of a set of core functional modules. These modules are [28], [29]:

- **Customer Relationship Management (CRM)**

The CRM module provides the ability to manage enterprise's sales funnel without effort, attract leads, follow-up on phone calls and coordinate meetings. In addition, The CRM module provides the ability to analyze the quality of leads in order to support the decision making and integrates contacts emails directly into the application to save time. Finally, it enables the tracking of sales teams and follow up the progress towards the desired goals with the new gamification feature.

- **Project Management**

The project management module helps an enterprise to organise its jobs and projects. This module provides the ability to work on tasks and issues using the Kanban view, to schedule tasks in the Gantt chart, and to control deadlines in the calendar view. Furthermore, the project management module provides specific stages creation for each project, therefore, they can be utilized by all enterprise teams in order to optimize their work in a simple and professional way.

- **Accounting and Finance**

Odoo accounting and finance module offers a better way for an accounting team to work with their customers and suppliers. In addition, it provides the standard accounting and finance features that include integrated analytic, budgets, assets management, and multiple companies' consolidation accounting and finance management.

- **Point of Sale (POS)**

Odoo Point of Sales is fully integrated with the inventory management module and accounting module. This means any transaction through POS will automatically be input into the inventory management and accounting modules. In addition, its ability for being used online or offline via different devices models and platforms that can display websites such as iPad, Tablet PC, laptop or industrial POS machine. Furthermore, Odoo's POS includes extra features such as customer service and the creation of invoices.

- **Warehouse Management**

The warehouse management module enables warehouse's users to decrease stock processing times, automate its transactions, reduce the stock levels, and get complete traceability on all operations. Furthermore, this module provides an advanced real-time reporting and custom dashboards to get a picture of the enterprise warehouse efficiency at a glance.

- **Website builder and e-Commerce**

Odoo's website builder and e-Commerce modules provide the ability to create websites and web stores without required knowledge in web development and design. These modules provide numerous functionalities to facilitate the creation of a website such as "edit inline" approach and integration with the enterprise features (i.e. e-commerce, call-to-actions, jobs announcements, events, customer references, blogs, etc.) and many others functionalities.

- **Manufacturing and Resource Planning**

The manufacturing module enables its users to manage all their enterprise assembly and/or manufacturing operations, to schedule manufacturing orders and work orders automatically, to review the proposed planning with the smart Kanban and Gantt views, and to use the advanced analytics features to detect bottlenecks in resources capacities and inventory locations.

- **Human Resources**

The human resources module enables its users to manage an enterprise human resources operations such as knowledge sharing, recruitment, appraisals, timesheets, contracts, attendance, payroll, etc.

- **Purchasing Management**

The purchasing management enables the automate procurement propositions, launch request for quotations, track purchase orders, manage suppliers' information, control products reception and check suppliers' invoices.

C. *Odoo ERP System Architecture*

Odoo is a multitenant system that employs the three-tiers architecture; Firstly, the database tier which is used for data storage; Secondly, the application tier which is used to process and perform the system functionalities; Finally, the presentation tier that contains the user interfaces (UIs) components. Figure 5 depicts the typical deployment of Odoo, where this deployment is known as a web embedded deployment [30].

As can be seen from Figure 5, Odoo architecture consists of the following three main components [30]:

- **PostgreSQL database server**

All databases of Odoo system are operated by the database tier. These databases consist of application data, and the system configuration parameters and elements. This tier is managed by the PostgreSQL, the open-source Object-Relational DBMS. Whereas Odoo modules are responsible for executing the direct SQL queries. In addition, the Object Relational Mapping (ORM) Layer is responsible for the most accessing to the relational databases. In addition, clustered databases can be deployed in this component.

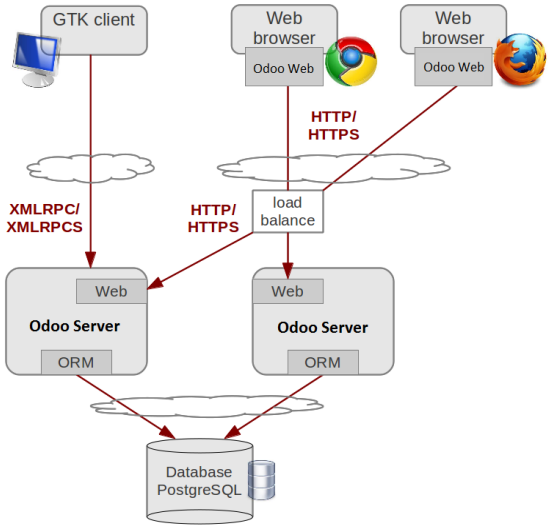

Fig. 5. Odoo architecture for embedded web deployment adapted from [30]

- **Odoo Server**

Odoo server is an application server that hosts specific business applications. This server provides a comprehensive development framework that contains a several features to develop those applications. Odoo ORM is one of these features that provides functionalities that allow access the PostgreSQL server. Likewise, the web layer is responsible to communicate with the web browser-based client through standard browsers to the server. In addition, this server acts as a library to support the previous features while hiding the low-level details and supporting the installation, configuration, and running the written applications in it. Furthermore, Odoo server has other services such as workflow engine or reports engine, and extensible data models and view.

- **Server: ORM**

The Object Relational Mapping (ORM) layer provides additional and essential functionalities on top of PostgreSQL server.

Python programming language are used to describe the data models and Odoo creates the underlying database tables by using ORM. All benefits of RDBMS are used and completed by Python flexibility such as unique constraints, relational integrity or efficient querying. The services that are provided by the ORM are:

- A consistency validation by performing powerful validity checks;
- An interface on objects (methods, references, etc.), which allows to design and implement efficient modules;
- A row-level security per user and group; more details about users and user groups are given in the section Users and User Roles;
- Complex actions on a group of resources; and
- An Inheritance service to allow fine modelling of the new resources.

- **Server: Web**

The web layer of Odoo server provides an interface to communicate with standard browsers. This layer is compatible with the WSGI application based on werkzeug. It manages the regular HTTP queries to server to process static file or dynamic content, and processing the JSON-RPC queries for the RPC that made from the browser.

- **Modules**

The role of the modules is to implement any business requirement, and the server is the responsible component to accommodate these modules and manage them.

- **Clients**

Odoo application logic mainly resides in the server-side, while the client sends a request to the server and receive the response. The retrieved results in the response are displayed in the form of lists, forms, calendars, etc. Furthermore, the user's interaction with the system can send queries to the server to modify its data.

D. MVC architecture in Odoo

In complex computer applications that present a huge amount of data, it is preferable to decouple data (model) from the user interface (view). Thus, any changes to the user interface will not impact the data management, likewise, data can be reorganized without changing the user interface [30]. The model-view-controller (MVC) solves this problem by decoupling data access and business logic from data presentation and user interaction, by introducing an intermediate component which is the controller. Odoo follows the MVC architectural pattern and semantic with:

- Model: The PostgreSQL tables which defining the structure of the data;
- View: views are defined in XML files in Odoo, and each file describes its related user interface; and
- Controller: The objects of Odoo that supports the business logic of the application.

The Odoo API can be accessed externally using two different protocols: XML-RPC and JSON-RPC. Clients may communicate with Odoo by using session-less XML-RPC, which is the recommended way to interoperate with Odoo. While web-based clients can communicate with Odoo by using the session aware JSON-RPC [30].

VII. CONCLUSION

In this paper, a model that consists of eight criteria was presented, these criteria attempt to assist the researchers within mobile ERP filed of research in the selection process of the appropriate ERP system. This model was evaluated and verified in a use case that attempt to address the usability issues of mobile ERP. In addition, an integrated overview was presented in this paper about the selected ERP system that resulted after applying the proposed model.

ACKNOWLEDGMENT

This work is funded by the Phoenix project (agreement number 2013-2447), that is supported by the Erasmus Mundus programme of the European Union and in collaboration with the Carl von Ossietzky University of Oldenburg, Germany and the University of Petra, Jordan.

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