Hybrid Model of the Mobile Information System in a Complex Warehouse System

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Abstract. *Modern warehouse systems are becoming more and more complex. They are in great need of methods and technologies that will ensure storage of goods at optimal locations, efficient recovery of the stock in hand, better transport of goods within a warehouse in a unit of time, more efficient use of manpower in the processes of manipulation of goods and accurate record-keeping as regards the current state of supplies in a warehouse. A solution to the mentioned requirements has been provided by the development of the warehouse information system (IS) that is based on implementation of mobile technology. Given the possibilities of the mobile technology, such approach has no longer any alternative.*

This paper presents a hybrid model of the warehouse mobile IS that is based on the following premises:

- the warehouse mobile IS needs to be designed as a relatively independent subsystem of the overall IS in an enterprise;

- the interaction between the application of the warehouse mobile IS and the Major Application of an enterprise's IS should be established via a special mobile IS database acting as a target database;

- the IS Major Application of an enterprise and the application of the warehouse mobile IS may be developed independently, within different development systems;

- there must be a feedback between the IS Major Application of an enterprise and the warehouse mobile IS;

- the feedback system ensures the necessary double-checking of all entry/exit transactions in a warehouse.

The basic features of the hybrid model of the warehouse mobile IS are as follows:

- a variety of types of database relative to the Major Application of an enterprise and the application of the warehouse mobile IS;

- various development systems of the Major Application of an enterprise and the application of the warehouse mobile IS;

- mobile information technology of different manufacturers, which requires specific approach to the development of applications, etc.

The development of the presented hybrid model of the warehouse mobile IS to the level of a software product, and its successful implementation in a demanding enterprise, as well as the bad examples of similar solutions in practice, in fact confirm the quality of the developed warehouse mobile IS and may serve as a model for the development of similar systems. In view of the fact that the introduction of mobile technology into the IS of a complex warehouse makes all processes in a warehouse dependent on the mobile technology, this paper also provides a review of certain problems relative to the implementation of available ICT systems that directly affect the functionality of an enterprise as a whole.

Keywords. major application, mobile application, warehouse, warehouse documents, ICT, mobile technology, hybrid model of information system

1 Introduction

A complex commercial system with massive daily flow of goods through a warehouse is eager to shorten the interval between the customer's order and the delivery of goods in an effort to thus gain advantage on the market.

One of the relevant technological possibilities to achieve that goal lies in the mobile technology, the implementation of which has no alternative any longer in the context of complex information systems.

The idea for this paper stems from the mentioned practical experience and a new

paradigm that has been created by using the possibilities of the mobile technology based on the handling of goods in a warehouse that is dependent on unconditional implementation of that technology.

The effects of the mentioned paradigm are reflected in an entirely new approach to the management of complex warehouse systems; in other words, in the completely different position, role, rights and capacities of warehouse workers, and also in the new possibilities of control of the flow of goods through a warehouse in the real time, the result of which is better use of the warehouse space, higher level of safety as regards the stock in hand, higher productivity of warehouse workers, and more satisfaction for the customers.

Another effect of the paradigm of the mobile technology relates to new requirements imposed on manufacturers of business software in terms of its implementation in the existing and new information systems, and serious problems occurring during the implementation of mobile technology in real business processes that are due to inteferences and problematic functioning of wireless communication in warehouse spaces.

In view of the above, this paper has been encouraged, on one hand, by authors' good experience in design, building and implementation of the mobile information system in the warehouse of a fairly large enterprise and, on the other hand, it is a result of certain open issues relative to the declared functions and possibilities of the integration of the mobile technology into software solutions to complex information systems.

2 Conceptual model of the hybrid mobile warehouse information system

According to certain opinions it is possible to transfer the entire management of business documents, such as warehouse-related documents, to the mobile technology. But,

the experience in complex trading enterprises questions those opinions and points at introduction of two necessary sub-processes in the overall processing of warehouse documents (Fig. 1).
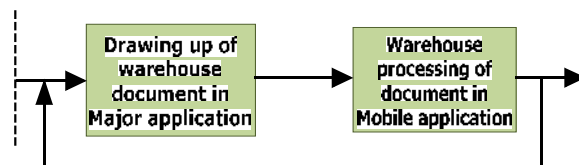

Fig. 1. Diagram of the processing of a warehouse document

Fig. 1. shows that the processing of a warehouse document is divided into two steps, or two interacting sub-processes: the first process is 'Drawing up of warehouse document in Major Application - in the office'; the second process is 'Warehouse processing of document in Mobile application– on location of goods in the warehouse'. The obtained feedback is the controlling indicator of the successfully completed physical/mobile and bookkeeping-related processing of a warehouse document.

The term 'Major Application' implies the basic client/server business application that provides support to a majority of business processes of a business system by mediation of standard desktop computers in a business network.

The term 'Mobile Application' implies additional client/server application that provides support to physical processes of the flow of goods through a warehouse by mediation of mobile PDA devices with a barcode scanner.

Traditionally, the term 'bookkeeping state of stock in hand' is clearly determined in the business applications of trading/manufacturing enterprises. This state is a result of computerized transactions of the goods on stock. These transactions are physically and temporally separated from the real process of manipulation of goods in a warehouse.

The implementation of mobile technology enables introduction of a new term: 'factual/real state of stock in hand', and that state is a result of the transactions of goods in the warehouse conducted in the mobile fashion. These transactions are physically and temporally coupled and are inseparable part of the real process of manipulation of goods in a warehouse.

It is precisely the two separate processes shown in Fig. 1, and the two earlier described terms, 'bookkeeping state of stock in hand' and 'factual/real state of stock in hand' that confirm the assumption about the need for a the system of 'Major Application' and the system of 'Mobile Application'.

The Major Application and the Mobile Application can be relatively independent, i.e. they can be designed separately and built in different development systems, with different databases. However, there must be a feedback between them. On one hand, the Mobile Application is the 'extended - operative hand of the Major Application, while on the other hand, the Major Application is the 'control system' of the Mobile Application.

The mentioned differences make the mobile information system of a complex warehouse (whose conceptual model is shown in Fig. 1) – a hybrid solution that can be created by integrating Major and Mobile Applications of different manufacturers, and by implementing mobile technologies of various manufacturers.

The base of the mobile application in the model shown in Fig. 2 represents the meta base that enables integration of the Major Application and the Mobile Application. It relies on the independence and power of the Major Application base, and ensures relative independence of the mobile part of an enterprise's information system in the real time.
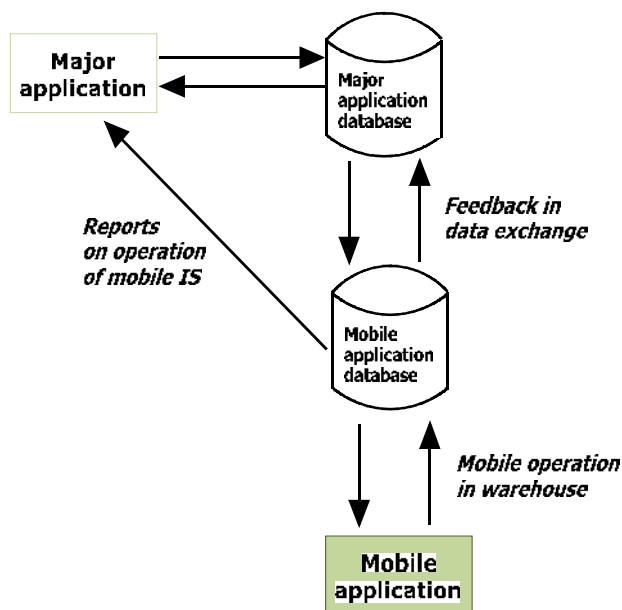

Fig. 2. Conceptual model of the warehouse hybrid information system

3   Options and functions of Mobile Application

From the point of view of an enterprise as the ordering party, the project of development of the Mobile Application for mobile PDA devices (Fig. 2.), as the base of the mobile information system in a warehouse, is a relatively undefined open system.

Introduction of mobile technology in the business operation of a warehouse, and establishment of wireless-online communication with the central database at any location within a warehouse, call for a substantial investment, which in return calls for adequate effects. This fact often results in overly idealistic and excessive requirements and expectations of investors when it comes to the implementation of mobile technology.

This leads to a conclusion that in most cases a solution to the mobile warehouse information system in one enterprise is seen as incomplete or even absolutely unacceptable by another enterprise.

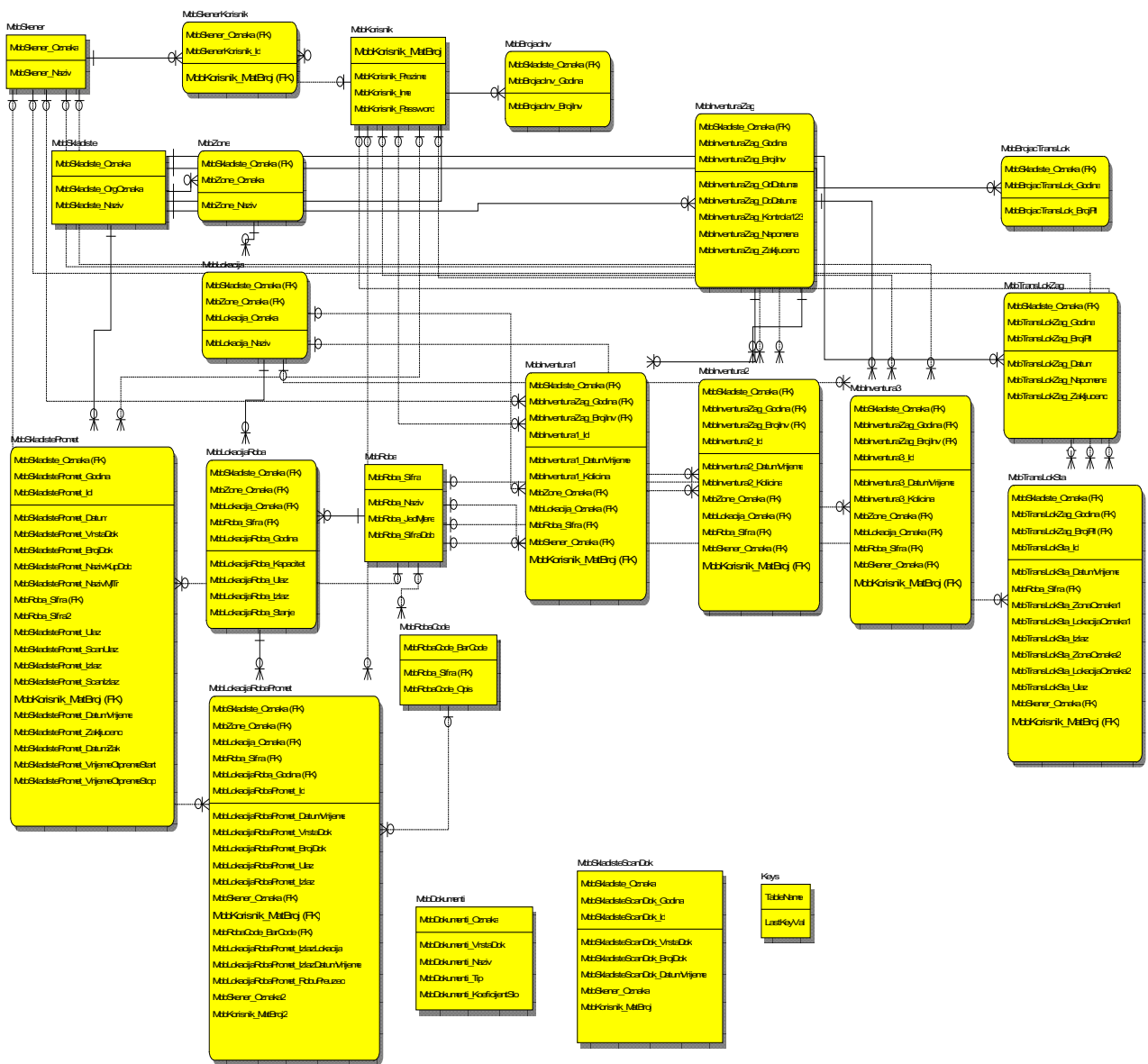Fig. 4. The logical relational model of database of the Mobile application

Fig. 3. Functional diagram of warehouse document mobile processing

Drawing up of warehouse document in GA

Printing of order for the warehouse in GA and updating of MA database

Mobile processing of warehouse document in MA

Adjustment of warehouse document and mobile processing in GA

Finalization of warehouse document in GA

This was precisely the case that the authors of this papers were faced with while working on the project of introduction of mobile technology in a complex enterprise, and developing a hybrid mobile information system in a warehouse.

The logical relational model of database of the Mobile application as a target database of the hybrid information system is shown in Fig. 4. That model proved successful in the program package named *TRENIS - MOBTRENIS* [1].

A detailed illustration of the integrating mobile processing of a warehouse document between the Major Application (GA) and Mobile Application (MA), which generates a number of possibilities of the Mobile Application, is shown in Fig. 3.

Below are some of the relevant options of the mobile application named MOBTRENIS [1]:
- full control over warehouse document processing by applying document's barcode;
- mobile processing of entry and exit of warehouse documents, with simultaneous operative navigation of warehouse items by a warehouse operator along the warehouse locations;
- mobile dispatch of goods from the warehouse;
- mobile relocation of goods in the warehouse;
- mobile taking of warehouse inventory;
- mobile entry of new barcodes of items of different standards;
- survey of current state of stock in hand per locations and zones in the warehouse;
- survey of current activities of warehouse workers, etc.

4 Certain problems with ICT that affect functionality of the warehouse mobile information system

The practical experience in the implementation of mobile technology as a precondition for performance of complex real business processes such as is the flow of goods through a warehouse, points to the fact that the information/communication technology (ICT) and hardware/software required for the implementation of mobile technology, has to be on an extremely high level in terms of technology, quality and accuracy for a business system to normally function and for the initial substantial investment into mobile technology to be justified. If this is not the case, the business system will soon come to a standstill and conducting of business processes will become impossible, which would lead to rejection of mobile technology and to an imperative introduction of an auxiliary scenario of the information system operation.

Among potential general factors that belong to the ICT domain, but are not related to the functions of the Major Application and the Mobile Application and may have a negative impact on the mobile information system, the following can be singled out as critical:
- construction and spacious congestion of the warehouse;
- quality and safety of designed wireless network;
- quality of mobile PDA devices;
- quality of and overall load of the central computer (server) on which the databases Major Application and Mobile Application are installed;
- selected HTTP server (Microsoft IIS, Apache and others), if the mobile application communicates via that server.

Unexpectedly, among the above-mentioned factors the authors of this paper found out that the greatest problem in the implementation of the mobile information system in warehouses was the unstable operation of Microsoft IIS. This instability was simply solved by shifting to the Apache system, and no proves of instability of the IIS operation have been identified.

Of course, the fundamental subjective problem in the functioning of the mobile information system may occur as a result of

a poorly designed project, or bugs in the mobile application itself.

The authors of this paper suggest the concept of the mobile application that was implemented in the project of MOBTRENIS [1] application, the functionality of which is based on the following premises:
- it is desirable that mobile application operates solely in the on-line mode, meaning that every transaction of the goods in the warehouse is registered instantaneously, i.e. in the real time, in the central database, at the moment they are entered;
- the information about the state of stock at locations visible to warehouse workers must be updated at any given moment.

Such mobile application is designed with two components [3, 4, 5]:
- the executive program for the mobile device acting as user interface of the system;
- web service through which that program is linked with the database.

The conceptual model of the MOBTRENIS mobile application is shown in Fig. 5.
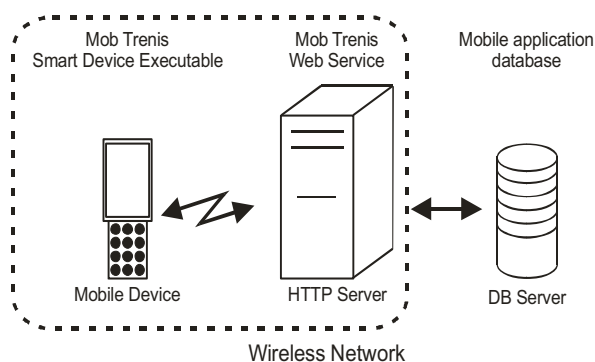

Fig. 5. Conceptual model of MOBTRENIS mobile application

The executive program is needed to allow the possibility of designing a rich user interface and also to provide access to the specific hardware of the mobile device, e.g. to the barcode scanner. None of this is achievable by means of the mobile web application.

Web service for mobile access to the central database is required to ensure safety and control of the central database, impersonation of the user, and implementation of the business logic of the system. The business logic can also be applied to an executive palm-based program, but this solution would result in the slower and less flexible work of complex business processes (because of its hardware that is less perfect that that of 'big computers'), since each amendment to the business rules would imply installation of a new version of the executive mobile program onto all mobile devices.

5 Conclusion

Requirements for the upgrading of the existing business applications and for implementation of various peripheral options into the existing information systems of an enterprise grow proportionally with the occurrence of new possibilities of the information technology. Mobile technology and its support to the warehouse processes in the real time is just one of those requirements that manufacturers of business softwares need to resolve. Otherwise, their applications will not be able to keep pace with time and the competition on the market.

This paper accentuates the hybrid model of the warehouse mobile information system that is based on separate projects of the Major Application and the Mobile Application with independent databases, but interdependent functions.

Also, accent has been put on the importance and delicacy of the implementation of mobile technology, by which the processing of goods in a warehouse is conditioned.

In addition to the term 'bookkeeping state of the stock in hand', a new term, 'factual/real state of the stock in hand' has been introduced, as well as the term 'current activity of the warehouse worker', which actually imply potential immediate new

effects of the online application of mobile technology in a warehouse, which ensures more sophisticated management of a warehouse system.

The authors of this paper have good experience with the presented concept of the hybrid model of the information system implemented in an actual enterprise via the *TRENIS - MOBTRENIS* applications system, but they also point out certain objectively unexpected problems that occur in the process of implementation of mobile technology in the information system of an enterprise, as described in chapter 4 of this paper.

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