Improving organizational efficiency and effectiveness in a Romanian Higher Education Institution

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Abstract: - In response to the significant changes in the competitive climate of public sector higher education institutions (HEIs), the Romanian universities face the need to improve operational efficiency by implementing advanced information systems. The purpose of this paper is to provide a solution for an ERP (Enterprise Resource Planning) system that could integrate all of a Romanian HEI's department functionalities, to propose a model that describes how the concepts of user competence and role may optimize an ERP system implementation in a Romanian HEI and to provide a possible architectural solution for developing a decision support system that can extract and report the information from the proposed ERP system.

Key-Words: - ERP, HEI, DSS, Competencies, Roles, Knowledge.

1 Introduction

In Romania, as in many other countries [9], higher education has moved from an elite system to one of mass education. Also, the student population profile has diversified. Government funding has been continuously reduced over the past years but the demand for education is considerably higher. In these conditions it emerges the need for solutions to provide a better management for these public institutions. As a response to these issues HEIs have considered the adoption of state-of-the-art technology to improve organizational efficiency and effectiveness.

Researchers have conducted studies to evaluate if a Romanian HEI is capable of sustaining such a project and which are the critical success factors that might affect the implementation of an information system in a Romanian HEI [1]. Most researchers stated that although are many differences between the "West European way" and the "East European way" of conducting HEI management (due to significant differences in organizational, epistemic culture [15]) the main reason for which HEIs do not undertake such projects is the lack of funds. As a result, in Romanian HEIs we will find that almost every faculty or department has its own software applications, developed in-house, applications that use various operation systems, tools, databases and protocols [1]. In this paper we will try to address this problem by proposing a solution for an information system adapted to the Romanian HEI necessities. Although many researchers [17], [25], [56], consider training a critical success factor in the implementation of an ERP system, we state that the appropriation of the system does not only depend on training but also on the manner of adapting the ERP system to the role and competence of the user. This implies more than just the position of a person in the HEI and refers the competencies and the knowledge he possesses. If we create and implement an information system that is not adapted to the requirements of the workforce involved in the HEI we will confront ourselves with lack of motivation problems and inappropriate use of information system in order to mitigate its supposed deficiencies.

Section 1 has introduced the study and shown its relevance. The remainder of the paper is organized as follows: Section 2 frames our research by introducing the background of the study. Having presented the landscape inspiring the study's research questions, Section 3 presents the solution that will be developed like framework in the future and discusses the significance of user competence and role in the optimization of this solution. Section 4 details the decision support system components that will be included in the framework. The paper is finalized with conclusions and suggestions for future research.

2 Background

University information system is an integrated business system for comprehensive management of critical function of university. It supports business processes of administration, education, and research management [21]. University information system is a typical corporate information system which supports several hundred functions to more than several thousands students, professors, and staffs in university. It could be realized in specially designed system integration type or in software package based ERP type. Particularly, university ERP as a software package based university information system provides the required functions through the only one integrated software package instead of several independent application systems in the past. Since it doesn't need any interfaces between different application packages, university ERP is strongly advantageous in process standardization and maintenance convenience. Also, all of the information within the system is stored in a single unified database that provides a benefit of enhanced report writing capabilities [21]. A typical internal hierarchy of an university ERP is showed in Figure 1. The internal hierarchy of university ERP consists of: portal (user services, interface, interaction and customized service), business logic (academic, research, administration) and system utilities (databases, network, security, user authentication, and statistics).

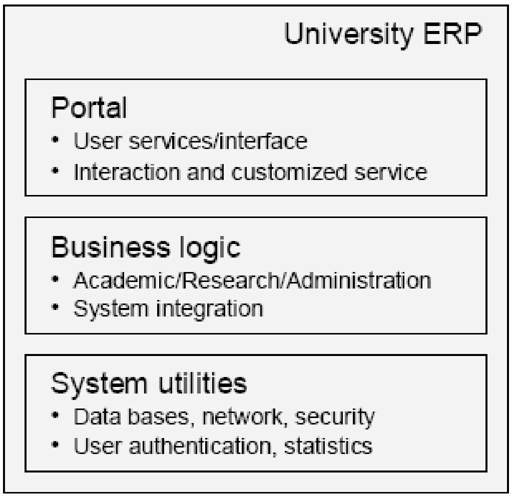

Figure 1 - Components of university ERP system (Source [21]: 502)

In the academic literature we found several studies focused on the implementation of ERP system. In the academic literature we found several studies focused on the implementation of ERP system [51], [6]. Shanks and Parr defined ERP implementation as the process of developing the initial business case and planning the project, configuring and implementing the packaged software, and subsequent improvements to business processes [46], ERP implementation should therefore be considered a „business project rather than a technological initiative" [36]. ERP implementation is considerably different from any traditional information system implementation for many reasons [43]:

- The integrated nature of ERP applications causes dramatic changes on work flow, organizational structure and on the way people do their jobs;
- ERP systems are not built but adopted, this involves a mix of business process reengineering and package customization;
- ERP implementation is not just a technical exercise but it is a socio-technical challenge as it poses new set of management procedures.

In that sense, it has become clear that ERP implementation differs from traditional systems development where the key focus has shifted from a heavy emphasis on technical analysis and programming towards business process design and human elements [45].

Some researchers were concerned about the existence of a large gulf between standardized generic solutions and the specific contexts, practices and requirements of particular organizations like HEIs. Their argument has been the need for better mechanisms for understanding the coupling between technical and institutional change [48]. Shoham and Perry proposed a model for managing organization-wide technological changes in universities on the basis of the existing mechanism, using knowledge management strategies for the purpose of change management [52]. Several researchers have presented the development of a new module for the management and administration of students assuming the existence of a certain kind of user, one with particular roles and responsibilities - a self -service user [46]. Other researchers provided analysis of the rollout of an ERP system in a HEI, their particular focus being on how the development, implementation and use of both generic and university specific functionality is mediated and shaped by a fundamental and long standing tension within universities: this is the extent to which higher education institutions are organizations much like any other and the extent to which they are "unique" [47]. There are several researchers that studied the importance of adapting the business process modeling to the user competencies, knowledge level and role [29], [30], [31], [63] and concluded that the analysis of the role of human resources in correlation to the technical or information processing processes is a key factor for improving the organization performance through a better adoption of ERP systems.

In the Romanian academic literature are no studies concerning the importance of adapting the ERP system process to the competence, knowledge and user role, therefore this study also aims to eliminate this gap by proposing a model that incorporates this concept.

In the current Romanian academic literature are few studies concerning the degree in which the existing ERP systems can be adapted to a Romanian university and if these systems represent a viable proposition for the

Romanian higher education sector, because we must consider the fundamental issue concerning the cost feasibility of system integration, training and user licenses that may, in the end, impede ERP system utilization.

3 ERP system for a Romanian HEI

3.1 Framework for an efficient ERP system in a Romanian HEI

Similar to general corporate information system, university ERP should be closely linked to the business goal and business rule in university for its successful operations. Considering the internal hierarchy presented in Figure 1 we present the case of actual implementation of an ERP system in a Romanian HEI in Figure 3. The main modules of the ERP system should be:

- Admission module for: pre-admission management, admission management and registration management.
- Academic module for: student administration, academic program management and research management.
- Administration modules like: Finance module, Human Resource module, Service module.

The university that is subject to our study has already implemented a system for the library management, which means that this legacy system needs to be integrated within the newly ERP system.

Detailed functionalities for each module are also showed in Figure 3 along with a comprehensive sketch of the portal mapping on the ERP system.

3.2 User competencies and roles in a Romanian HEI context

Competence results from a combined implementation of knowledge, know-how, abilities, attitude and behavior. It encapsulates the ability of an individual to perform an activity in a job-relevant area as well as what is required from this individual to realize effective performance [29].

A role encompasses a group of functions to achieve a purpose, based on the application of competencies. Organizations can be considered as systems of interacting roles [31], where a role is considered both as a set of activities or as an expected behavior.

A role can be linked to a workstation, or to an organizational position, and the interpretation of the notion of role in the university leads to consider the organization as a network of roles defined independently from the persons who operate [8]. Therefore, the concept of role may be of prime interest in order to describe the interaction of human actors with the ERP system.

The proposed model to be used in the development of the Romanian HEI is presented in Figure 2.

The user occupies a position (job description) characterized by a role. Performing this role requires competencies. Competencies can be required by an activity.

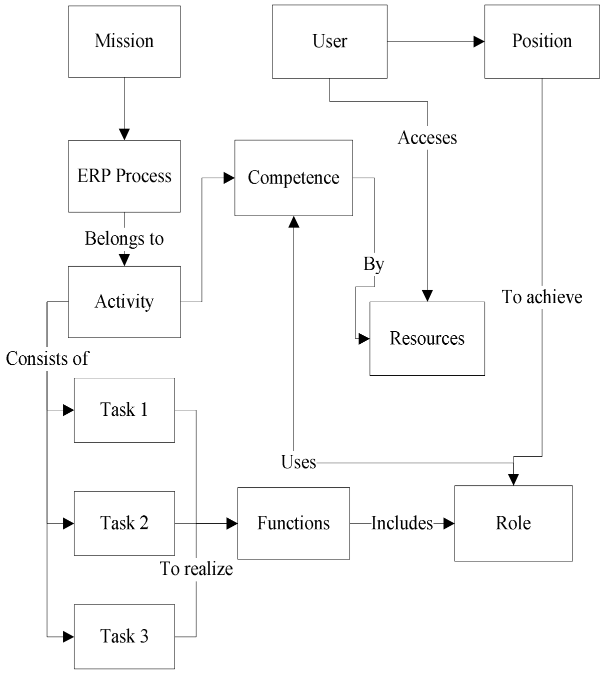

Figure 2 - The general model.

The figure also shows that a process, aiming at achieving a mission, can be composed of activities which are composed of tasks. Performing a task requires functions which define a role. The user competencies are based on several resources. Resources are data, information or knowledge. We intend to use this framework to better adapt the university ERP specific activities and processes to the necessities of the personnel involved in the future implementation of the information system to be created.

4 Decision support systems in HEIs

Through Decision Support Systems the managers of HEIs can manipulate large sets of data in a short period of time in order to take decisions. In essence, managers at every departmental level can have a customized view that extracts information from transactional sources and summarizes it into meaningful indicators. DSS can gather data from the ERP system implemented, from different functional areas or modules such as: financials, academic, human resources, admission and service modules. In Decision Support Systems the multidimensional model is used to be able to overhear the business requests.

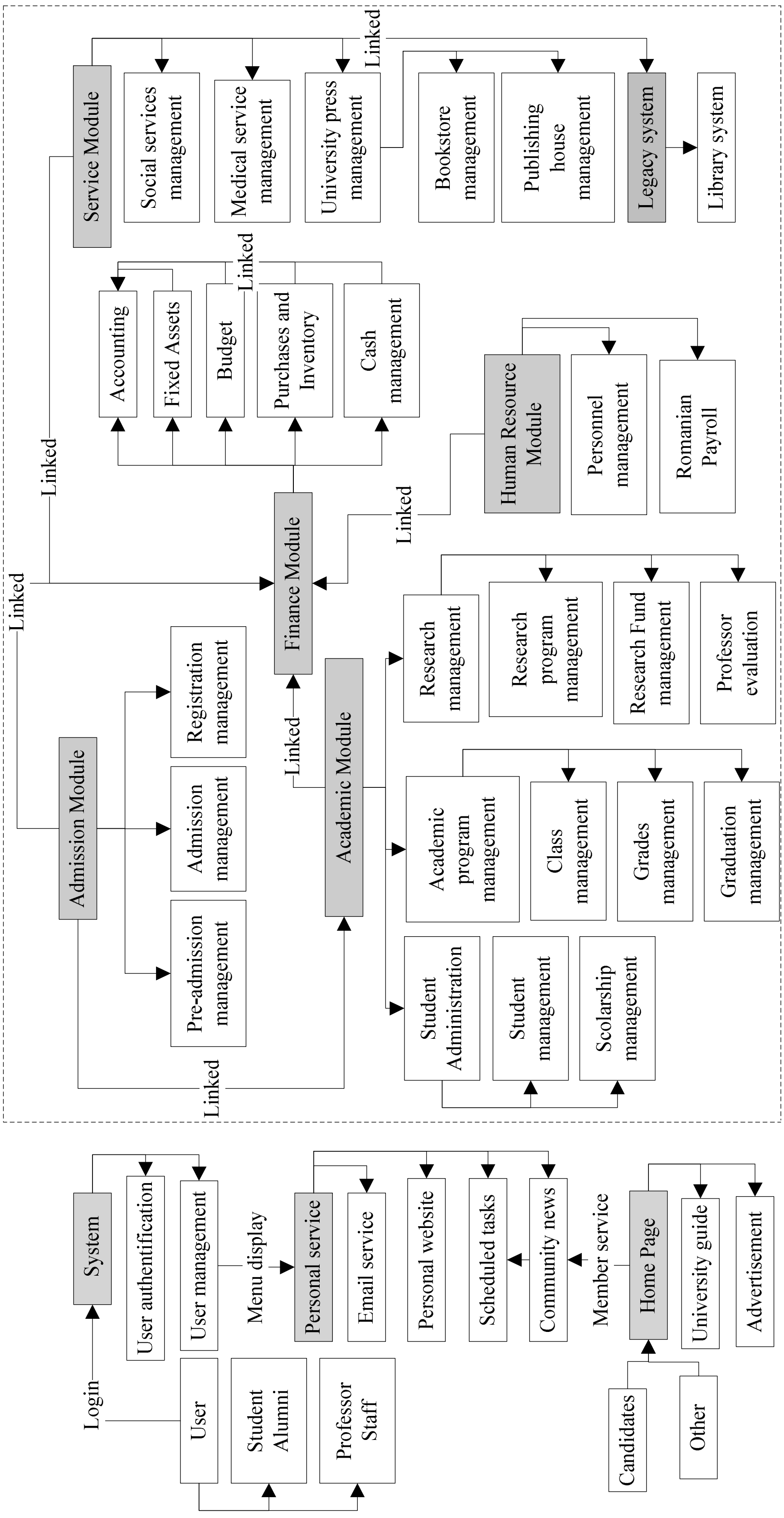

Figure 3- A possible solution for an efficient ERP system in a Romanian HEI.

All we need is a business vision over data structure so the star schema or the n-cube based models have to design and incorporate business aspects or demands not only the facts or the relationship between data.

The managers request a synthetic view over facts and indicators and these key performance indicators are built from the entire organizational data or even external data. Another request is to provide a friendly graphical interface with advanced capabilities of slicing and dicing through data and easily get a new perspective over data by rotating dimensions and drill down or roll up over hierarchical levels. So we need a multidimensional model in which these operations can be made easily, in real time and that can it overhead the entire business model with relationship between dimensions, facts and hierarchies and it is based on the entire organizational data at operational level, tactical level and strategically level. Based on these considerations we propose an extension of the star or the constellation schema but with aggregate data and hierarchies in fact tables not only in dimension tables. The model is structured over three distinct levels and we can call it a pyramidal model with the following structure [24] as shown in Figure 4:

- Organizational level (or the base of the pyramid) – containing dimensions and facts with an organizational scope, at a general level, that shape and are common to the entire activities. Such dimensions can be: <time>, <faculty>, <education> (EDULEV), <item> and facts: HR (human resources), purchasing, administration (ADDM) etc. Data are at a detailed level with multiple hierarchies over each dimension table.
- Departmental level - containing dimensions and facts for the departmental levels of the organization and particular activities in these departments or field of interests, group by data marts or data centers. Such dimensions can be: <account> (ACC), <student>, <employee> and facts: payments, salaries, cash management (CASH MGM), incomes and costs (VEN COST) etc. Data are at a detailed and aggregate level with specialized hierarchies over each dimension table.
- Strategical level - containing dimensions and facts derived from the base dimensions and facts, with specific elements for the strategic analysis, like <plan>, <budget> and facts: cash-flow (CF), key performance indicators (KPI). Data are at an aggregate, synthetic level with specialized hierarchies over each dimension table.

The main characteristic of the model is that between the dimension tables and the facts from different levels of the architecture can be establish a relationship and also the fact tables can have hierarchies and class attributes that can be used for drill down or roll up.

Advantages of the model:

- Flexibility – new elements or objects like new dimensions or facts can easily be included in the model without affecting the existing architecture or re-modeling the system and the loading process for a specific level can be made without refreshing the whole data;
- Real model of business requirements – the three level architecture is based on the real model of business requirements thus this model can be mapped on the each level of the pyramid;
- Performance in the drill-down or roll-up operations – because the dimensions and facts are separated at each level we can easily navigate through hierarchies from a level to another;
- Incremental development – the model can be build in stages and each stage can be validated and used before the next stage;
- MIS and EIS support – the bottom and top levels can be used for designing and developing a Management Information System (MIS) or a Executive Information System (EIS) because these systems can use the specific dimension and fact tables from these levels.

Disadvantages of the model:

- High complexity – because it is containing three different level the business model need to be careful analyzed and designed in order to identified the proper and suitable dimensions and facts and also the hierarchies at each level. An inadequate choice can have a major effect on the performance of the entire system;
- Moderate performance of the interrogation process – in order to perform a complex query the model need to establish many relationships and joins between the fact and dimension tables and this can reduce the performance of interrogation;
- Top-down and bottom-up development – In order to overhear the entire aspects of the business process we need to build the systems in two directions: first top-bottom to model the strategic requirements and second, bottom-up for validating and setting up the hierarchical flux of data.

Decision Support System's architecture will be structured on three distinct levels:

- Data Management – represented by relational databases, data warehouses and other type of data sources;
- Model Management – level of extract, transformation and processing of data. This level is based on different type of models for statistic interpretation, analyzing and forecasting data
- Data Visualization Tools - provide a visual drill-down capacity that can be used to examine data graphically and identify complex interrelationships.

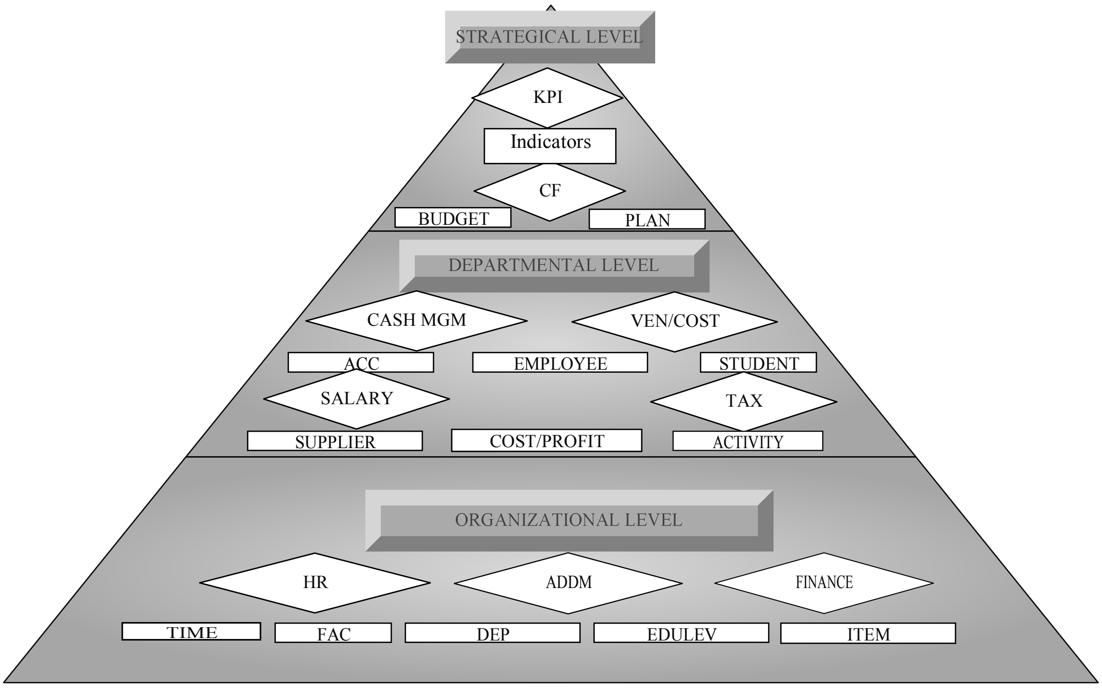

Figure 4 - The pyramidal model for Decision Support Systems in HEIs.

DSS attempts to present data in a form that is relevant for strategic decisions.

The architecture can be implemented by the following technologies:

- *Data Warehouses* - a data warehouse collects and organizes data from both internal and external sources and makes it available for the purpose of analysis. A data warehouse contains both historical and current data and it is optimized for fast query and analysis.
  Data are organized in another type of schema which contain fact tables and dimension tables. A fact table is related with dimension tables and contains measures and formula which enable a much easier way in finding data. Dimension tables are structured on different hierarchical levels of aggregation (e.g. Time dimension can have day, week, month and year as hierarchical levels).
  Data presented in fact tables derived from different type of data sources like relational databases and user files. Data warehouses extract, transform and process data for high-level integration and analysis. Although a data warehouse can make it easier and more efficient to use the DSS, it is not required for an DSS to be deployed. Organizations can extract data directly from their host system database for their analysis and reporting purposes, but in a more difficult way.
- *Online Analytical Processing (OLAP)* - an OLAP engine is a query generator that provides users with the ability to explore and analyze summary and detailed information from a multi-dimensional database. Traditional relational database systems handle this situation by using multiple queries. In many cases, the queries become so complex that even the developer finds them difficult to maintain. OLAP overcomes this barrier by enabling users to analyze multi-dimensional data.
  OLAP systems have typically been implemented using two technologies: ROLAP (Relational OLAP), where data is stored in a RDBMS and MOLAP (Multidimensional OLAP) where dedicated multidimensional DBMS is used. There are also version of HOLAP (Hybrid OLAP) and DOLAP (Desktop OLAP) systems. Managers can use an OLAP engine or typical operation like „slice and dice” data by various dimensions and then drill down into the source data or roll-up to aggregate levels. OLAP provide tools for forecasting data and „what-if” analysis. OLAP can only mark the trends and patterns within the data that was requested. It will not discover hidden relationships or patterns, which requires more powerful tools like data mining.
- *Data Mining* - Data mining tools are especially appropriate for large and complex datasets. Through statistical or modeling techniques, data mining tools make it possible to discover hidden trends or rules that are implicit in a large database. Data mining tools can be applied to data from data warehouses or relational databases. Data discovered by these tools must be validated and verified and

then to become operational data that can be used in decision process.

In many cases the development of a decision support system involves the design and the implementation of a data warehouse. Different factors such as high costs and resources or an improper system design may lead to a failure in over 50% of these cases. One of the main factors of failure is that the data warehouse is built only for specific tasks or requirements and the expansion of the system cannot be achieved or achieved at very high costs. For the project lifecycle we can apply the framework described in the book [22]. The system has to gather data from an ERP system with modules. So the need for a data warehouse is obvious and we have to choose between the two data warehouses solutions: stored data vs. virtual extraction. Because of time and costs and in order to test as soon as we can the DSS functionality we will first choose the second solution: virtual data warehouse. There will be many more changes in the structure of the organization and the impact of these changes may affect the DSS system. So, we need another solution, and, based on our previous researches on Object Oriented modeling, we can choose this type of modeling. The particularities and the characteristics of MD cannot be easily accomplished with the basic elements of OO modeling. Some extensions of these basic elements have to be made. In [22] we defined a set of object-oriented extensions that can be used for modeling the components and requirements of a data warehouse. We proposed an extension by means of stereotypes to the Unified Modeling Language (UML) for MD modeling and thus OO approach can help us to improve the designing phase and the development cycle and also we can re-use some parts of the prototype that will be implemented in a HEI in order to design and implement the system in the organizational environments.

5 Conclusions

The ERP system was seen by the management of a Romanian HEI as the solution to address the growing governmental information requirements and improve competitiveness in the academic sector.

Developing scalable and flexible ERP systems in HEIs involve important resources like: time, high-costs and human resources, efforts and it require a flexible modeling for the special business needs. One of these risks is the system design that stem from poor conceptualization of an enterprise's true business needs before the systems is deployed and for every change in these requirements the prototype must be also revised. That is why we need to link the future ERP processes (the informational part of the proposed model) to the future user role and competencies (human resource part of proposed model). The ERP system framework can be developed using the phases proposed in [22] and also a possible solution is the object oriented modeling in order to re-use the components and capture in the same place the proprieties and operations.

The presented model can be improved by elaborating on the security issues emerged when a user is to access certain resource based on his competencies. Also the model can be complicated by making distinction between the types of knowledge the user can access - explicit or tacit and ways to surface the second one. These two problems will be subject to a subsequent study.

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