AMICO: The Asset Management for Industrial Complex Enterprise

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Abstract: Asset management plays a crucial role in productive activities of an industrial factory. Several commercial softwares exist but they generally present some limitations, among which the closed nature towards integration. The paper presents the AMICO project, a software platform conceived to overcome traditional limits of existing commercial solutions. A research investigation has preceded the definition of the system; it allowed to highlight the current state of the market related to the asset management softwares and pointed out the technological enhancements which could have been implemented. Among them, it highlighted the importance of a central information system able to synchronize information flows and activities. Thanks to a centralized architecture, powerful and innovative features like a cooperative workflow engine and an expert system has been introduced in the AMICO project.

1 INTRODUCTION

This paper presents the first results achieved inside a research project called AMICO (The Asset Management for Industrial Complex plant). AMICO is an ongoing project carried on by XENIA Srl, a SME Software Company located in Catania, and the DIEEI (Department of Electrical, Electronic and Computer Engineerings) of the University of Catania with the contribution of the Regione Sicilia (ITALY), based on European Regional Development Fund (P.O. FESR Sicilia line 4.1.1.2).

The main objectives motivating the development of AMICO take the cue by the matters of the Digital Factory (Wenzel, S., Jessen U. and Bernhard J., 2005) which set the integration of the activities characterizing modern enterprises as one of most important goal to reach.

In the past few decades, ICT has offered several software tools but only recently holistic solutions (such as ERP, MRP, etc.) able to fulfil the requirement of digital integration have started to take place (Umble, E. J, Haft R. R and Umble M. M., 2003), (Aloini D., Dulmin R. and Mininno V., 2007). Such type of software solutions aim to be easy scalable, agile in customization and modular. The software solution proposed by AMICO has to be framed within this context. AMICO wants to offer an innovative solution for the management of the industrial factory assets and corresponding documentation, able to integrate the workflows of the associated industrial processes and provide an environment of co-design and interoperability among the people involved in the work-orders activities.

The initial requirements of the projects have been determined according to the result of a detailed survey of the current art of market aimed to generalize and extend, as much as possible, the scope of the platform. In this direction, innovative features like a cooperative workflow and an expert system to support the management of the work-order activities have been highlighted and implemented.

The paper is organized as it follows. Section 2 presents a short survey about some of the most diffused commercial solutions of asset management software and it points out the enhancements proposed within the project AMICO. In Section 3 an overview of the AMICO platform is presented with particular emphasis on its main features, i.e. the cooperative workflow engine and the expert system. Finally, in Section 4 conclusions involving the use of the AMICO platform in real industrial scenarios are discussed.

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2 STATE OF ART

One of the most important activities inside an enterprise consists in the management of existing asset documentation; such an activity has to warranty freshness and consistency of all the documentation containing information about productive processes and corresponding equipment. In general, these types of information are not homogeneous and can vary depending on the type of activity and equipment (i.e., the number of documents, certification, reports and so on); moreover, information's stakeholders may be either internal or external to the enterprise organization (i.e., *collaborative design*).

Asset management software has to be conceived to support this critical activity. Currently, several commercial solutions are available on the market; they support asset documentation management in different ways. For this reason, a preliminary survey concerning the main features of some well known commercial software of asset management was conducted. This investigation was used to determine what improvements can be valuable in respect with current state of art. The analysis was focused on the core functionalities (e.g. presence of an unified platform of document and asset management, the main features of the repository and the workflow management) and some advanced functionalities (like use of expert systems, dynamic workflows, RFID support and so on).

More than 10 well known and commonly used asset management tools have been considered; their references have been intentionally omitted. The results of this investigation are summarised in Table 1; for each of the functionalities considered in the analysis, the table shows if it is generally supported (√), partially supported (P), and not supported at all (N).

One of the main limits observed is that commercial products do not fully support centralized repository. Traditionally, the very different functional departments of an enterprise rely on different specific tools (electronic spread sheets, text editor, etc.) for the implementation of their activities and workflows. In these scenarios, departments independence and activities parallelization lead to sacrifice the consistence and freshness of the information knowledge.

The drawbacks of not having a centralized database are that:

- information are fragmented into several repositories, if not even maintained into a paper documentation;
- due to unreliability of databases, activities concerning new developments and updating must be preceded by on-site inspections;
- report activities concerning status of the equipment are difficult and the impossibility to access reliable and fresh information increases the risk of non-compliance with security standards and legal requirements.

On account of what said, the adoption of a central database is one of the most challenging features to realize; the implementation of a unique common information repository represents one of the key features of the AMICO project.

Table 1: Functional Requirements offered by several existing commercial solutions.

	Functional Requirements	Availability
CORE	Unified platform of document and asset management	P
	Centralized repository (documents and asset)	P
	Integrated management of workflow	P
ADVANCED	Dynamic/flexible workflows	P
	Expert system for the verification of assets consistency	N
	Co-design environment supported by synchronized workflow	N
	Management of concurrent updating	N
	RFID support	√
	Browsing of CAD files	N
	Wireless client	√

LEGEND: √: Available; **P**: Not fully supported; **N**: not supported at all.

Another limitation of the available solutions in the market is relevant to the "Integrated management of workflow"; this limitation consists in the lack of workflow management platforms to favour a collaborative approach for the execution of the work-order activities. Traditional software solutions offer workflow platforms of management which are just able to track and monitor the status of work-order activities; in these solutions, more complex operations (like authorizations to create, access, update documentation, etc.) have to be performed outside the workflow environment by the operators involved in the activity. Another important goal aimed to reach within the AMICO platform, is the implementation of a collaborative workflow environment, realized thanks to the availability of the above mentioned centralized repository (which maintains assets status and work-orders information fresh and consistent) and by the use of customizable rules of permission which enable the operators to

access secured resources and asset documentation.

Considering the advanced functionalities shown by Table 1, the analysis carried on has highlighted that none of the main software solutions implement any type of Expert System for the verification of assets consistency. This feature would be of valuable support for software of asset management since it can help users in the preparation of work-orders or in the activity of co-design with third-party companies.

The features listed so far can contribute to the achievement of another important goal, namely the realization of a quite general asset management platform, easily adaptable to a wide variety of industrial enterprises (Jordan, W. C. and Graves S. C., 1995), (Jenkins G. P and Wright D. S., 1998), (Chase, R. B. and Aquilano, N. J., 1977), (Brandolese A., Brugger G., Garetti M. and Misul E., 1985). In fact, the adoption of a centralized architecture in support to a co-design workflow management environment allows adaptability to any type of asset management activities and guarantees independence from a specific implementation.

3 AMICO

The AMICO projects aims to the implementation of a centralized information system for the integrated management of the enterprise, supporting all functional areas activities providing a unified vision of data, documents and equipment and warranting information freshness and consistency.

The initial objectives of the project were inspired by requirements identified in large industrial enterprises to have a centralized tool warranting the alignment of assets and documentation and integrating the operating workflows with the work order activities.

The main idea behind the project AMICO is based on the definition of asset, intended as any type of element which contributes to the enterprise activity, be it a physical object or an immaterial element. In this way, assets are the main objects handled by the integrated software platform: they are stored and kept updated inside a central database which supports all the process activities for the entire life of the equipment.

In order to satisfy the project requirements, the following activities must be performed:

- creation of a functional and organisational model for asset and documentation management;
- implementation of an integrated information system warranting integration among data and processes activities performed by distinct enterprise functional areas (i.e., people of different teams);
- integration of a co-design environment for the management of workflows, related to enterprise process activities;
- the implementation of innovative applications able to automatically control, verify and warranty consistency of database information with the real status of assets either stored or checked out.

Figure 1 shows the functional blocks which constitute the AMICO platform: it is possible to highlight two distinct functional information flows which are interfaced by both “Engine workflow management” and “Expert System” entities. On the left, the functional blocks handling production server’s repository of the production server are shown; asset and documentation can be accessed and managed by the authorized personnel the System Administration panel; moreover high level functions of search and update are provided by the related functional blocks. Consistency and congruence is maintained by the functional blocks “Asset Integrator” and “Asset Consistency Check”. On the right part of Figure 1, a generic order workspace is presented: when a work order has to be processed, the most fresh asset’s status to be used (i.e., information and documentation about the elements of the process involved) is retrieved (Check out) and transferred into the so called “order’s workspace”. This workspace is the information environment, within the production server, used by all team units authorized to operate on the work order; in this way modifications of the work order are carried out in a safe way, as the coherence of the asset is maintained in the repository of the production server (as shown in the left part of Figure 1).

Publishing and check-in operations are performed during the work order activities, with the support of a powerful workflow engine guaranteeing a step by step verification of asset modifications’ and implementations.

In order to realise this important feature, the platform includes a software module implementing a collaborative workflow management and co-design environment to monitor and support the authorization processes on for external contractors involved in work-orders operations. The latter (as shown in Figure 1) is positioned between a generic workspace of order, typically managed by personnel of a contractor team, and the Public Repository of Asset and Documentation (i.e., the central

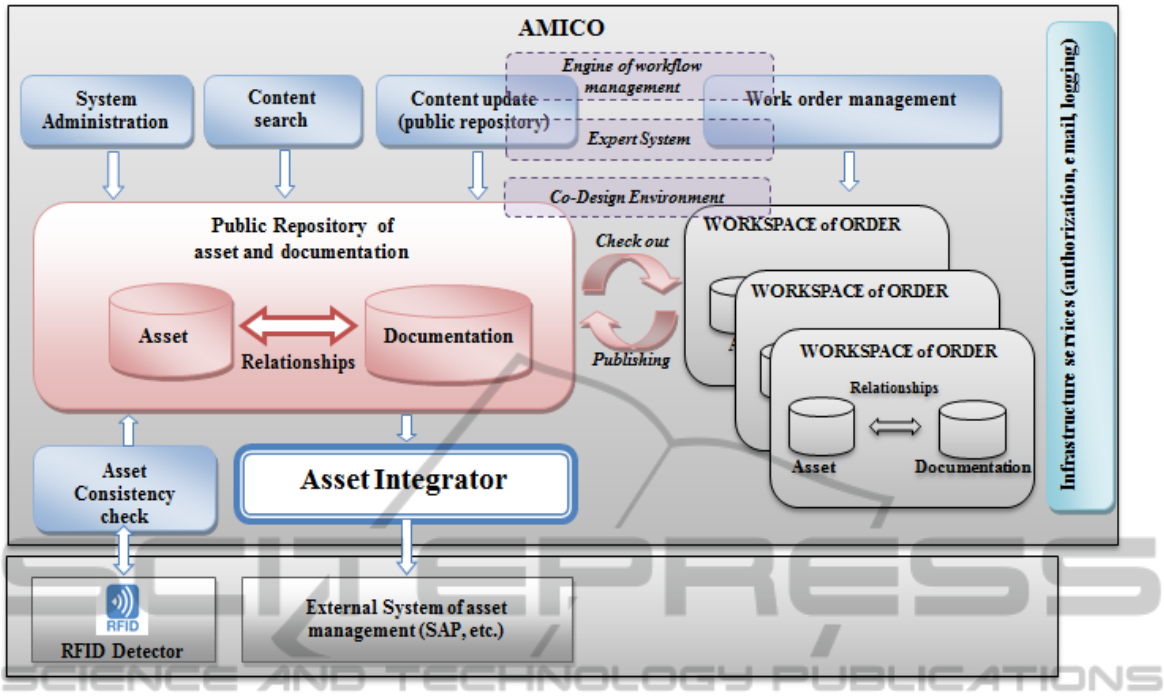

Figure 1: Functional Blocks constituting the AMICO Platform.

repository): in this way, when a documentation stored in the central repository is required by the contractor, the request is automatically taken in charge by authorized personnel.

The next subsection will describe the workflow management here implemented.

The other novel feature of AMICO is the implementation of an Expert System supporting documentation management activities. As it will be shown in the following, the Expert System implements a Business Rule Management System (BRMS) to provide users with a list of possible relationships among all documents related to a work-order.

3.1 Workflow Management

As well as the internal know-how of the enterprise is well maintained inside the public repository of the AMICO platform, so robust protocols for the execution of work-orders are ensured by the definition of appropriate dynamic workflows (Biegus L. and Branki C., 2004), (Dogac, D., Kalinichenko, L., Özsu, T. and Sheth, A., 1998).

AMICO fulfils this requirement by providing an engine implementing a collaborative environment for the design of workflows (Held M., Blochinger W., 2009); such workflows gurantee the integrity of the entire work order process and related know-how. This feature is implemented through a continuous synchronization among internal and external enterprise resources (i.e., management and teams in charge to perform the operations).

The basic principle is to map any type of work-order into an electronic workflow. Through a user-friendly design tool, the authorized personnel will be able to create the workflows associated to any types of work-order process: these workflows will be collected in a catalogue populated and maintained in the central database. More complex workflow structures can be designed by also involving multiple actors and granting different level of authorizations.

These workflow models can be instantiated and executed when a work-order (or a set of work-orders) is going to be processed. A dedicated runtime environment will maintain and concurrently execute all instantiated workflows, while data congruency will be guaranteed through synchronization with the central database.

Check-in and check-out operations are required to access the workspace related to the work-order (right side of Figure 1, where publishing corrensponds to check-in operation). Centralized repository (left side of Figure 1) will not be modified until the work-order is completed or updating operation (scheduled in the workflow) has been authorized. In order to ensure integrity of multiple

accesses, mechanisms of automatic communication among the actors accessing the same resources are used (e.g. automatic emails, etc.).

3.2 Expert System

The activity of asset and documentation management requires specific skills, related to the different processes and domains of the enterprise. Such competence acquisition requires a long and wide experience. A deep knowledge about enterprise processes may be not sufficient to have a comprehensive view of the relationship occurring among large amount of assets.

The utilization of an Expert System (Malhotra Y., 2001) has to be framed within this context; it may solve the aforesaid limitation. The use of an Expert System provides two main advantages: the first is that it can partially replace the role of the expert user, supporting and training inexperienced personnel; the second is that it can also support expert users when operating on activities characterized by a large amounts of inter-dependencies.

AMICO's Expert System is providing also support for documentation management in the preparation of work-orders or co-design with third-party companies. The Expert System, by processing of relevant rules and input parameters, will be able to suggest a set of documents to be included as part of the work-order. This process and the achieved results are similar to the analysis that an expert user would apply. In addition, the Expert System is scheduled in order to process data periodically, providing a result that is always synchronized with the changes of the database.

The Expert System will make use of the central database (through appropriate views or other data structures) to access data concerning work-orders, assets and documents as required by the inferential algorithms. The output of the Expert System (i.e., the list of suggested documents and the set of information provided) will be stored inside dedicated data structures within the central database.

The inferential engine is based on two main broad categories of rules:

- rules related to relationships which exist in the work-order management model, as inferred by the analysis of the historic;
- rules not directly related to existing relationships, but obtained by "experience" through the analysis of the historic.

For each document in the recommended list, the Expert System will provide an indication of the proposed criteria and the level of criteria reliability (likelihood) calculated through the analysis of the historic.

The Expert System behaviour is based on the concept of *Facts* and *Rules*. Facts are information used to verify whether or not particular events or conditions occur. Rules are more complex criteria that look for the occurrence of a combination of facts and indicate the actions to execute.

These actions can, in turn, modify the status of the system and trigger the execution of other actions.

Figure 2 shows the Expert System Architecture defined and implemented inside AMICO platform. As it can be noticed, the Expert System is deployed within an Application Server and can be interrogated by a generic Client application through a Web-service. The Expert System includes the following key components:

- Working Memory: where System knowledge is stored. Each element of knowledge is called "Fact". Facts can be inserted, updated, and removed from the Working Memory. In our specific implementation Facts are data related to documents, checklists, contracts, taxonomies, facilities, assets, etc...;
- Production Memory: it contains the guidelines used by the Inferential Engine to verify the conditions stored into the Rules and related actions have to be undertaken;
- Inference Engine: it is composed by the Pattern Matcher and by the Agenda. The former is in charge to verify matches among Rules and Facts, while the latter handles the order of execution of actions, being capable of solving the conflicts raising from simultaneous matching of multiple Rules.

The Expert System is based on the *Drools* Open Source Framework (JBoss Community, 1), a Business Rule Management System (BRMS) distributed by the application server *JBoss* (JBoss Community, 2).

Drools implements an object oriented formalism to describe information knowledge: data can be mapped into a JAVA object, through the Object

Relational Mapping (ORM) *Hibernate* (JBoss Community, 3) and exposed to the Expert System inside the Working Memory.

Drools implements and extends the algorithm RETE, RETEOO (Sottara D., Mello P. and Proctor M. A., 2008), (Sottara D., Mello P., Proctor M. A., 2010).

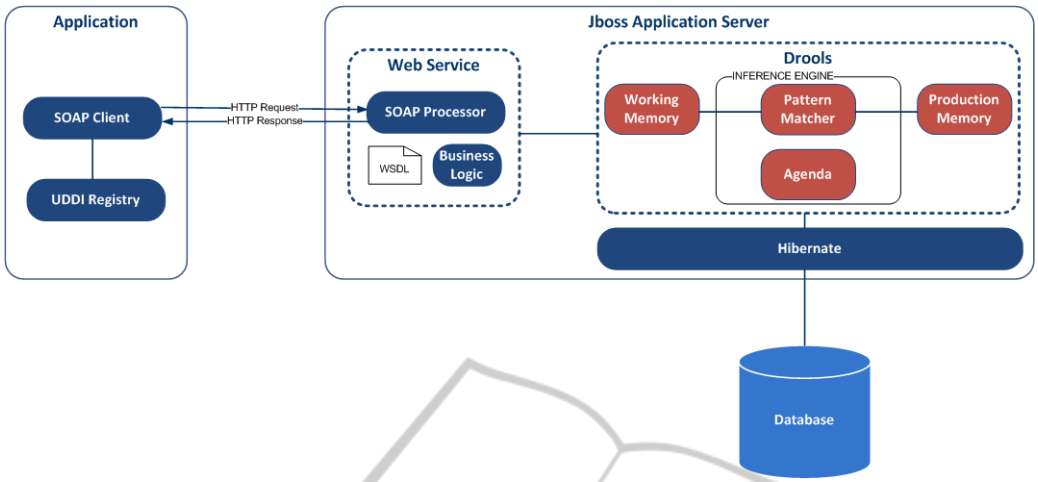

Figure 2: Architecture of the Expert System.

4 CONCLUSIONS

In this paper the AMICO platform, a software for the asset management of complex industrial enterprise, has been presented.

Key features of the platform were pointed based on the results of a preliminary research activity highlighting the main limits of existing commercial solutions.

The implementation of a unique centralized database able to store and ensure consistency among all the enterprise information has been targeted as the main key feature to be provided. The effort required by the implementation of the centralized architecture is justified by the advantages which such an architecture provides, i.e., a powerful workflow engine for co-design, able to coordinate internal and external teams and an Expert System supporting management of the work-orders documentation.

In order to implement such centralized architecture for the information knowledge management, the concept of asset was introduced and used to create a functional and organisational model of taxonomy.

Some big companies operating in the Oil/Energy industrial sectors have already expressed interest in the AMICO Platform. One of these companies is *Raffineria di Milazzo*, an oil refinery based in Sicily, which has declared its availability to act as a pilot site for the global validation of the system, once it will be completed. The company has also expressed the willingness to subsequently adopt the system as the reference platform for document and asset management activities. So far, it has acted as external consultant of XENIA and has provided much of its information content and business data in order to create a development environment which will be used later on and exploited as test environment for further experimentation. In such context, the system will handle approximately 60.000 to 70.000 assets and 40.000 to 50.000 documents, it will manage complex workflows involving co-design activities with third party companies and will integrate with the existing IT infrastructure (SAP, etc.).

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