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CMMS – An integrated view from maintenance management to on-line condition monitoring

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***Abstract*—Nowadays, Enterprise Asset Management (EAM) systems or, more specifically, Computer Maintenance Management Systems (CMMS) need to fill requisites like the following ones: To work in all platforms, independently of operating system, being this cross-platform and multi operating system. However, CMMS also need to work in any language, being this native, where they were developed or any other, like English, Greek or Arabian.**

Even the precedent challenges weren't big enough it is also necessary that CMMS receives and manages data from any type of sensors, independently where they are placed, locally or remotely, and the signals transmitted through wire or wireless.

In consequence, the on-condition predictive maintenance reached a new level to enlarge the availability.

Furthermore, it is also necessary to manage the configuration of the EAM itself to be able to communicate with the several existent platforms.

There are new technologies that represent new limits, not beyond tomorrow but for today. Such technologies like Augmented Reality, Artificial Vision and even holography have potential to increase maintenance performance.

The physical assets are each time more and more strategic to the organizations competitiveness then the EAM need to manage not only the maintenance of assets but also all their Life Cycle Cost, including investment, renewal and withdrawal aspects, and also resources optimization. This is a complex equation that increased in complexity along the time and, simultaneously, ought to be managed in a friendlier way by the final user and, yet more, its cost must be, each time, cheaper than before.

These are the main subjects that will be discussed in the paper and also the proposed solutions, both the software and hardware solutions in an integrated view, that represent not only a state-of-the-art but a step ahead in the physical asset management area, in general and in maintenance management, in particular.

Keywords—Maintenance; CMMS; EAM; Operating System; On-condition Maintenance.

I. INTRODUCTION

The Enterprise Asset Management (EAM) systems and or Computer Maintenance Management Systems (CMMS) are being entering in a new phase with a lot of challenges that are occurring simultaneously and are transforming the current systems into a new position that will put the present systems in a pre-historic position.

In fact these systems must work over Operating Systems (OS) like Linux, Windows, iOS, or others, and in any type of platforms, as a Personal Computer, a Tablet and a SmartPhone. Additionally, they must communicate with data acquisition systems even each one has its own specific protocol to transfer data to other devices.

The heterogeneity of the systems also implies an additional difficulty in the communication among them, namely in the relationship between maintenance companies and their customers, mainly when both have an EAM and the potential common data that must be shared.

Moreover the EAM also needs to incorporate components like Expert Fault Diagnosis Systems (ES), Augmented Reality (AR), Geographic Information Systems (GIS), among others.

These are the main subjects that are treated in this paper that is organized as follows:

- The chapter two makes the discussion of EAM versus CMMS;
- The chapter three deals with the problem of CMMS multiplatform;
- The chapter four deals with the On-Condition sensing and CMMS communication;
- The chapter five deals with the problems of Communication among different CMMS;
- The chapter six deals with questions referring to the incorporating new technologies in CMMS;
- The last chapter presents the conclusions and some tendencies for tomorrow.

II. EAM VERSUS CMMS

A Computer Maintenance Management System (CMMS) software package is an information system which main purpose is to support the management of maintenance activity. This information is intended to help technicians to do their work more effectively, to monitor the equipment performance and to aid the maintenance staff decision. CMMS data may also be used to verify regulatory compliance.

An Enterprise Asset Management (EAM) is an information system to manage the whole life of the Physical Assets of an organization. It covers such things as the acquisition, commissioning, operations, maintenance and decommissioning/replacement of plant, equipment and facilities. "Enterprise" refers to the management of the Physical Assets across departments, locations, facilities and, in some cases, business units. By managing assets across the facility, organizations can improve its utilization and performance, to reduce capital costs, and asset-related

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operating costs, extend Physical Assets life and subsequently helps to improve Return Of Investment (ROI).

As can be seen there are several differences between a CMMS and an EAM; however, they are commonly understood as the same.

Nowadays, because the enormous evolution of the maintenance sector, and by consequence their standards, the EAM tend to reach a widely field of application than CMMS. The following standards correspond to the most recent Physical Asset Management view:

- ISO 55000:2014 - Asset management — Overview, principles and terminology;
- ISO 55001:2014 - Asset management — Management systems — Requirements;
- ISO 55002:2014 - Asset management — Management systems — Guidelines for the application of ISO 55001.

The NP 4492:2010 (Requirements for the provision of maintenance services) and associated standards, as will be seen in chapter four, corresponds to an approach within the CMMS systems that have their core in the maintenance activity.

However, this is an approach that has given its first step. It is necessary to wait before giving the next step in order to understand when the right time reaches to make the convergence and the synergy between them.

III. CMMS MULTIPLATFORM

Nowadays, some of the most important commercial OS in the world are Linux, Windows, iOS and Android, where the CMMS must work. Additionally, it must work in any type of platforms, as a Personal Computer, a Tablet or a Mobile Phone.

The main problem of the existing EAM/CMMS is their functioning that is mostly based on a Client-Server platform, over a browser that directly connects to the server using a TCP-IP connection, among others. Usually they work with a relational database, based on a Structured Query Language (SQL), with a user interface developed in a specific tool.

The biggest challenges start from this point because it is necessary to "convert" old programs for new platforms with new tools.

Additionally, it is also necessary to consider the new challenge that arises from Cloud Computing, where both clients and suppliers can host their data and share or not them when customer and supplier establish a commercial maintenance contract.

Some of the challenges related to the creation of new platforms, namely the mobile devices, are the following ones,

- Generic Model for a Mobile Application
- Selecting a Template

This application can be separated in two big sides, the server side where all information is stored and processed and the mobile side where all information is accessed or entered.

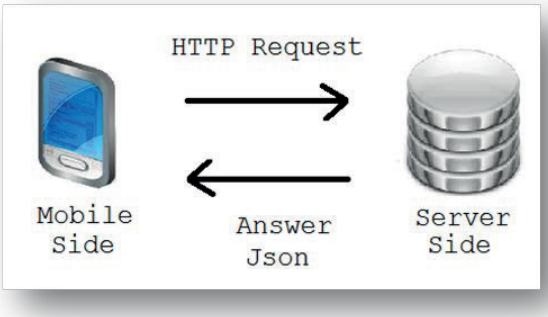

Fig. 1. Interaction between the server side and the Mobile side

The server side is running a Rest server (Fig. 1) which receives and manages all requests to the server. This Rest server is a PHP script, that is able to receive HTTP requests, either GET or POST requests, and it is able to respond in XML, HTML or JSON.

The Rest server is also used as a form of security, because it works between the database and all requests from outside, not allowing direct access to database. On the other hand the database should be SQL type, for easy development and integration with the Rest server (Fig. 2).

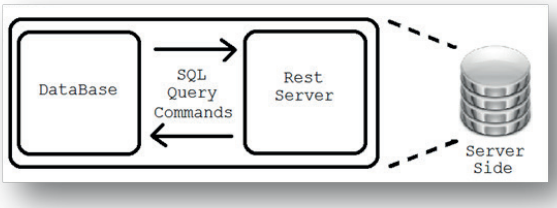

Fig. 2. Server Side Diagram

The mobile side must be able to communicate with the server in order to obtain all the required information, for this the device must be able to connect to the network via wireless or via General Packet Radio Service (GPRS). It is also necessary that the device is capable of reading barcodes; this can be achieved through image capture or scan which requires the mobile to have a camera or a laser scan. The device must also have in its hardware list a touch screen sensitive enough to capture signatures, a camera to take photos to store on the database and a Global Positioning System (GPS) system to gather the location of the device. Linking all this, the mobile device must also have to be able to run an internal database to implement an offline mode. For several years all these features could only be found in expensive industrial devices, such as the PDA Datalogic Lynx. But, nowadays, any Smartphone is capable to fulfill these requirements; because these reasons it was decided to use a Personal Digital Assistant (PDA) and a Smartphone for this work.

At the beginning, the application should check if the device is connected to the network and that the server is functional before starting work. After this check, the application should ask the server to get the list of all types of perishable equipment and if all goes well displayed. After this the user needs to choose the type of item that he wants to catalog.

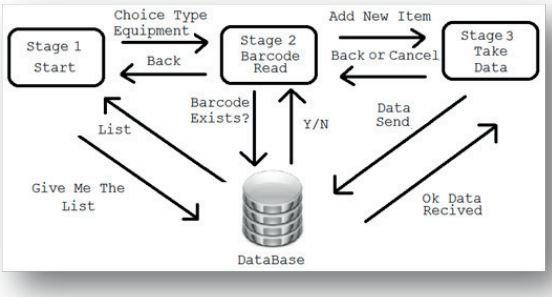

Fig. 3. Basic scheme of functioning of the application

On the next stage, the application will be allowed to scan barcodes, and after that, it should ask the database if the barcode was already been previously taken. If so, ask the user if he intends to overwrite the previous entry and if he says yes or is a new entry, the App should jump to its third stage.

In the third stage the user should collects photos, information about the location of equipment, comments about the equipment's state, and finally getting the signature of the user.

After all the information has been collected on the third stage it should be sent and processed by the server. The application should revert back to stage two and wait for a new barcode reading process. This behavior is illustrated in the flowchart of Fig. 3.

This new and friendly access to CMMS is a step away to manage the maintenance interventions, work orders, maintenance auxiliary tools, and so on.

IV. On-Condition Sensing and CMMS Communication

Nowadays the EAM/CMMS have more and more modules associated to several data acquisition systems, being these ones aimed to control temperatures, vibrations, effluents, among others. However, these new capacities that are added to EAM have specific, proprietary, communication protocols, what difficult their s connection to other system beyond the proprietary; the proprietary systems predominate, but this situation tends to change progressively.

The standardization of the communications protocols is a big problem in order to put the EAM/CMMS in a new level of development, price and market generalization, what is an urgent step to give to reach the best availability and Life Cycle Cost (LCC) of physical assets.

The OSA-CBM (Open System Arquitecture for Condition-Based Maintenance) under the MIMOSA (Machinery Information Management Open Standards Alliance), that is a standards organization that manages open information standards for operation and maintenance, tries to define the architecture of an open system for maintenance conditioned with seven levels, [1] (Fig. 4):

1. Data Acquisition;
2. Data processing;
3. Monitoring the condition or state;
4. Evaluation of the operating state / fault detection and isolation;
5. Forecast / prediction of dysfunction;
6. Decision Support / recommended actions to correct the dysfunction;
7. Presentation - User interface.

Fig. 4. OSA-CBM / MIMOSA

Under this context, the implementation and monitoring of the condition of physical assets, and interconnection with a CMMS that manages Working Orders (WO) is not dependent on any proprietary software vendor. This means that the end user (owner / operator) can select the data it deems appropriate without having to worry about integration problems or be forced to choose a single supplier to provide data in the format it need for integration and maintenance management of assets in your CMMS.

From this perspective, SMIT (Integrated Modular System for Terology) treats Physical Assets, integrating them in a modular information system that communicates with any database engine in a completely transparent and independently of the manufacturer and operating system involved [2].

V. Communication among different CMMS

Nowadays there is more and more necessity that each CMMS communicate among them and, particularly in the case of the providers certification, because the sharing of physical assets data in order to make possible the communication between client-supplier. About these problems it is particularly interesting to discuss the NP4492:2010 that is supported in the following standards:

- NP 4483:2009 - Guide to the implementation of a maintenance management system;
- NP EN 13269:2007 - Maintenance - Instructions for preparation of maintenance contracts;
- NP EN 13306:2007 - Maintenance Terminology;
- NP EN ISO 9000 - Quality management systems - Fundamentals and vocabulary (ISO 9000:2005);

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- NP EN 13460:2009 - Maintenance - Documentation for maintenance;
- NP EN 15341:2009 - Maintenance – Key Performance Indicators (KPI);
- CEN/TR 15628:2007 - Maintenance - Maintenance Qualification of personnel.

One of the multiple requisites of NP4492:2010 is related to information systems, as is defined in chapter 5 – "5.1.1 Information management - The management of a company providing maintenance services requires the support of a management information system appropriate to the complexity of the activity carried".

And in item "(5.1.2 Documentation requirements) - The documentation of the maintenance provider shall include: Documented procedures and records required by this standard; Documents, including records, determined by it as necessary to ensure the planning and operation, as well as their effective control".

The above points, in many situations points out some difficult situations between client-provider, namely when both have a specific CMMS and these don't communicate. Then, the client has the information of their own assets and the provider must elaborate, again, new dossiers of those assets, what is a paradox.

The above problems make to emerge a new problem that is the necessity to have some standardization of the main data related to assets managed by any CMMS when the maintenance providers are certified and the customers require a supplier with this kind of profile.

In fact, it is nonsense to duplicate data when the client has a CMMS because it necessarily implies that, during the time the supplier manages the maintenance contract, he responds by the information, like WO, historic, KPI, and so on. If the CMMS client-provider do not communicate, at the end of the contract the provider data is not uploaded to the client CMMS. However, at this point the client can buy the provider's CMMS in order to access the data, but, if is true, the client will take two systems. But, if the client would have another contract with other supplier, the same problem potentially occurs. Then, probably it will have to buy a third system, and so on! It is a crazy situation that must be urgently solved.

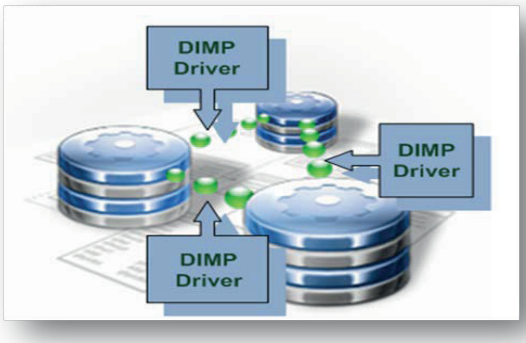

Fig. 5. Data Interchange among Multiple Platforms

It can be added other problems, as is the case of spare parts, because in some situations they are of the client responsibility and in other cases of the supplier. Then, if their CMMS are different and or do not communicate, the confusion is incremented.

The solution can be reached through a channel that obligatorily contains the main CMMS data fields, including the type of each field and its sequence, to share among the several maintenance players CMMS in order to optimize the role of each player. This solution can be called Data Interchange among Multiple Platforms (DIMP), as is illustrated in Fig. 5.

VI. Incorporating New Technologies in CMMS

One situation that can be more efficiently managed is during and after maintenance interventions, because, usually, the WO are printed to be used during interventions and its fulfillment is done after these. What happens is that there are several data that have the risk to be forgotten due to lack of time between intervention and WO fulfillment in office.

The above situation will be easily solved by the mobile solution referred in this paper (chapter 3), permitting to fill all WO data immediately after each maintenance action is done.

Other value-added can occur during the interventions itself, namely when these ones are not planned, because the technician can access on-line to a fault diagnosis tool, if it exists.

But the interest of the technology under discussion begins since the moment that equipment is purchased, because it permits to make its registration in site, including bar-code reading and so on. In fact, a correct registration of equipment dossier in database is determinant for a correct accompanying of its Life Cycle Cost (LCC), including WO, human resources, materials, and so on, as it was above referred.

When an intervention request reaches, namely the most urgent ones, and needs a quick response, a digital tool, like a tablet or a similar one, can immediately receive the information and the respective WO can be created; then, the technician, without loss of time, can, immediately treat it, make the interventions, and fulfill the WO.

Additionally, with the introduction of new technologies, like Augmented Reality (AR), 3D models, Expert Systems (ES), and so on, this new devices and applications create synergies in order to minimize intervention time, increase quality, minimize risks, and maximize availability. Fig. 6 shows an example of a flow chart of an inference operation of a CBR-ES [3-4].

In fact, if a technician use an integrated system with all these tools, AR, 3D and ES, the maintenance intervention time can be reduced, the errors minimized, and the efficiency incremented, [5]. But there are some additional benefits as is the fact that technicians less experienced can work like the fact that technicians less experienced can work like the most experienced ones, due to all the auxiliary tools that they have integrated to aid them (Fig. 7).

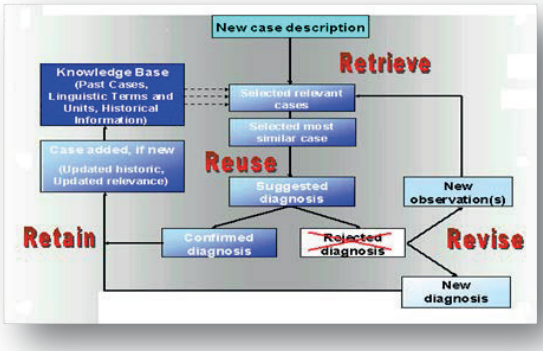

Fig. 6. The four phases of a CBR fault diagnosis system

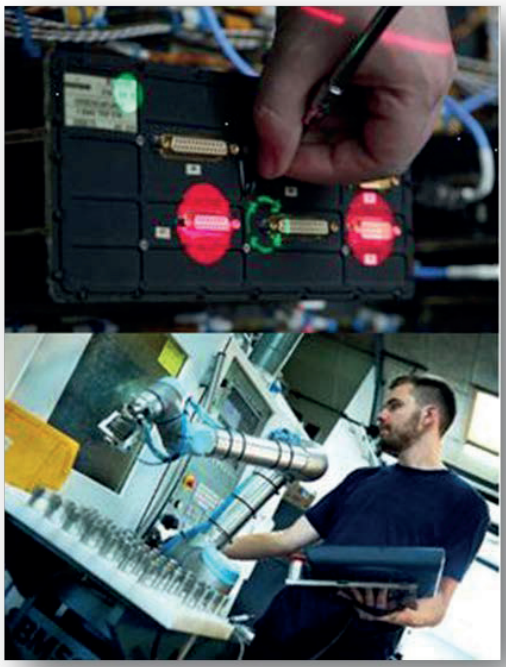

Fig. 7. Several Technologies converging to support maintenance interventions (upper) AR, AstroVAR project; (bottom) cooperative robots, Universal Robots.

VII. Conclusions

The paper makes a short discussion of the CMMS in an integrated view from maintenance management to on-line condition monitoring, with emphasis to the communication among heterogeneous systems and multiple platforms.

It also discusses the relation between EAM and CMMS, in a time where everything is changing.

The communications among different systems, platforms and acquisition systems, where OPC/MIMOSA is trying to give a step ahead it is also proposed a Data Interchange among Multiple Platforms (DIMP) to make possible the data interchange among suppliers and clients, permitting a relation win-win.

Finally, the incorporation of new technologies in CMMS is also treated, namely the expert systems, that are not extensively used in this type of systems, even having very rich history files.

Additionally, 3D technologies, Augmented Reality, among others, are nowadays tools that have to be incorporated in EAM/CMMS to permit the maintenance activity be the key success to the organizations competiveness.

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