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Indus-RCMW: Accompanying Tool for Industrial Remote Maintenance Work

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Abstract- According to the technological development and the new information and communication technologies NICT, the globalization, the race for competitiveness that drives the search for total quality followed by reduction of the cost. The industrial world has changed a classical world to the modern world while removing any obstacle that influences the place of business in the market. The integration of NICT in different departments of the company has a positive impact in improving the performance of the company, including the Maintenance function. Our contribution focuses on designing a support tool that allows a remote maintenance industrial end to remove the barriers of time and dimension as well as the preservation of a knowledge base to keep different work maintenance and to analyze and monitor each production equipment.

In this article we will present the Indus-RCMW project, it is a tool based on NICT to support the work of remote maintenance, while providing a model of the nucleus, and the different tabs allowing performing remote management maintenance (preventive maintenance, corrective maintenance) between operators maintenance.

Keywords-*NICT, Remote Maintenance, knowledge base, Indus-RCMW, Modeling.*

I. INTRODUCTION

In this article we will present the Indus-RCMW (Industrial Maintenance Remote Collaboration Work) project, its architecture, its core, while locating the various spots that can make maintenance operators to perform remote maintenance after presenting a summary of industrial remote maintenance projects in the literature.

II. FIELD OF STUDY

A. *Industrial Maintenance: Between the classical and the modern concept*

Maintenance has long been the curative role whose sole purpose was to restore the equipment in good working condition and reduce downtime. According to the AFNOR standard, maintenance is defined as the set of all technical activities, administrative and management during the life cycle of a well- designed to maintain or restore it to a state in which it can perform a required function. But with the development of control methods and diagnostics, maintenance has evolved to integrate preventive actions, which are systematic deviation (based on periodic checks) or conditional types (vibration analysis of the oils ...) this form of maintenance remains low contribution to the concepts of time and size [30].

The evolution of maintenance is not limited at this point, and the technological development of ICT has changed the concept of traditional maintenance to a remote maintenance concept that removes the barriers of time and dimension. This remote maintenance on access technologies, data processing, information and knowledge exchange between actors and remote appears to solve the problem of limited number of maintenance personnel with the skills, versatility and a high-level expertise. These new forms of service tend to ensure maintenance tasks without physical access to equipment to maintain. Thus, there are two types of remote maintenance: remote maintenance and E- maintenance.

B. *Tools contributiong to the concept of remote maintenance*

The objective of our work converges to the design of a cooperative organization and proposing the study of the different actor contributing to the virtual work environment [31] protocol. These tools are generally intangible resources which consist of two resources: human resources and virtual resources.

- *Human Resources*

The presence of human resources aims to bring to the organization (or service), the staff necessary for its proper functioning, usually competence for the exploitation of ICT must exist with higher skill levels [29] in order to have a successful operation Indus-RCMW tool to fill perform various maintenance tasks remotely with this project.

Piloting the Indus-RCMW tool we need three types of personnel: the technician site, the group of local experts and an external expert.

The table shows how each member of the staff of maintenance.

TABLE I. VARIOUS HUMAN RESOURCES WITH THEIR SPECIFICATION

staff	Specification
the technician site	They Perform the repair of equipment (corrective maintenance) on the production site and the periodic inspection of equipment (preventive maintenance) in collaboration with a set of local experts in the business with a tool ICT. They manage the work.
local experts	they Organize the procedures of preventive maintenance for each piece of equipment, The monitoring a repair task for corrective maintenance, repair achievement standards for the most common problems ... The decision support in the case of a new problem. (nature unidentified)
External expert (M : XX)	They organize interventions for preventive maintenance and corrective for an unknown failure in the center of local expertise. The decision support in the case of lack of skills of local experts (nature unidentified & solution unidentified by local experts)

- *Virtual Resources*

The presence of human resources for remote maintenance is not enough, this is why the appeal of computer tools (virtual resources) that contain tools to help cooperative work to fill supply work group flexibly as groupware, a database contains all the information that can help validate and perform maintenance work, and finally, the tool of the Internet with a communication interface for real-time interconnection between resources human (technician site expert group, external expert).

The following table shows the specification of each virtual resource

TABLE II. VARIOUS VIRTUAL RESOURCES WITH TEIR SPECIFICATION

Tools	*Specification*	*references*
Groupeware	'Software group work' is a collection of applications (Groupware) to facilitate communication, coordination and collaboration between the members of a working group, that is to say, to facilitate cooperation and make effective group work. It is a technology that covers areas as large as cooperation, human-computer interaction and interpersonal interaction via digital techniques.	[9] [31]
Base de données	This tool contains the core of maintenance either preventive or corrective. The existence of this database provides us with technical documentation and knowledge base of each production equipment, to start the Indus-RCMW project in the process of industrial maintenance.	[19]
Human–computer interaction (HCI)	That starts collaborative work remotely perform remote maintenance end of industrial equipment for assistance via the Internet, while maintaining interoperability between these virtual resources. These systems (HCI) allows access to support and maintenance information, as well as the provision of HTML pages that connects the database and guarantee a remote communication with the personal group (group experts, site technicians, external experts).	
Internet	The Internet offers a diverse enough value via its own speed and low costmaking it potentially the most interesting communication medium in the world. The main advantage of using the Internet is to have access to large amounts of information in real time. Can make decisions on the most recent data and wider. The internal network of the company and especially the maintenance department is connected to the internet to allow maintenance workers, local or external experts to exchange electronic messages, search for information about an anomaly to have assistance technique, and participate in discussions related to their activities (corrective maintenance, preventive maintenance)	[8]

- *Scenario of remote work*

The technician site can perform corrective maintenance in the case of detection of a failure and the periodic inspection of equipment maintained if there is a difficulty in resolving the failure, he asks the decision support with the local group of experts

There are in the literature some platforms remote maintenance designed to achieve remote many maintenance tasks remotely (See (3.1)).

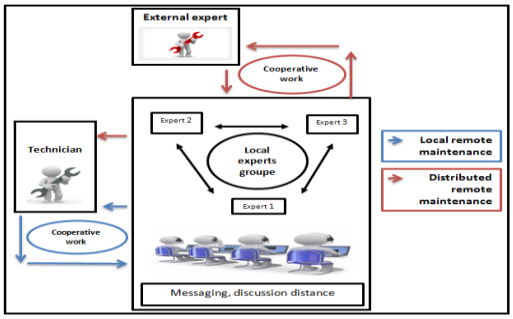

Figure 1. Scenario for maintenance in the platform Indus-RCMW

If the members of internal maintenance technician site group of local experts) do not resolve the fault, in this case the group of local experts may seek decision support to an outside expert (technician of the supplier Machine X) as available for solving the problem.

C. *Synthesis platforms for industrial remote maintenance in the literature*

The following table shows an overview of different platforms remote maintenance and e-maintenance in the literature according to their operating.

TABLE III. SYNTHESIS PLATFORMS FOR INDUSTRIAL REMOTE MAINTENANCE INF THE LITERATURE

Plateformes	Spécification	Référence
MIMOSA «Machinery Information Management Open Systems Alliance»	This is a complete development information system dedicated to the management of industrial maintenance was invented by the U.S. in the 90s. This project was carried out following an approach based on integrated enterprise environments (EAI: Enterprise Application Integration) approach to establish a cooperation network maintenance military equipment.	[27] [22]
TELMA «TELéMAintenance industrielle»	This is an experimental project that is related to the new requirements demanded by industry regarding remote monitoring, remote maintenance and e-maintenance equipment whatsoever in terms of maintenance and safe operation.	[25] [26]
PROTEUS	Generic platform for e-maintenance, developed by Cegelec in collaboration with the CNRS (via the Automatic Control Laboratory of Besançon) and Schneider Electric. It was inspired using Internet technologies and enabling collaboration including actors, coupling with the traditional tools of business management ERP (Enterprise Resource Planning) type, diagnostic aid, and accessibility various resources (databases).	[6]
TEMIC *« TELéMaintenance Industrielle Coopérative »*	e-maintenance platform favoring collaboration of actors maintenance through a network of mobile phones	[19]
NEMOSYS *«Naval E-Maintenance Oriented SYStem»*	It is a developed at the DCN (Direction des Constructions Navales) project for maintenance of embedded systems	[7]
DYNAMITE «Dynamic Decision in MainTenance»	Project using TELMA platform focused on communicating components allowing local actors to maintain equipment to communicate and collaborate with experts remote maintenance	[14]
TATEM «Technologies And Techniques for nEw Maintenance concepts »	Aeronautical maintenance project to reduce maintenance costs on aircraft facing increasing their technology.	[37]
SMMART «System for Mobile Maintenance Accessible in Real Time»	project based on the combination of new wireless technologies to communicate in hostile environments and thus control the maintenance and life cycle of critical components	[35]

III. CONTRIBUTION TO THE DESIGN OF THE INDUS-RCMW PLATFORM

Industrial RCMW is based on flexibility and adaptability to a remote between group members to maintain liaison multifunctional platform with a graphical interface and a reliable communication tool to solve an industrial problem.

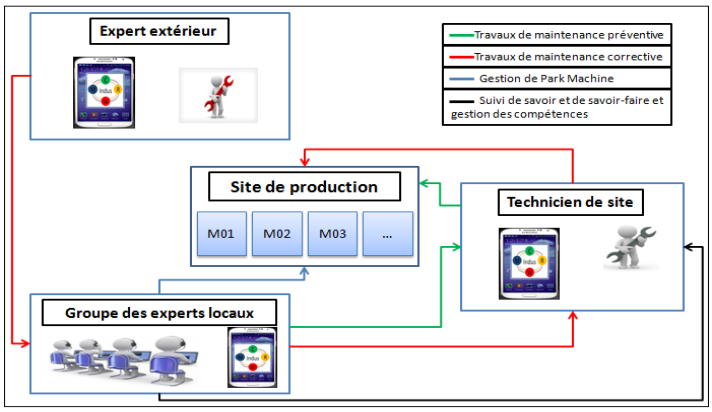

Figure 2. Indus-RCMW platform activity

A. *Presentation of Indus-RCMW platform*

- *User Login*

Each staff using the Indus-RCMW platform must identify in user space to provide access to its corresponding interface (Fig.3)

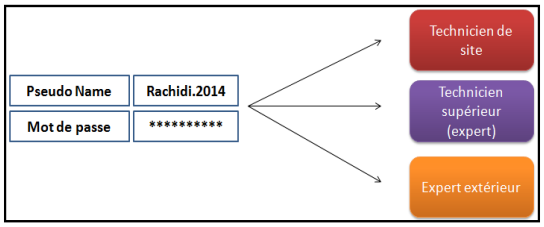

Figure 3. User space

After identifying the group for remote maintenance, each group member must have a graphical user interface work.

B. *Work module for the technician site*

The GUI technician's site includes a set of functions. Demand response on which the fault detection is reported for the start of a corrective maintenance, a section of the production sites, each site contains all the equipment installed; each device contains a set of periodic work to be performed for preventative maintenance. (Figure.4)

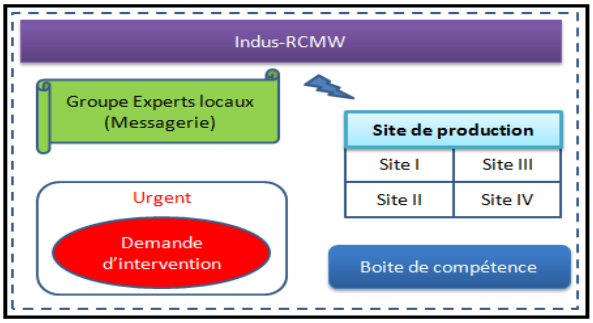

Figure 4. Work module for the technician site

- *Corrective maintenance work*

For corrective maintenance, the technician detects a failure of the site (by clicking the button to request action) filled a digital record on machine X (fig.5), if he can detect the nature of the failure, failure becomes a problem identified. Otherwise, the technician starts a conversation with the remote group of local experts to identify the problem, once the nature is found, it must be associated with the failure and automatically saved in the root of the problems, the next step is the resolution of the problems identified, based on the necessary documentation (dossier technical equipment).

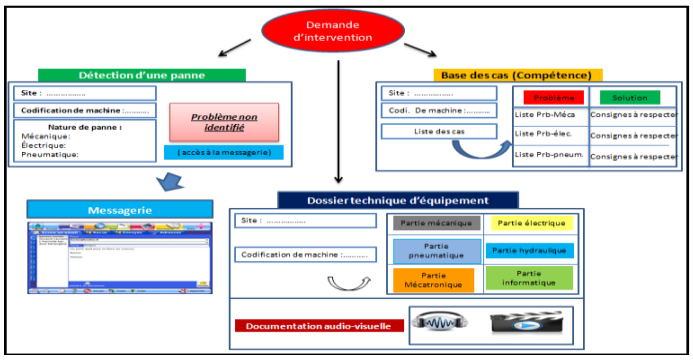

Figure 5. Corrective maintenance work for the technician site

Problem resolution is mainly by the technician of the site if the associated solution to the problem is stored in the base case, if starting a conversation on the diagnosis of the problem (site technician, expert local group or Group local experts with outside expert) to locate a reliable solution (decision support).

Once the solution is found, the phase that comes next is the implementation of the corrective maintenance task by following the instructions that are downloaded assisted by the group of local experts details…Finally, the validation to keep track of the work already done.

- *Preventive maintenance work*

Regarding the task of preventive maintenance, the group of local experts sends a request to site technician for the periodic inspection of a Machine X, the technician consults the production site by choosing the desired machine for periodic inspection, it between the preventive maintenance schedule while keeping the maintenance procedure and recording in the machine maintenance record. Once the work done, the technician sends a request to the group of local experts to validate the task of preventive maintenance.

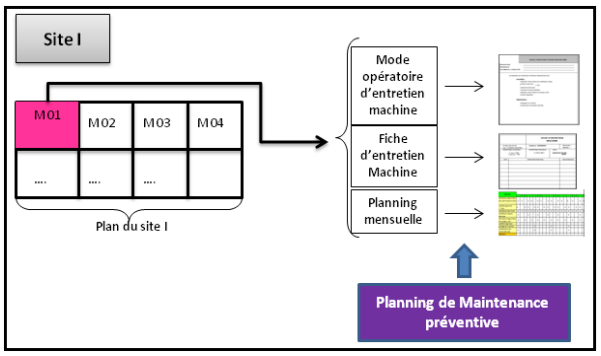

Figure 6. Preventive maintenance work for the techniain site

- *Improving and monitoring skills:*

The introduction of the Indus-RCMW platform by the emergence of web technologies and networks, and exploitation of ICT in maintenance, a new form of maintenance emerged is the remote maintenance

Indeed, the degree of knowledge and expertise of the maintenance operator is increasingly required. View knowledge in technical fields (mechanical, electrical, automatic...). The agent of maintenance must have an extreme interoperability with ICT in order to have a reliable control of the Indus - RCMW platform.

Adding a box dedicated to the management of competence, allows the maintenance agent to have extensive knowledge in the field of computer science that is to say having the ability to manipulate computerized tools such as Smartphone ... computers, smart tablet...

The case management skill is composed of two sections: formation and evaluation.

- The formation includes courses dedicated to the exploitation of the Indus-RCMW platform and technical training regarding new equipment.
- The assessment includes testing and monitoring to assess skills and knowledge for the development of grade.

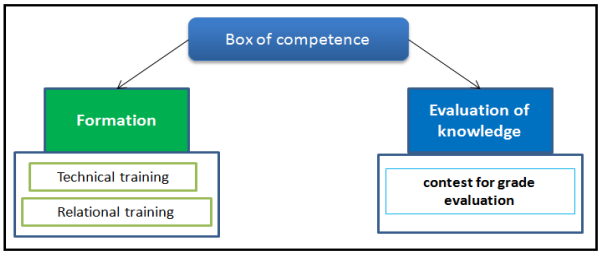

Figure 7. Box of competence

C. Work module for the local expert

The work module for the local expert has several buttons (fig.8) each button contains a set of tools to aid in solving the problem on the one hand and improving the efficiency of industrial facilities on the other.

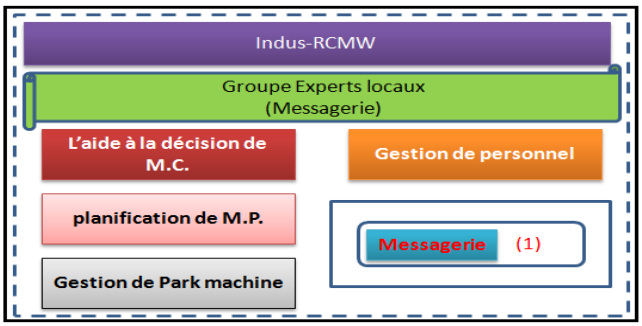

Figure 8. Work module for the local expert

Without forgetting its role as relational (integration of a case management person), regarding the evaluation and improvement of knowledge and expertise of technicians site.

- *Corrective Maintenance work*

The local expert assists and monitors a repair task for corrective maintenance, repair achievement standards for the most common problems...; the decision support in the case of a new problem. (Nature unidentified)

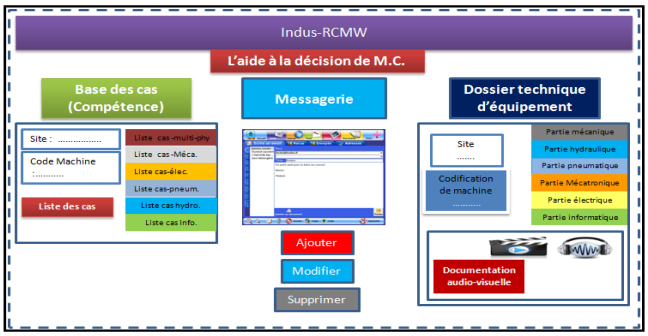

Figure 9. Corrective maintenance work for the local expert

- *Preventive maintenance work*

The experts group refreshes the periodic work for each machine, using calculation methods related to maintenance management as indicators MBF (Maintenance based on reliability) [12] as well as methods of quality as 'FMECA (failure Modes, Effects and Criticality Analysis) [23], the Pareto chart (chart 80/20), or the method ... ISHIKAWA, ensuring a reliable systematic forecasting tools production in order to bring in the maintenance procedure to be operational site technicians (fig.10).

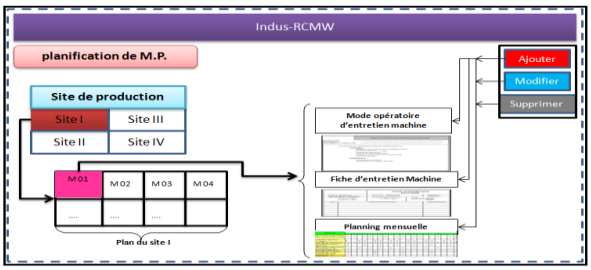

Figure 10. Preventive maintenance work for the local expert

- *Management of staff*

The group of local experts can handle the responsibility of individual site technicians. Indeed, they allow you to add training regarding new installations and new machines, training related relationship management and group management in order to have a continuous evaluation of their knowledge and expertise.

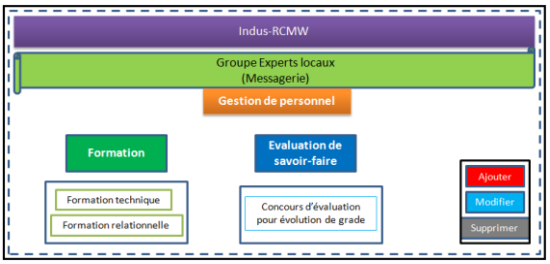

Figure 11. Evaluation and monitorning skills of the technician site

- *The management of Park Machine:*

This module contains all the information to ensure efficient management of maintenance.

The group of local expert and using the results obtained by the various maintenance optimization methods [21] [15] [28], can supply all the information relating to reliability of each piece of each machine and have provided a forecast of their equipment.

This module also contains a box that contains the various technical documentations for each machine; its mechanical parts, electrical, pneumatic, and a new box for the audio-visual documentation.

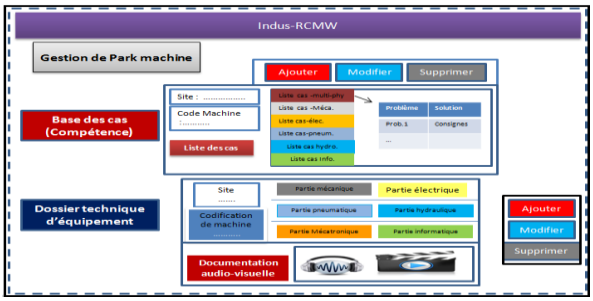

Figure 12. The management of Park Machine

D. *Module work for the external expert*

The module work of the external expert has a box for different machines associated to each client, as well as a mail order remote communication with different clients around a problem for decision support.

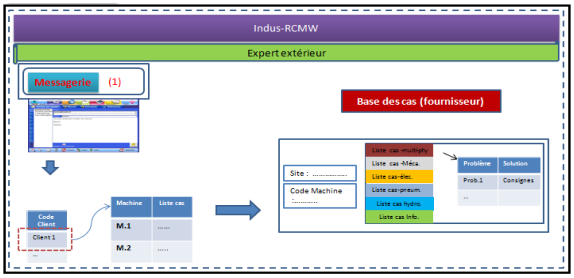

Figure 13. Module work for the External expert

The external expert organizes interventions for preventive maintenance and corrective for an unknown failure in the center of local expertise; the decision support in the case of lack of skills of local experts. (Nature unidentified, solution unidentified by local experts group)

E. *Messaging module and discussion*

There are already many applications of mobile communications market. They can be separated into two categories:

TABLE IV. DIFFERENT CATEGORIES OF COMMUNICATION APPLICATION

Categories	*Specification*	*Example*	*references*
1st category	Only sends messages	Whatup Gmail	[36] [38] [18]
2nd category	Sends messages Make calls (VOIP)	Nimbuzz Skype Viber	[34] [33] [1]

Some studies (communications security) states that the application (Viber) is assumed one of the most reliable applications in telecommunications [1], [11].

Using the mobile application VIBER allows us to ensure communication between the technician and the site group of local experts on the one hand and the communication between the external expert group with local experts, to exchange share and distribute various information on the work of industrial maintenance.

IV. CORE ARCHITECTURE PLATFORM

A. *Modélisation sous UML :*

At the end of designing different tabs for each member of group maintenance, we model the various tables constituting the Indus-RCMW platform using UML (Unified Modeling Language) to generate the source code of the database the Indus-RCMW platform.

UML is a tool that allows the specification, visualization, modification and construction [3] from pictograms (schematic graphical representations) for software development [17] and OOP (Object Oriented Programming) [4].

UML contains 13 diagrams for modeling an Object throughout its life cycle [10]. The following figure shows the use case diagram of the Indus-RCMW platform:

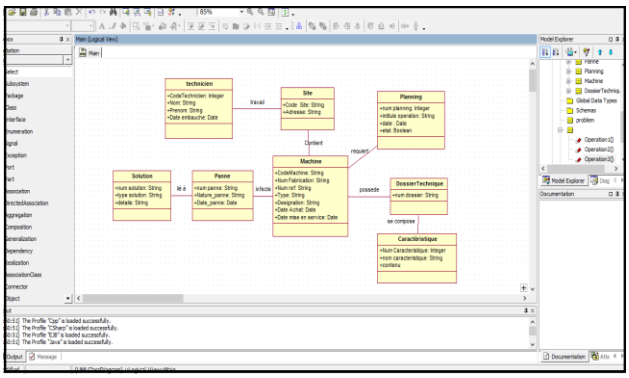

Figure 14. Modeling under UML

B. *Base de données*

Modeling in the UML modeling software (StarUML) [32], we allowed the generation source [10] database of the Indus RCMW-platform code, and contain a set of tables defining each player starting Indus-RCMW platform:

```
        Date_embauche DATE NOT NULL,
        CONSTRAINT PK_technicien11 PRIMARY KEY (CodeTechnicien)
        );
CREATE TABLE DossierTechnique (
        num_dossier VARCHAR ( 255 ) NOT NULL,
        CodeMachine VARCHAR ( 255 ) NOT NULL,
        CONSTRAINT TC_DossierTechnique23 UNIQUE (CodeMachine),
        CONSTRAINT PK_DossierTechnique17 PRIMARY KEY (num_dossier)
        );
CREATE TABLE Machine (
        CodeMachine VARCHAR ( 255 ) NOT NULL,
        Num_Fabrication VARCHAR ( 255 ) NOT NULL,
        Num_ref VARCHAR ( 255 ) NOT NULL,
        Type VARCHAR ( 255 ) NOT NULL,
        Designation VARCHAR ( 255 ) NOT NULL,
        Date_Achat DATE NOT NULL,
        Date_mise_en_service DATE NOT NULL,
        Code__Site VARCHAR ( 255 ) NOT NULL,
        CONSTRAINT PK_Machine16 PRIMARY KEY (CodeMachine)
        );
CREATE TABLE 3 (
        num_dossier VARCHAR ( 255 ) NOT NULL,
        Num_Caracteristique INTEGER NOT NULL,
        CONSTRAINT PK_319 PRIMARY KEY (num_dossier, Num_Caracteristique)
        );
CREATE TABLE Solution (
        num_solution VARCHAR ( 255 ) NOT NULL,
        type_solution VARCHAR ( 255 ) NOT NULL,
        details VARCHAR ( 255 ) NOT NULL,
```

Figure 15. Extra database script of Indus-RCMW

To avoid all information overloads of data we will use a single table to generate three sub tables while using query to filtration and separation:

- *Table of failure* that contains a list of failures for each equipment.

```
SELECT * FROM `panne` WHERE Nature_panne = '0';
```

Figure 16. Filtration request for the liste of failures

- *Table of problem* which contains nature associated with each failure for each equipment.

```
SELECT * FROM `panne` WHERE Nature_panne not like 'x';
```

Figure 17. Filtration request for the list of problems

- *Table of Standards* (knowledge base) contains the solutions for each type of problem with the instructions to follow and respect.

```
select codemachine,nature_panne,date_panne,solution.type_solution,solution.details
from panne,solution
where solution.num_panne=panne.num_panne;
```

Figure 18. Filtration request for the base cases

C. Human Computer Interaction (HCI)

Different virtual resources for Indus - RCMW platform must be integrated into a graphical interface (HCI Human computer Interaction) which allows you to start a cooperative working remotely at the end to make remote maintenance of industrial equipment for assistance via the Internet, while maintaining interoperability between these virtual resources.

There are different forms of communication interface, classic applications [17] called ' desktop software ', and hosted on a web application server called applications.

Web applications refer to software application hosted on a server and accessed via a web browser [5].

Unlike traditional software, the user of a web application does not need to install it on his computer. He just needs to connect to the application using their favorite web browser. The current trend is to offer user experience equivalent software installed directly on computers functionality.

The technologies used to develop web applications are the same as those used in the creation of websites.

There are three type of web application that can be compatible with the hardware resource that is a Smartphone tablet computer ..: The Android [24] applications, iOS applications [13], as well as web applications [5].

For the group of local experts can use an emulator to enjoy the operating system developed by Android or iOS on a computer in order to maintain interoperability between computer hardware for the remote control in the maintenance platform

V. CONCLUSION

In this article we presented a platform for industrial Maintenance entitled Indus-RCMW , this platform allows collaborate, cooperate and share between the various maintenance personnel for solving an industrial problem remotely (corrective maintenance), or the monitoring equipment (preventive maintenance) without the existence of a qualified personal near the malfunctioning equipment.

Industrial RCMW enables effective management of park Machine (existence of the base case for each device) and a robust monitoring knowledge and know -how related to the management skills of maintenance personnel.

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