Towards new Web Services based Supervisory Systems dedicated to Nomadic Operators

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Abstract
This paper outlines new approaches and motivations about supervisory HMI, such as mobility and information access by different human actors belonging to the organization, by using diverse interaction devices, exploiting Web Services and their underlying technologies. The basic concepts are explained in the context of industrial supervision adopting a service oriented architecture (SOA) design approach which makes it possible to integrate real time information from different systems more easily than traditional ones. A representative supervisory scenario which illustrates the approach is described and discussed.

Keywords: Web-based Supervision, Human-Machine Interaction (HMI), Web Services, Services-oriented Architecture, Mobility, Context-Awareness.

1 INTRODUCTION

In several industrial domains (Transportation systems, energy, chemical processes…), the supervision room design was always considered as crucial by the designers; computerization of supervision rooms has been made systematically according with available technologies since about fourty years. The human work in supervision rooms has become more and more highly cognitive, relatively to tasks which can be very complex, often impossible to automatize (Sheridan, 1988; Hoc, 1996). In fact the automatization of industrial processes allows the calculator to be completely autonomous during the normal functioning; in this case, the operators have to monitor the evolution of numerous variables, to verify the production quality and/or the safety. In case of dysfunctioning, they have to intervene individually or collectively; they can be assisted by more or less intelligent assistance systems (Rasmussen, 1986; Moray, 1997). The reasons provoking incidents can be difficult to understand; in most cases, the human work is made under temporal constraints, which is source of stress and human errors (Reason, 1990; Vanderhaegen, 2003). The complexity of a supervisory system is often proportional with the number of equipments and variables to supervise.

Nowadays, thanks to wireless networks and appearance of several kinds of mobile PC variants, the operators can use new operational solutions to monitor and command the equipments, without the constraint to be on a fixed workpost; thanks to the evolution of new information and communication sciences and technologies,

different information medium can be used: PDA, Pocket PC, cell phone… (Gomes, 2003); they are object of numerous realizations in process industries. The interaction modes coming from these evolutions have to respond to the new supervisory needs, particularly those depending on the elements characterizing a given context (ex.: geographic position, external noise), work context (ex: presence of other operators), or personal context (ex: knowledge).

The possibilities offered by the web technologies, notably Web Services (Chauvet, 2002) and Services Oriented Architecture (SOA) (De Gamma, 2003) allowing a new approach for creating new interaction models in supervision have been tackled in (Idoughi et Kolski, 2006). Moreover, certain aspects related to HMI, such as HMI plasticity (Thévenin et al., 1999), use context, multimodal HMI, multi-media HMI, can also be specified by Web services and their underlying technologies; few works have been realized in this sense to obtain a knowledge feedback relating web and Internet technologies exploitation in supervision context, despite potentialities underlined by several authors (Hung et al., 2003; Warnier et al., 2003; Yang et al., 2003; You et al., 2003).

Information necessary for supervision is distributed: its access and processing are often carried out in different locations (inside or outside the supervision site). The information media has become very heterogeneous, because of the diversity of the field equipments and the access means, the operating systems, the programming languages, the numerous types of databases. Therefore, it seems necessary to consider the supervision within an enterprise in a heterogeneous and distributed environment, which is linked with several types of use contexts; we can say that supervision becomes the core of the enterprise: human actors have to interact with all the business processes. Hence, supervision has to bring numerous views of the enterprise according to the needs and aims of each actor thus allowing plant information exchange easier between plant and information systems such as Manufacturing Execution Systems (MES), Enterprise Resources Planning (ERP), and so on. Thus, the wide area distributed supervisory systems have more than one control system and each of them typically connects to internet or intranet via their HMI.

In the first part of the paper, we underline several new concepts in HMI based on web services, particularly mobility, context awareness and adaptation. In the second part, we envisage their application in the supervision field. Finally, a mobile service based supervisory scenario is presented and discussed in the last part.

2 MOBILITY, CONTEXT-AWARENESS AND ADAPTATION

Mobility notion covers several aspects in the current enterprises where several profiles of nomadic users coexist, with different needs. These nomadic users can be operators on duty being able to intervene remotely, the sales engineers who need to request orders or know the inventory position. They can also be technicians in charge of the maintenance of an infrastructure or a geographically distributed installation.

We distinguish two types of mobility: (1) *Operator mobility* where the human operator moves and performs several supervisory tasks from several fixed supervisory work stations (control room for instance) with an access to the network, but without a mobile equipment at hand, and (2) *Operator-terminal mobility* where

the operator moves with mobile equipment at hand (ex: PDA) in certain sectors or zones inside or outside the enterprise.
The scenarios of use of the mobile devices equipped with or without wireless connection can give place to a variety of supervisory applications, for instance: (1) to acquire information of measurement and control by the operators going directly to the equipment then synchronizing their electronic message minder with a central PC and put thus up to date a centralized data base in order to optimize the follow-up of the production, (2) to allow a category of operators to access the information system of their company during a displacement (made inside or outside the company). The warehousemen provided with a PDA with integrated codes bars reader, can prepare deliveries or refer stocks by specifying job numbers. The nomadic operators provided with PDA equipped with GPS functions can thus be localized constantly thanks to the systems of localization (Location-Based-System). Some applications of such systems are quoted: to find mobile users in vicinity or a given zone, to receive the alarms based on the proximity of certain localizations and events.
The context includes the localization and the identity of the people and the objects in the vicinity as well as the modifications being able to intervene on these objects. The context relates to the changes of the physical environment, the user and the resources of calculation according to (Schilit, 1994; Pascoe 1998; Dey 1999). (Brown, 1997) restricted context with the elements of the user's environment by introducing time, the season, the temperature, identity and localization of the user. For (York and Pendharkar, 2004), the use and the context in an application of mobility represent a combination of the task and environment in which the user evolves/moves.
According to certain authors, there exist several types of contexts such as: (1) the task context which describes what does a user, the objectives of the user, the tasks and the activities, (2) the social context which describes the social aspects of a user, (3) the personal context which describes mental and physical information concerning the user (mood, expertise…), (4) the space-time context which relates to certain types of attributes like time, the localization and the movement and finally (5) the environmental context which relates to the neighborhoods and the vicinity of the user.
A certain number of context-based systems were developed to show (1) the utility of taking into account varieties of contexts and (2) the efficiency of technologies or algorithms considering the context; see for instance (Want et al., 1992; Long et al., 1996). Interesting approaches concerned work on the field (Kortuem et al., 1999; Pascoe et al., 1998) and the assistance during displacement in tourist places (Cheverst et al., 1999; Davies et al., 1999; Long, 1996; Hariri et al, 2006).
It was also shown that the concept of context is useful to various levels in connection with mobility. On the system level, it can be exploited for example for the management of resources and energy aware to the context. On the application level, the context awareness allows adaptive applications and a context based on the services. On the HMI level, the use of context can facilitate a passage of an explicit human-machine interaction to an implicit one, then towards a transparent user interface (Schmidt, 2000; Weiser, 1991).
Concerning the adaptation of the HMI to the context of use, (Keidl, 04; Pashtan, 04; Maamar, 05; Lopez-velasco, 05) highlight three dimensions of the adaptation which

are: adaptation to the user (personal characteristics...), adaptation to the device (hardware and software constraints) and adaptation to the environment (localization...).
However, there is little research undertaken in the supervision field that is characterized by dynamic and evolutionary contexts in which various types of nomadic actors work. We will present some ideas relating to the supervisory HMI in the following section.

3 APPLICATION TO SUPERVISORY HMI

We are interested in the supervisory HMI having the capacity to create nomadic user interfaces (1) being able to dialogue with the processes, and (2) integrating capacities of Workflow allowing to assign tasks to the human operators according to their profile and the supervision context. We consider the HMI of a supervisory system based on the Web services model. A model of mobile supervision HMI consists of several Web services devoted to the mobile supervision and the communication (interaction) between various human actors (operators in control room, teams of maintenance, engineers of production, decision makers, managers, experts, etc.) constituting the overall organization of the company independently on their geographical place within the company and their access means.
With this intention, we propose a model of supervision based on the services oriented context considering the adaptation of the user interface to the context of use, the dynamic reconfiguration of the interface according to the evolution of the human-machine interaction, and the dynamic adaptation to the diversity of the platforms available in the physical environment of the user. This comes to palliate the limits of the already existing techniques of adaptation which are rather often specific or slightly meet the design process or the requirements for new contexts.

Transformation of mobile supervisory scenarios into Web services and Workflow of operators' tasks.
This consists of defining the components of the supervisory system where access is done by Web services and where a user can be either an application thus an automated Web service, or an operator requesting a function (task) through a server of services. The scenario of a supervisory task corresponds to the invocation of one or more Web services giving rise to one or more Workflow defining a composed service (Van der et Van Hee, 2002) and implemented according to a choreography of Web services (Arkin et al., 2002). The various categories or classes of Web services relating to an aspect of the supervision and being able to compose the supervision are Web services directed not only towards the operators in the control room, but also towards many other members of the organization; these Web services enable them to interact with the process or other actors using mobile devices. All these categories of web services are specified according to the needs expressed by the various operators.

Needs & Requirements expression for Web services based model design.
The recent new developments and standards in mobile technologies and the advances of wireless networks, has transformed the nature of the services into mobile services and made them accessible from mobile devices connected to the network. The

approach of mobile services (or mobility of services) which we recommend makes it possible to the operators to truly concentrate on their tasks whereas the mobile services should be aware of their context and be able to adapt automatically to the changing context of the supervision. This approach passes ineluctably by a first stage which is that of understanding the users' needs for innovating services in the supervision field. This consists of identifying a whole set of Web services that can be carried out either by the mobile device itself, or by another device, or by a human operator who requests the device for a given service via a HMI; a Web service can result from the execution of a certain number of services of different categories, then composed and invoked according to a combined operator/business logic carrying out a supervisory task.

These services should be specified by taking account of the heterogeneous and constraining characteristics of the Input/Output devices, and specifying the various common needs for the human operators enabling them to achieve their various supervisory tasks, thus allowing easy access and information retrieval related to localization, context and user profiles.

These specifications must be encoded in the form of descriptions of Web services and hosted locally on the side of the supplier of services thus allowing the deployment, the dynamic discovery and the composition of Web services in the mobile environment. As soon as an operator enters a new environment of supervision (new context), descriptions of available and distributed services will be dynamically embarked in a personalized interface through a wireless communication solution (i.e. via a mobile HMI).

Services based on localization can also be defined and chosen according to criteria, defined by the operator, corresponding to his/her supervisory strategies. We define in this way context-based web services.

The operator needs are diverse and evolve continuously. Context awareness denotes the possibility to provide the operator with pertinent and crucial information concerning the current situation and the environment of a supervised entity.

The localization like a position or a zone of a space represents a context of particular importance as well as time. It is an attribute of the physical type context which can be used like an observation aid of vicinities (Gellersen et al., 2000). The localization thus becomes significant information from which other contexts can be induced (Dix et al., 2000). Some other authors have introduced yet another concept as significant as the position or localization which is the concept of presence thus being able to have a useful impact on the mobile human-machine interaction. The concept of presence makes it possible to a user to know the status of another user in a given environment (present, absent, on line, off line, on standby…). The moment for performing a task can be as significant as critical as its localization in certain mobile applications thus being able to have direct implications on its representation on the mobile devices (Baber et al., 1999).

This is particularly true when it is about an environment of supervision. The current localization of an operator in a factory, the operator profile, the time and the date of execution of a task are some examples of supervisory contexts.

Mobile services based Model.

The users can access the information provided by the Web services any time, anywhere and whatever the physical access device. It contains various components of Web services of supervision providing various functions and useful information concerning the supervision context. The overall functioning of this model can be summarized as follows: (1) the user discovers the service either starting from a reference point, or following a multi diffusion of messages through the network, or referred by other services, (2) he or she uses the service, or while subscribing himself/herself to the service, or by receiving a notification of the description of the service, (3) It carries out an action through the mobile interface, (4) the user or the service finishes the communication session by sending termination messages.

Two main types of actors (operators) in this model are necessary: (1) mobile services users representing the human operators equipped with mobile terminals carrying out one or the applications implementing the mobile services realizing the tasks in a given local environment, and (2) the supplier(s) of mobile services representing process engineers, experts in supervision, ergonomists, Web specialists, experts in information technology, suppliers of solutions and even the equipment suppliers.

Among the characteristics that should be considered in this model towards achieving the adaptation of the IHM to the context of use, are *user profiles* and *device profiles*.

The *user profiles* are located in a reference frame of user profiles. During the process of recording of the user in the system, the user specifies various information relating to his or her preferences corresponding to his or her profile: name and first name, planning when on duty, phone numbers, access rights, access code, native language, status (available, unavailable, etc.) dependent on the concept of presence. This information has to be updated progressively according with the experience acquired. This makes it possible to provide a mechanism of personalization which can belong to the global context of the user; this mechanism allows thus the discovery of Web services satisfying the specifications and user's needs.

The *device profiles* are recorded in a reference frame of device profiles. A user using the system can use various types of available devices. Consequently, for each device used, its profile is sent in the reference frame (design features, etc.) where only modifications concerning the characteristics of the devices have to be updated.

Interactions, notifications of services and diversity of “mobile device” users.

The HMI components which are exchanged between the user and the service managing the supervision HMI are XML-based messages descriptions, processed by a presentation engine and finally presented to the user. In other words, these HMI components contain in fact abstract descriptions of HMI elements which can be presented to a user in a form which has to be adequate and adaptable to the mobile device at hand. A user can subscribe to a service by providing some contact information for notifications; the service uses this information to send notifications in the forms of HMI components adaptable to the various contexts as already specified.

Each mobile device has its own HMI characteristics. Consequently, each Web service has to consider this diversity in a suitable and adequate way. The concept of adaptation of Web Services to the user has been already tackled in (Keidl, 04; Pashtan, 04; Maamar, 05; Lopez-velasco, 05).

4 MOBILE SERVICES BASED SUPERVISORY SCENARIO

We illustrate the use of the mobile services model (described above) through the following scenario: due to a critical event related to an equipment, causing disturbances on the production flow, and at one time close to the team shift, the supervisor in chief in the control room, having taken knowledge of such a situation and in order to avoid the breakdown of the production, decides to launch a special emergency procedure in order to contact and reach a certain number of actors to be implied or involved by such situation. These actors are in particular: (1) the operators from the next shift having to be informed and aware of the current situation; the supervisor in chief would like to provide them with all the necessary details to anticipate pro-actively the information or data exchange thus allowing them to have a preliminary idea or sight of the process before their arrival to the factory and taking possession of their workstation, each operator has his own different access device, and supposed to be in different remote location – inside and outside the factory, thus using different network communication means, (2) a process expert having to intervene when it is necessary, (3) the equipment supplier having to intervene for remote diagnosis and repair which is supposed to be world wide, (4) the production line manager moving around and within the factory, (5) the general manager in charge of the supervision of the overall factory having to be informed of the least detail on the situation; finally (6) the firemen who are implied in the management of this situation in case of major accident. Moreover, all these actors are supposed to: have different input/output devices (device profiles), be contacted or reached differently according to their profiles (user profiles) and finally have different networking communication infrastructure (Figure 1).

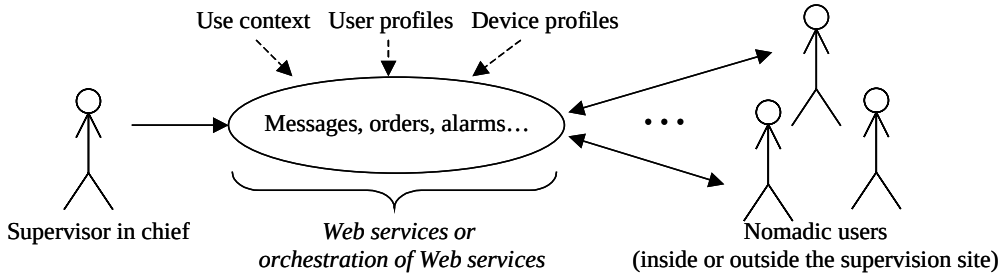

Figure 1. Global approach

With this intention, the supervisor in chief needs a convenient means via the supervisory HMI allowing him or her to initiate the procedure, follow and keep trace of all the stages of the exchange and interaction processes occurred between the various operators involved in this situation.

The procedure initiated by the supervisor in chief consists in fact in an invocation of a category of Web services relating to the management of a similar situation. They are Web services that deal and process the events and alarms (i.e. call of an operator or a group of operators on duty, execution of an order, execution of a script, an external application, vocal announces, etc.), the management of the operators and

organization on duty (definition of an operator by multiple attributes, definition of profile operators, concept of group and team on duty, planning, shift management, etc...), the management of traceability of alarms and intervention (consignment, statistics, etc.) and finally the choice of the suitable media to receive alarms (vocal messages: fixed telephone, portable telephone; written messages: SMS, Pager, email, Fax, teleprinter, etc).

Such a scenario shows that the proposed approach can be of great help to the operators in their task. Indeed they are not worried about the choice of who the human operators to contact are, nor what the means to use to alert them are. Indeed, the supervisor in chief can only be required to start or give the tripping order to the supervisory system so that a particular procedure is immediately launched. The various operators thus called or implied and the various transmitted messages depend only on the configuration of the Web service managing (assisting) the team on duty and considering suitable operator profiles.

5 CONCLUSION & PERSPECTIVES

In this paper, we have proposed a new approach for supervisory HMI design, by the way of Web Services and their underlying technologies; these technologies are HMI-oriented and can satisfy new needs and constraints related to operators' mobility. The Web services oriented model of the supervisory HMI brings up the modeling of a nomadic user activity in terms of Web services. So, with a Web services approach, it is possible to go from classical activities in control room towards activities outside the control room, and/or with the use of remote supervisory functionalities. A Web services based supervisory system can be studied according with mobility and ubiquity points of view; it allows HMI adaptation related to contexts of use for the different operators, by considering user profiles and diverse information sources. So by implicating the well-adapted operators, at both the right moment, and place (not only into the control room), by transmitting them pertinent information, such approach may increase the reactivity of the supervision teams, reduce the problems duration, may increase the rentability and the productivity. The web services approach is also interesting because it is an open and multi-support one: it does not depend on the diffusion canal (web, wap, PDA...).

This research will be of interest to business managers integrating supervisory functionalities in their mobile workforce as well as hci designers and developers of future supervisory mobile HMI. Our research perspectives concern the specification and mockup of a nomadic supervision application, and its evaluation according to several scenarios (as seen above).

ACKNOWLEDGEMENTS

The authors thank the Région Nord-Pas de Calais and the FEDER (TAC MIAOU and EUCUE Projects, TAT SART Project) for their financial support. The authors thank also the anonymous reviewers for their numerous useful remarks.

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