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IT technology implications analysis on the occupational risk: cloud computing architecture

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Abstract

The present paper is divided into three major areas: the analysis of occupational risk implications at national and international level, the European priorities in terms of occupational risk and the existing cloud computing services. Since human resource is present within each organization, it is required a comprehensive and actual assessment of the processes in which they participate. Like in any daily activity, processes and people contribute to the emergence of risks. If each organization creates healthy and safe workplaces that means that it contributes to the sustainable development of the area in which it operates. It can be said that occupational risk assessment and occupational health and safety is the foundation for optimal functioning of the enterprise, thus aiding in reaching the enterprise objectives. The combination of these key concepts, occupational risk and occupational health and safety with technological developments contribute to an innovative approach to risk. This paper presents the literature review, European strategic directions and their implementation in occupational risk assessment in Romanian organizations, analysis of work accidents in Romania compared to EU and authors addressing occupational risk assessment using cloud computing by developing the associated architecture.

Peer-review under responsibility of the Organizing Committee of CENTERIS 2014.

Keywords: Occupational risk, occupational health and safety, cloud computing, risk, hazard, health, risk management, e-health;

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1. Introduction

Human resource is an essential entity to any organization, so the occupational risk assessment is imminent. The human factor is the primary cause for most work accidents. The approach policy to occupational risk assessment must meet the criteria laid down in Law no. 319/2006, which introduces measures to encourage improvements in the health and safety of workers at the workplace. Occupational risk assessment is a tool that demonstrates the principles of prevention in the organization/unit. This means that each organization must anticipate hazards that can cause accidents at work or occupational disease, instead of reacting after such events have occurred in the workplace [1]. An essential step to implement a responsible approach to health and safety at work is the evaluation of occupational risks [2]. The safety and health is one of the key items in the general management [1,2].

National statistics regarding working accidents, occupational diseases and absence from production due to occupational causes and accidents are not a reflection of reality and that is why the economic and social effects of those elements are hard to evaluate and stand as a base for coherent national strategies [3]. At international level, there are a lot of available references, guides, specifications, national and international models aiming to the management of occupational health and safety that had evolved in different proportions from country to country[4]. In Romania the only method to solve this problem: health and safety at work, is the one of the National Institute for Research and Development [3,4]. This is a time and resource consuming method because there is not developed software, only rules and checklists to be completed manually (without using the computer).

This paper is organized as follows: in section 2 and section 3 we present the literature review, being preceded by Priorities for occupational risk in Europe for the years 2014 to 2020 and the analysis of occupational accidents in Romania. Research priorities in health and safety and accident analysis in Romania helped to identify the categories of risks and the fundamental priorities. Section 4 assesses the risks in Romania by: severity, frequency and average. This assessment has established categories of hazards that are included in the proposal from Figure 9. In the main section of the paper, section 5, we present new technologies in addressing occupational risk to systematize: description of cloud computing, the implications of this concept, arguing intense use of cloud computing in organizations, key drivers and advantages, description of the proposed approach and the scheme associated with the authors approach and how we can post/put the proposed architecture in cloud computing and the benefits of using this technology.

2. Literature review

Occupational risk assessment is the process of evaluating risks to workers' safety and health from workplace [5]. This process is a systematic examination of the elements of work that considers: what could cause injury or harm, whether the hazards could be eliminated and, if not, and what preventive or protective measures are, or should be, in place to control the risks [2]. Occupational risk assessment is a structured process that leads to the generation of a report/plan that is made available for inspection and control bodies [6].

We firstly need to look at the terminology used in job expertise, in order to go further on our research. According to Law on health and safety no. 319/2006 (published in Official Gazette/Monitorul Oficial no. 646/26.07.06):

- Professional work: activity done in state or private organizations based on contractual relationship between employer and employee [6],
- Occupational Risk : risk developed in the workplace, in the process of work as a result of the hazard sources [7],
- Management of health and safety at work: a set of interconnected components of decisional, organizational, informational, motivational character, within the organization, through which it is implemented the management processes and relationships of OSHA , in order to get and maintain the required level of health and safety at work [8,9],
- Working conditions: all of the conditions in which the work process takes place: technical (technical processes used and the characteristics of the means of production), organizational (all measures applied to the organization of work and production) and environmental (all the physical and social environment characteristics in which the production takes place) [10].

- The workplace (system human – work tasks - production means – work environment): Assembly consisting of one or more performers and production means that interact based on an informational circuit under certain conditions of the work environment for succeeding in reaching the proposed objectives [11,12].

Occupational Security and Health Agency documents generate a complex knowledge base for scientific research on health and safety by promoting: best practices, statistics, publications, legislation, tendencies regarding research activity through the working groups formed at international, European, and national levels [6].

3. Priorities for occupational risk in Europe for the years 2014-2020

EU priorities regarding occupational risks are formulated in OSHA report [13] of January 2014. The report's objective was to identify priorities for OSH (occupational health and safety) research in the coming years in accordance with the Europe 2020 strategy and the Horizon 2020 programme and their priorities and key objectives of 'smart, sustainable and inclusive growth' and 'excellent science - competitive industries - better society. Occupational risk strategic directions proposed at European level are summarized in Table 1.

Table 1. Overview of research priorities [after [14]]

Proposed direction	Actions
The economic dimension of occupational health and safety	Develop further the methodologies for estimating the socioeconomic costs of occupational diseases, work-related stress and violence at work.
	Strengthen research on the economic dimension.
Occupational health and safety communication and risk communication	Decision-making at the company level under OSH.
	Identify and characterize stakeholder and target groups.
	Evaluate the communication channels and media.
	Investigate the possibilities to use the new technologies.
Intervention research	Develop risk communication.
	Evaluate the OSH interventions at all levels.
Demographic change — sustainable work for healthier and longer working lives	Develop comprehensive intervention models and strategies.
	Evaluate the association of work, health, work ability and work motivation with work participation.
	The age of the employees.
Globalisation and the changing world of work	Health inequalities and work.
	Major health problems.
	Health management in restructuring.
	Changing organizations, new employment and work patterns, and psychosocial risks.
	Violence and harassment at work.
Occupational health and safety research for safe new technologies.	OSH in small enterprises.
	Risks in green technologies.
	Information and communication technology: opportunities and risks in the working environment.
	Electromagnetic Risk.
	Unknown risks of technology.
New or increasing occupational exposure to chemical and biological agents	Chemical Risk and Biological Risk. Management Risk.
	Mixed exposures in complex workplace settings.

Based on EU priorities [14] regarding occupational risk, the authors set the foundation and treat (by exemplifying how they treat the proposed direction) the following strategic directions :

- The economic dimension of occupational health and safety: development of an assessment system that requires low cost and the maintenance is affordable.
- Occupational health and safety communication and risk communication: the use of modern technologies that allow communication at all levels of the organization.
- Intervention research: risk assessment at all levels of the organization.
- Occupational health and safety research for safe new technologies: identification of risks in new equipment and technology used in the organization and the dynamics of the proposed evaluation system.

Note that the authors treat all EU priorities in terms of technology and the dynamics imposed in the period 2014 2020, concluding therefore that the work presents a multidisciplinary sciences interconnection by integrating IT, management and health and safety.

4. Analysis of occupational accidents in Romania

Based on European priorities regarding occupational risk in the period 2014-2020, the authors propose the architecture of occupational risk assessment using Cloud Computing. Initial to the presentation of the technological solution for occupational risk assessment, the authors present the case of accidents at work in Romania in the period 2010-2013 to complete the action field and the weaknesses which need to be strengthened by the developed proposal. This statistic is presented based on the Labour Inspection in Romania, all the data has real and complex character based on Romanian organizations. For the data on the evolution of labor accidents in Romania, the authors conducted the study on *three main directions*:

- Industry: dividing the 99 identified activities in the work environment in 11 sectors,
- Use of index frequency as extremely important information (showing scale status of the consequences of occupational risk),
- 2010-2013 analysis period, recent and relevant in developing an emerging tool in occupational risk assessment.

In the analysis of work accidents the following indicators are taken into account [15,16] :

- *Frequency rate*: number of accidents per 1,000 workers,
- *Severity rate:* the total number of work incapacity days per 1,000 employees ,
- *Average rate:* the number of days lost, on average, by an injured worker.

At European level, every year, over 5,580 people lose their lives after the occurrence of work accidents, and another 159,000 die of occupational diseases [13]. In 2013, in Romania it was recorded a number of 3,627 injured people, including 199 fatalities (314 in 2012). In the same period there were 24 collective labor accidents in which 115 people were involved, of which 10 have died [17]. Evolution of work injuries in the period 2010-2013 is systematized presented in Table 2.

Table 2. Frequency rate, Severity rate, Average rate and Work injuries - evolution, 2010-2013

Year	Work injuries	Frequency rate	Severity rate	Average rate
2010	3678	0.79%	41.3%	63
2011	4029	0.86%	43.2%	65.5
2012	4187	0.88%	45.1%	66.4
2013	3627	0.76%	41.8%	64.4

Analyzing Table 2, it is observed that there is a downward trend in terms of frequency rates, severity rates and average rates, leading to an evolution of the occupational risk assessment in Romanian organizations. Heading towards European priorities it is quantified the need for integrative approaches to follow the four proposed directions, the system innovation and the reduction of work accidents. In an analysis of work accidents evolution curves are observed for different sectors, so it requires a detailed and comprehensive analysis of occupational risks of the 11 sectors defined by the authors. Evolution of injured persons and fatalities for 2010-2013, in Romania, is presented in Figure 1, Figure 2, and Figure 4:

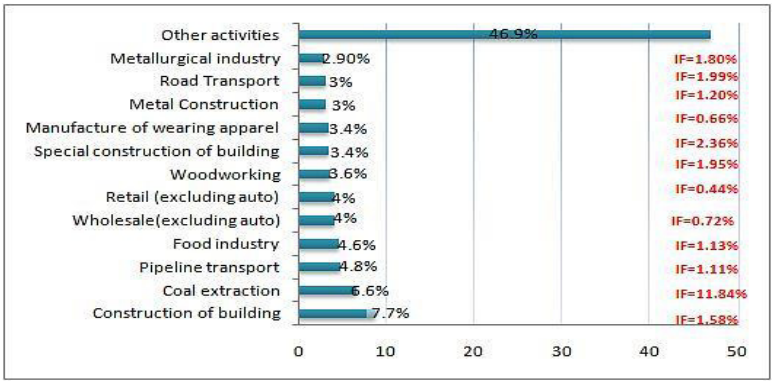

Fig. 1. Number of work injuries 2010

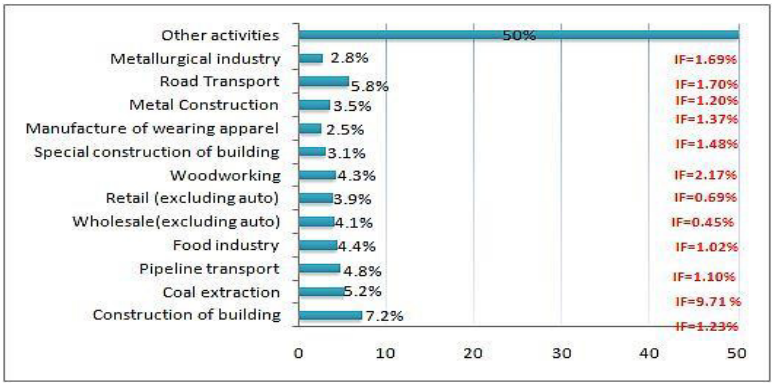

Fig. 2. Number of work injuries 2011

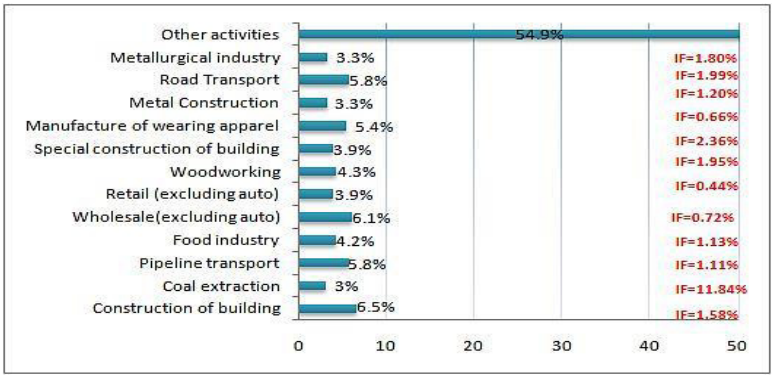

Fig. 3. Number of work injuries - 2013

According to studies carried out by the labor inspectorate in Romania, accidents analysis revealed that people *aged* 40-50 years have the highest share of 32.4% of all injured. Analysis of accidents in terms of *seniority at work* reveals that 63.3% of the total 2,295 injured people are workers with up to 5 years work experience (of which 30.8% or 1119 injured people are workers with 1-3 years work experience), and those from the work experience groups 5-10 years and 10-20 years are 19.2% and 10.1% of all injured.

Analyzing the implications of occupational risks described above, the proposed structure of occupational risk is systematized in Fig. 4, being the base of the cloud computing architecture proposed.

The proposed approach for occupational risk ontology design consists of the following stages: capitalizing knowledge and systematizing the European priorities in the field of occupational risk, the situation of accidents at work in the period 2010-2013, the law on occupational risk and the 11 areas of occupational risk identified in the Romanian work environment. Based on these preliminary stages it will be showed the occupational risk assessment approach using cloud computing architecture.

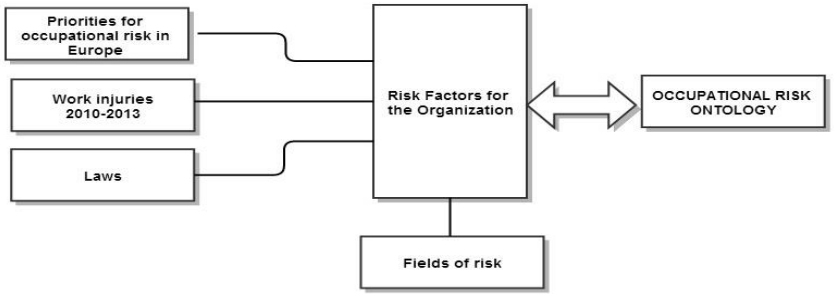

Fig. 4. Proposed approach for the occupational risk structure

5. New technologies in addressing occupational risk

There are efforts to make the transition from traditional solutions for occupational risk assessment and e-health services to Cloud approaches. Until now there have been developed a number of approaches to this concept, so we can say that this opportunity is now increasingly addressed. The new system for access to information technology (IT) - Cloud Computing - significantly reduces costs, IT complexity and scope while increasing the real optimization for work-loads and delivery services. Cloud computing allows a very high degree of scalability, offering superior user experience and is based on the new Internet-based evaluation principles [18].

5.1. What is cloud computing?

Cloud Computing is a set of hardware and software resources that can be accessed on demand on the Internet, in the form of a service [19]. Cloud computing includes 3 three fundamental models: Infrastructure as a service (IaaS), platform as a service (PaaS), and software as a service (SaaS) [20].

- Software as a service (SaaS): The applications are hosted by a cloud service provider and made available to customers over a network, typically the Internet.
- Platform as a service (PaaS): The development tools are hosted in the cloud and accessed through a browser. The developers can build applications installing any tools on computer.
- Infrastructure as a service (IaaS): The cloud user outsources the equipment used to support operations, including storage, hardware, servers, and networking components.

There are different approaches of the three services offered by cloud computing depending on the country and on the subject. Organizations around the world are deploying cloud computing for critical applications and other uses. The differences in adoption rate are far greater between countries than between industry groups [21]. Through a systematization of the works in the literature [22], the authors concentrate these implications in the charts below, on fields and countries, Figure 5.

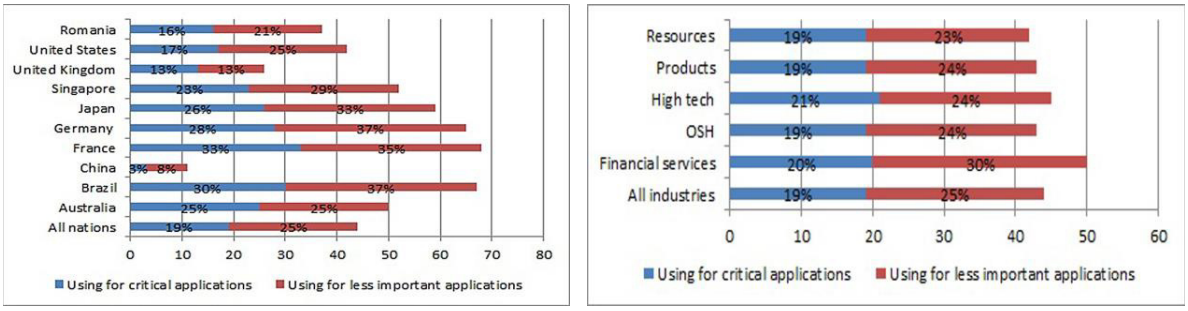

Fig. 5. Average of private cloud platforms and software, infrastructure, process and platform services.

It can be noted the active involvement of Brazil and Germany in using cloud computing, being innovative and using emerging approaches. Regarding areas (fields), cloud computing is used mainly in high tech and financial services, differences between areas being small. In an analysis [22,23] of the types of services using cloud computing, Figure 6, it is apparent the inclination towards SaaS solutions.

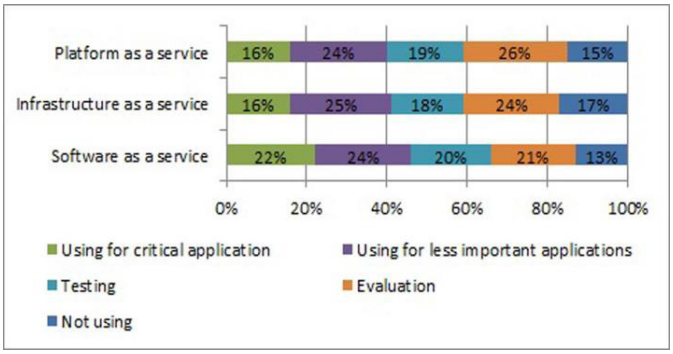

Fig.6. Usage of Cloud Computing (SaaS, IaaS, PaaS)

5.2. Drivers of cloud computing structure

Because the opportunities offered by cloud computing begin to be exploited by more and more organizations, it is required a systematization of the drivers of cloud computing to exemplify the importance of using this concept in e-health. The main drivers are summarized in the Accenture Institute for High Performance report [22], Figure 7.

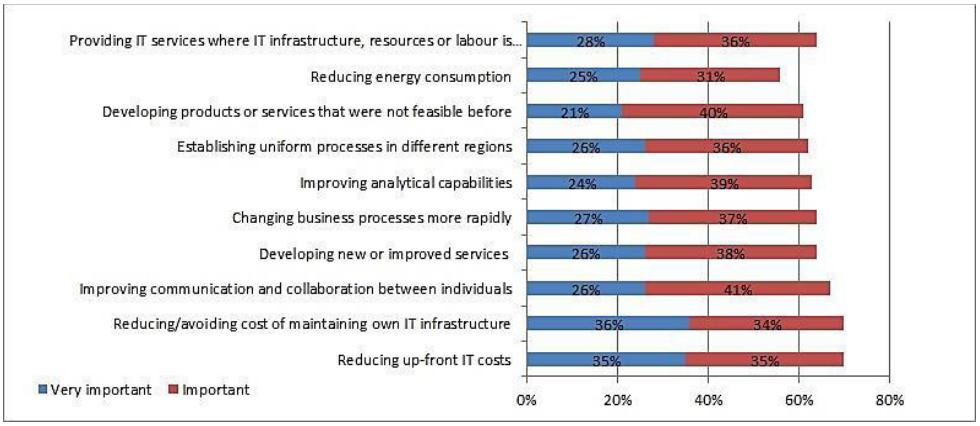

Fig.7. Key Drivers of cloud computing

Among the key drivers there are: reducing cost, adaptability, energy reduction, uniformity of solutions and concurrent use of different solutions. Thus, so many advantages of using these services being highlighted we should approach cloud computing in e-health, specifically in occupational risk assessment.

5.3. Cloud Computing and Occupational Risks

A prerequisite of currently developed solutions is that they are delivered SaaS (Software as a Service). The benefits of such a request are numerous, so that organizations realize the advantage of implementing such a solution.

The benefits of SaaS delivered solutions fit the following:

- Reduced costs and reasonable effort for staff so that operational activity is not affected during implementation
- Zero initial investment and competitive TCO (Total Cost of Ownership) by contracting a SaaS solution with periodic payment services.
- Costs predictability through periodic payment services.
- Simplifying the IT environment through hosting the risk assessment solution in a professional data center.

In the e-health there are a number of approaches to occupational risk assessment using cloud computing. Among them were Rolim and et, DACAR solution and CARE solution. *Rolim et* al proposed a cloud-based system to automate the process of collecting patients' vital data via a network of sensors connected to legacy medical devices, and to deliver the data to a medical center's "cloud" for storage, processing, and distribution. The main benefits of the system are that it provides users with 7-days-a-week, real-time data collecting, eliminates manual collection work and the possibility of typing errors, and eases the deployment process [23]. *DACAR* aims to develop, implement, validate and disseminate a novel, secure, "in-the-cloud" service platform for capture, storage and consumption of data within a health care domain. The objectives of the project include: development of novel distributed and secure infrastructures based on role and inter-domain security polices; smart device and system integration platform based on novel digital forensic security technology; generic risk assessment strategy for smart device and system integration; clinical evaluation, dissemination and commercialization [24]. *CARE*, CyberHealth for Aggregation, Research, and Evaluation, was mainly proposed to enable data integration, filtering, and processing for data mining in e-health. They identified a need for an infrastructure for data integration and languages, algorithms, and tools to analyze medical information to discover new medical patterns. With this approach, heterogeneous data from different sources can be integrated, processed and analyzed to improve health understanding and medical treatment effectiveness [25].

Analyzing the needs of the e-health environment, the authors propose occupational risk assessment solution in SaaS. The SaaS systems in the cloud will be replaced with local systems in the next years, thus, it will be easier to create new SaaS systems which is based on standard modular parts [26]. In order to assess the occupational risk the

authors have developed the diagram of Figure 10 (see appendix), which includes the basic steps of a management system: (1) define the purpose and description of the analyzed system, (2) identify hazards based on checklists in the areas defined by the authors in the risk analysis (metallurgical industry, road transport, metal construction, manufacturing of wearing apparel, special construction, woodworking, retail, wholesale, food industry, pipeline transportation, building and construction cool extraction), (3) identifying the risks associated with sources of risk identified in the 11 fields, (4) assessing the severity, likelihood and consequences of identified risks, (5) treatment of identified risks, (6) communication and control, (7) preventive and control measures and (8) continuous monitoring (resumption). Risk assessment is performed through a qualitative assessment [27,28] of factors: severity, probability and consequence. These qualifications are: low, medium, high. Allocated coding for low is bit 0, while for medium and high coding is bit 1. If the product is 1 it is proceeded to treat and prevent future occurrences. Just for occupational risks with medium impacting on the workplace environment a space is allocated in the treatment plan. This treatment plan is communicated to all levels of the organization as a priority for achieving organization objectives and health and safety at work. This solution is developed using databases and HTML programming, using the services offered by cloud computing. The architecture for implementing the solution is found in Figure 9.

To identify occupational hazards [18] in the workplace it has been prepared a checklist which is included in PaaS. This list may be extended depending on the activity of the organization. Active involvement of all employees in the process of gathering information helps to correctly identify the hazards. Using the MySQL on a general hazard identification list it was created a knowledge base containing: award rules, rules for calculating the scores and probability assessment rules. After querying the knowledge base for a sector, you will see the result of the risk assessment, the assessment conclusion and methods of prevention, protection and proper treatment. At the bottom are Security Mechanisms, which are used to meet the authentication, data integrity and confidentiality requirements. Infrastructure as a Service includes the required base for developed application.

The applications are hosted by a cloud service provider and made available to customers over a network, typically the Internet, SaaS.

Cloud Computing - cloud services and storage - is accessible from anywhere in the world over an Internet connection and occupational risk assessment is easy to assess. The UML (Unified Modeling Language) deployment diagram is shown in Figure 9.

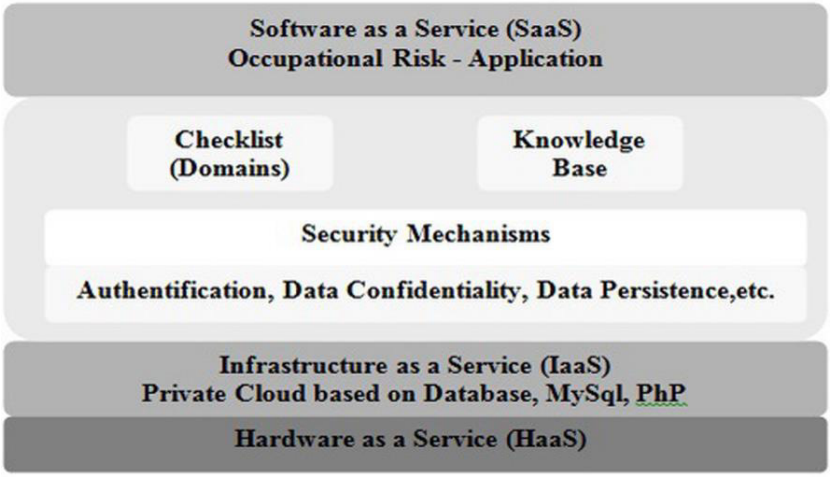

Fig.8. Conceptual architecture of the proposed platform

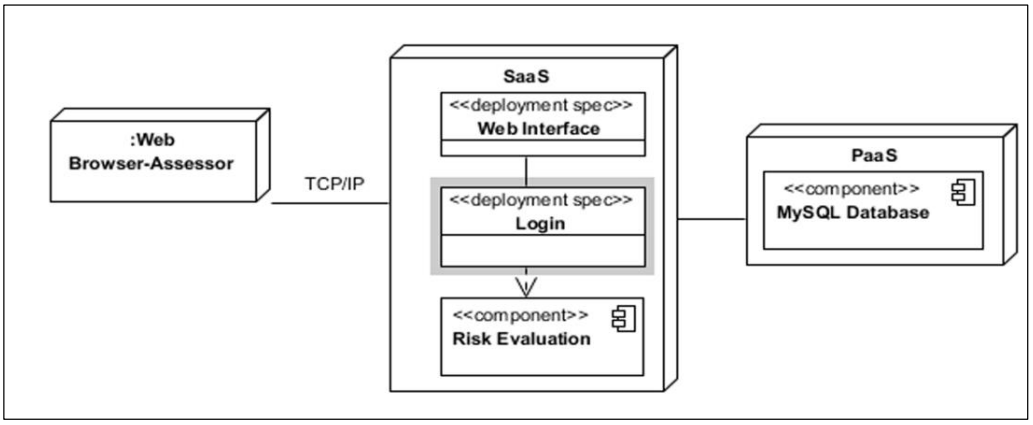

Fig. 9. Deployment diagram for occupational risk assessment approach

The evaluation process is as follows: the evaluator accesses through a TCP / IP the risk assessment platform that is in cloud computing. At this point we get a login interface and then we can begin the evaluation process. When the evaluation process is started, the database of MySQL is called, which is in IaaS and the evaluator gets the checklists afferent to the risk assessments. The scheme of the evaluation process is shown in Figure 10.

Conclusions

This paper presents the literature review, European strategic directions and their implementation in occupational risk assessment in Romanian organizations, analysis of work accidents in Romania compared to EU and the authors addressing occupational risk assessment using cloud computing by developing the associated architecture. Based on the literature the authors have selected the defining concepts of occupational risk: hazard, risk, accident, consequence, severity and probability that have been integrated in the proposed solution. Following European strategic directions for the years 2014-2020 this solution correlates with the main proposals: the economic dimension of occupational health and safety, occupational health and safety communication and risk communication, intervention research and occupational health and safety research for safe new technologies [29]. The four selected directions contributed to the choice of technological support for software implementation and the developed analysis. Being defined the directions and terms that were used, it was pursued an analysis of work accidents in Romania to define the most important 11 fields in which we are sizing the hazards in organizations. To implement risk assessment there were selected the services offered by cloud computing based on research conducted by the authors. Following the presentation of data and analysis on the use of cloud computing it was considered mandatory to use this new and approachable concept. A literature review of health Cloud issues was presented in this paper with emphasis on the importance of the concepts involved, implementations and challenges. Considering the risks and benefits of using Cloud Computing architecture, the authors have proposed a strategy of adopting this approach in occupational safety and a risk assessment system. In future research we will test this possibility of risk assessment on various organizations.

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Appendix

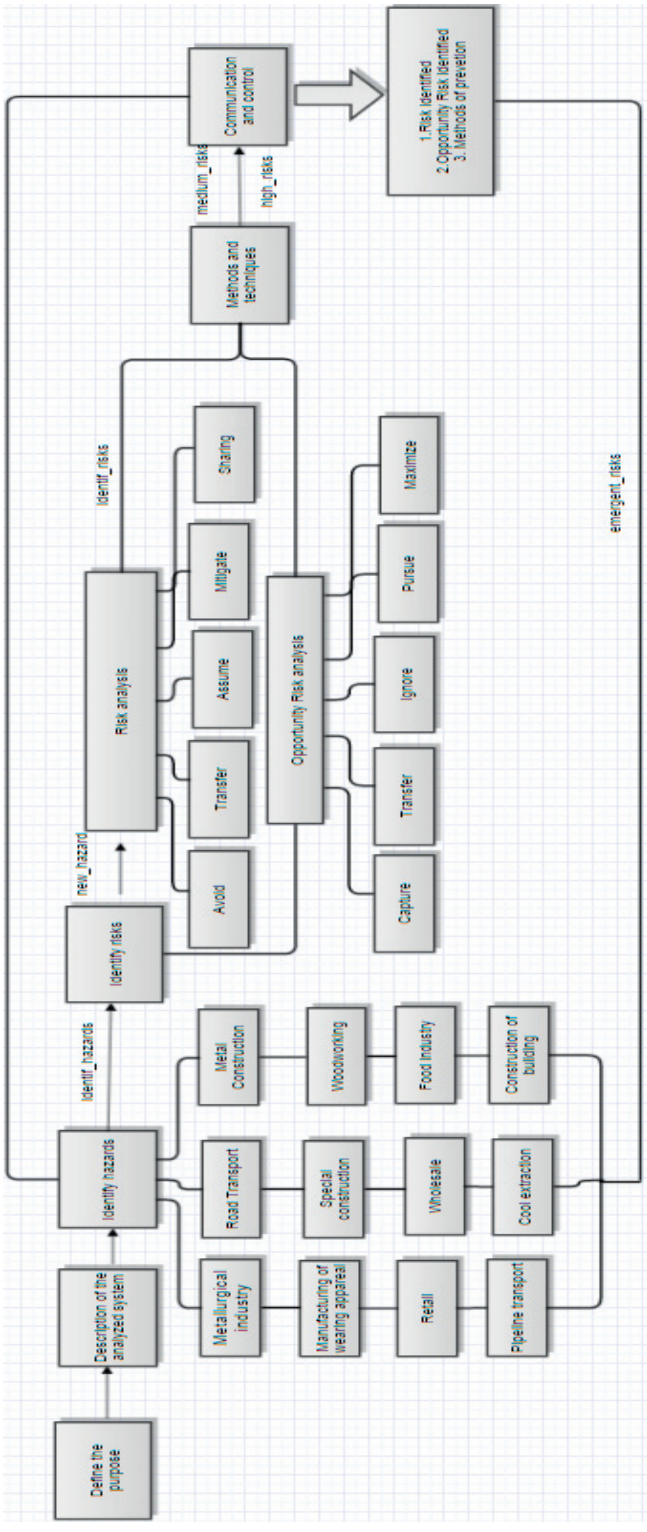

Fig. 10. The concept model structure of the occupational risk assessment