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EXPERT SYSTEMS RUNNING ACROSS MULTIPLE CLOUDS. A SUSTAINABLE PERSPECTIVE

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Abstract: *An expert system running across multiple clouds takes cloud computing to the next level of innovation. It emulates the decision-making ability of a human expert. Organizations have workloads running in many cloud locations, therefore applications become complex combinations of interconnected software components.*
The organizational strategies include sustainable approaches for resource management. Expert systems, through Cloud computing, provide alternative resources, reliable services and minimum costs. This paper concentrates on an innovative expert system that manages the cloud infrastructure.

Keywords: *Cloud, expert systems, security, sustainable perspective, innovation, efficient costs, IDS*

Introduction

As Green IT has been issued, many organizations have started to decrease IT costs and overcome economic recession [6]. Since Cloud Computing has become increasingly accepted as one of the most promising computing paradigms, the information become vulnerable.
Companies seek for opportunities in order to achieve sustainable development (Opriș, 2014). Innovation is a path to decrease the negative effects that companies exert on the environment.
It becomes a sustainable solution for organizations (Morioka et al., 2016; Engert et. al., 2016) and integrates a strategy that captures value (Lloret, 2016) for business environment and social actors [9]. The resource depletion rhythm can be decreased (Soma et. al., 2016) using alternative solutions such as Cloud computing.
The circumstances in which decisions are made depend on users' judgment (Martin, 2015) and values [8].
Companies have to satisfy many stakeholders' requirements, meaning that they deal with a significant amount of information.
Cloud computing can be a strategic driver that influences the decision making process (Morioka et al., 2016) [9]. It is an emerging technology incorporating new benefits for businesses, which offers access to massive, but simplified, informational resources (Chang et al., 2016) [2].
The conditions under which companies create value reflect their performance and awareness of the fragile relationship with the stakeholders (Lloret, 2016). Some et al (2016) write about new forms of governing in the Information Age, with impact on the social relationships, economy and science.
They also draw attention on uncontrolled flows of information that can change the balance of power from one user to another.
Once the companies accept outsourcing the information in clouds, imminent threats appear. An important challenge for Cloud computing systems is to protect the information. Incorporating values into sustainable decision-making (Martin, 2015) implies that limitations of any innovative technology are about to be assumed. As a consequence, expert systems running multiple clouds provide solutions for information security.
Therefore, the systems in the cloud must safely protect against both insiders and outsiders. Currently, to provide secure and reliable services in the virtualization space represents an important issue.
Cloud computing systems need to contain an Intrusion Detection System (IDS) based on expert systems that can provide alternative resources, security, sustainable process and scalability [6].
An expert system represents a computer that emulates the decision-making ability of human experts.It is able to manage significant amount of specialized knowledge.
These systems solve problems that require the expertise of large-scale human. Among the most important features of an expert system, it includes the ability to process a large amount of knowledge and the ability to simulate human reasoning.
The general elements of expert systems are: knowledge base, decision engine and user interface.

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According to different criteria, expert systems can be classified as: systems that think like humans, systems that think rationally, systems that act like humans and systems that act rationally.
Artificial intelligence and the expert systems subcategory are based on mathematics and various disciplines.
Expert systems involve complex developmental stages. These steps are essential to satisfy the initial system: initial problem, knowledge acquisition, design and implementation, testing, user manual and system documentation, maintenance.
Cloud computing is one of the emerging technologies that will led the next generation of internet [1]. This paradigm enhances collaboration, agility, scalability, and availability for end-users and enterprises.
Cloud modal is composed of five essential characteristics, three service models and four deployment models [7].

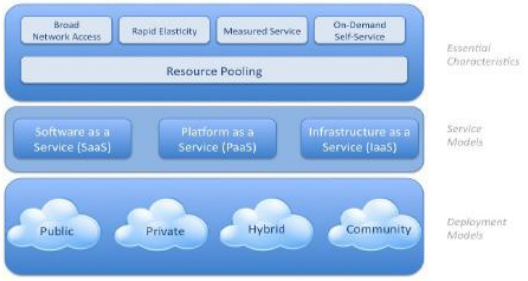

Figure 1. NIST- Cloud Computing definition [6]

The cloud service models are Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS).
The cloud deployment models are private, community, public, and hybrid.
Efficiencies of different cloud computing models can be determined by measuring and analyzing the cloud infrastructure metrics: hardware costs, software costs, real-time provisioning costs, system administration costs [7].
Cloud computing has been rapidly developed along with the trend of IT services. A critical aspect of cloud computing is assessing the risks, such as data integrity, privacy and recovery. IT security becomes complicated by externalization of the security model [6].
Intrusion Detection Systems represents the most popular devices for protecting information from various types of attack.
An intrusion is a set of actions that attempt to compromise the integrity, confidentiality and validity of a protocol or computer network.
Detection systems and intrusion prevention of IDPS (Intrusion Detection System - Prevention), identifying critical incidents, registration information, trying to eliminate incidents and generate reports of security conducted after detection [6].
Currently there are several types of IDS. The most common are: network-based, passive and active systems, IDS based on anomaly, signature-based IDS [7].
With the extensive use of cloud computing, security issues came out on a growing scale.
In fact, the information become exposed to cyber-attacks and their resulting damages.
This paper is divided into five sections. The first section presents an overview of cloud computing, expert systems, IDS and security.
The second section contains a review of the most important existing solutions. The third part describes the recent cloud attacks.
The fourth partre presents the proposed architecture using expert systems for detecting intrusion in the cloud location. The last section reveals the conclusions of the paper.

Review of current expert systems solutions

Cloud Computing necessitates new business processes and system changes complying with all stakeholders' needs. It is a challenge for the organizations as it includes costs, (Chang et al., 2016) human resources, natural resources and risks [2].
Although costs may be considerable, the way to reverse the negative impact on the natural environment is through technological innovations (Smith et al., 2015), such as Cloud computing, but the loss of data may cause serious problems for organizations [14].
Outsourcing all data to Cloud service providers may bring uncertainty in decision making process.
The impact of losing data could have serious impact on companies'continuity (Chang et al., 2016). Once an intruder penetrates the security measures and organizations lose information, their survival among competitors is uncertain [2].
In order to protect the information in clouds, the expert systems where developed. The first one, used for the analysis of molecular structures, was Dental.
In the early 1980 appear the first commercial applications of expert systems (XCON, XSEL or CATS-1).
Edward Feigenbaum is a computer scientist working in the artificial intelligence domain. The science was called "the father of expert systems."
He said that the key insight of early expert systems was that intelligent systems drive their power from the knowledge they possess rather

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than from specific formalisms and inference schemes they use.
These systems were introduced by Stanford Heuristic Programming Project led by Feigenbaum. The researchers tried to identify domains where expertise was complex: diagnosing infectious diseases (Mycin) and identifying unknown organic molecules (Dendral).
The expert systems are developed and implemented in many fields, including accounting, audit, planning, risk analysis, plan vulnerabilities, anti-malware detection system.
Frederick Hayes – Roth, is an American computer scientist. In 1983 he divided expert systems applications in 10 categories: interpretation, prediction, diagnosis, design, planning, monitoring, debugging, repair, instruction and control.
In 2008, Seda Sahin et al. describe an expert system for access Telecommunications Network. Expert systems are playing a large and growing role in telecommunications [7].
Zeng Li (2012)et al. propose an expert system for Cloud evaluation of commercial Cloud Services.This system concentrates on processes and experiences rather than results of cloud services evaluation.

Attacks in the Cloud Computing

Classification of cloud computing intrusions is given as follows: unauthorized access, misuse, cloud attack, data security and flash crowds [4].
Attacks in Cloud Computing are subject to several accidental and intentional security threats, including treats to integrity, confidentiality and availability of its resources, data and infrastructure.
Cloud computing systems are susceptible to all typical network and computer security attacks.
According the report on the cyber security alerts 2015 of Romanian National Computer Security Incident Response Team (CERT-RO) there are different types of alerts [10].
The alerts collected and processed by CERT-RO have been classified in Figure 2.

No.	Alert class	Number of alerts	percentage
1	Vulnerabilities	53,424,880	78.33 %
2	Botnet	14,171,061	20.78 %
3	Malware	393,380	0.58 %
4	Information Gathering	102,167	0.15 %
5	Cyber Attacks	61,751	0.09 %

Figure 2. Top 5 security alerts 2015 [10]

In the statistic report the alerts collected by CERT-RO in 2015 dropped by 13% (68,205,856) compared to 2014(78.769.993) [3].
In 2014 Mouna Jouini et al. made a classification of security threats in information systems. The paper presents a model with external and internal threat [4].

Expert Systems running multiple Clouds

This paper proposes an expert system running multiple Clouds to provide alternative resources, reliable services and minimum costs.
It emulates the decision-making ability of a human expert and acts like an intrusion detection systems.
One expert system detects intrusions from multiple clouds with minim efforts. A system that acts like IDS provides stronger security.
The workflow of the proposed architecture is designed in Figure 3.It is centered on the expert system.

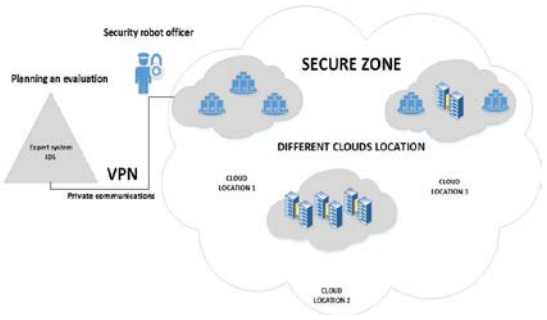

Figure 3.The proposed architecture

The expert system connects automatically to different clouds locations using private and secured communications.
The system planning an evaluation for detecting the intrusion in the clouds zone. Before connecting to the secure zone, a security robot officer checks if the connection is safe.
In the secure zone the expert system begins to solve cases, learn cases, repair case, test cases form different cloud location.
The position of security robot officer represents a security level before authenticating in clouds.
After the evaluation, the expert system generates a results report.
Organizations have workloads running in many cloud locations. The expert systems in the paper concentrates on an innovative architecture.

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CONCLUSIONS

In conclusion, Cloud computing offers a sustainable perspective on resources.
It is an alternative through which the natural resources scarcity could be slowed down. Outsourcing data to clouds saves costs, space, energy and helps protecting the natural environment.
In this paper we have presented a novel expert system based on IDS running across multiple clouds. The system evaluated and solved all attacks inside de cloud zone.
The first part of the paper presents a descriptive introduction of cloud computing definition and modals, expert systems and IDS. In section 2 we decided to make a review of expert systems used by organization.
The third part of the article represents the proposed architecture. It is a significant fact that the proposed expert system presents cloud innovative benefits, like autonomous on-demand secure communications links, scalability, secure authentication.

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