# The Cloud Computing Technology or How „Extreme Performance" Can Be Achieved in Business

Manole VELICANU, Daniela LITAN, Larisa COPCEA (TEOHARI), Mihai TEOHARI
Economic Informatics Department,
Academy of Economic Studies, Bucharest, Romania
manole.velicanu@ie.ase.ro, litan.daniela@gmail.com, larisa.copcea@gmail.com, mteohari@gmail.com

*Extreme performance, the reuse of resources or less money and time spent on the employees' training… not until long ago, all these "phrases" were mere desiderata for companies, irrespective of their size. "Today", however, all these things are possible by dint of cloud computing technology (or complete virtual machine).The cloud computing concept involves the possibility of using upon request hardware and software resources located in different places as to the user, and made available for the latter by means of shared servers. In this paper, we shall depart from the information context that made for the advent of the cloud computing technology, then we shall analyze the latest products appeared on the market that successfully "promote" the cloud computing model (Oracle Exalogic Elastic Cloud, Oracle Exadata Database Machine X2-8), in the end of the paper we present several proposals of practical applications for this technology.*
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## 1 Introduction

The current information context is the one that usually determines the development of a new information technology. In informatics there are research ideas continuously, but they can be finalized and applied only if the current information context allows it. Otherwise, the ideas will remain pending and they will be implemented only when this is possible. *The information background* is provided firstly by the existing information technologies but also by other elements such as: endowment with computing technique, information training, economic situation, market demands, customers' training etc. *The information technology* refers to a set of processes – processing carried out through a series of operations, methods – methods of knowledge, operators – operations carried out on inputs, conditions – work restrictions, means – working tools and interfaces, all these being used with a view to obtaining some information products. Therefore, the information technologies provides processes (how) and means (what with) of processing the information resources in order to obtain information products.

The concept of *Complete Virtual Machines* – CVM represents a new trend in information and signifies a dynamic set of computing resources scattered in different geographical locations within a computer network, but logically managed as a whole – virtually as a single giant computer - complete virtual machines. It is necessary to have computing resources – adequate hardware and software for such complete virtual machines [1]. We believe that such a concept could be developed and implemented due to a favorable current information context which includes a series of new information technologies such as: Grid Computing, NC architecture - Network Computing, database machine, business intelligence, distributed information applications, SOA architecture - Service Oriented Architecture.

**Grid Computing** – GC represents a set of techniques and methods applied for the coordinated use of multiple specialized servers that act as a single computing system, logically integrated, very powerful [2]. The computing resources are taken into account at the level of an organization that will be used optimally, jointly, obtaining thus the complete virtual machines for the company. The technology was implemented in early 2000s and then shortly after, for the first time with a database, by the Oracle Company which launched the 10g version.

Some *principles* of the GC technology have been used, adapted and extended for the new trend in CVM as: virtualization extended outside the organization, the dynamic provision of computing resources adapted to new situations in a global computer network, joining the resources and sharing them with solutions to very large size, the automatic adjustment of systems which provides the dynamic character and increases complexity, the unified management extended for larger sizes and new situations.

We consider that for CVM, the concept of unified management of the computing resources has expanded from one company level across multiple companies.

**Network Computing – NC architecture** requires a set of components which interact in order to develop information products that work in an environment structured on more than two levels, with the support of several types of computers (including Network Computer – NC), several types of servers connected to the Internet [2].

*The development of working environments* for data management within computer networks was as follows: centralized architecture – implies that the data are stored in a central computer and the retrieval requests are made at a terminal, the client-server architecture – implies that the data are stored and accessed on a sever computer and the retrieval requests are made on a client computer by a man-machine interface, *NC architecture* – implies that there are several types of computers in the network (network computer, personal computer), several types of servers (for data, applications, Web etc), which means working in an environment structured on more than two levels.

We have concluded from the studies carried out that a series of NC architecture *principles* have been taken over and adapted for CVM as follows: open systems involve the training from the start for the taking over "on the fly" of the new components, increased flexibility for easily adjusting to the changes that may occur, interoperability of component heterogeneous systems, large-scale standardization etc.

**Database machines** are some computers specialized in data storing and processing, designed to manage the database and which can get easily connected to a main processor through a high-speed channel [3]. The role of building and using some database machines is the most efficient use of computing resources in information applications with database. We refer therefore to hardware and software dedicated computers for working with database. At this moment, modern database machines are being used with maximum performance both for managing large volumes of database [4] (Data Warehouse and OLAP - On Line Analytical Processing), and for processing current transactions (OLTP - On Line Transaction Processing).

We consider that this concept regarding the most efficient use of computing resources has been extended, as far as CVM are concerned, from one physical computer to a complete virtual machines.

**Business Intelligence** is a concept that involves an open and flexible architecture that integrates several information technologies with a view to store all relevant data for a company. They are transformed into information and knowledge necessary to form the basis of the decision-making process [4]. The Business Intelligence architecture requires a system that is based on some data sources, which is extracted by filtering (as threads) the necessary information to build a Data Warehouse. It will be managed by specialized interfaces (OLAP, data mining) to fulfill the necessary levels of management.

Our experience in Business Intelligence as to storing and processing large volumes of data has been particularly useful for understanding CVM, where such problems arise. We have concluded that the specificity consists in the fact that large volumes of data will be scattered over various geographical areas, and their unity will be a virtual one.

**The distributed information applications**

have been developed in recent years according to new technologies, due to the emergence and widespread use of mobile computing equipment. The experience from the distributed database systems [2] is still valid, but new information technologies have been added: mobile systems, Web environment, multimedia etc.

It results that the CVM benefit from the techniques and methods concerning the data distribution in the network of computers, but they have been adapted to the new information context.

**SOA architecture** (Service Oriented Architecture) is an integrated solution both for simple applications – at departmental level and for complex applications – at organizational level. This architecture is applicable to software products or to the standardization of the computing technique within an organization. SOA proves its efficiency when operating in various heterogeneous working environments. The logic of the solution consists in decomposing the problem into smaller related components according to functional criteria. The components are not mere miniature copies of the whole, but distinct unities, weakly joined, sharing common methods and able to operate interdependently. The services can be performed either by defining some methods that should access all the applications – integrated, or by working on an infrastructure for such methods – for example the Web services.

Since using the service-oriented architecture one can rich a high interoperability among the different computing resources, irrespective of the working platform used, the result is that this thing is very suitable for CVM. We will point out this fact below, when speaking about CVM architecture.

## 2 The basis of Complete Virtual Machines - CVM (cloud computing)

Having as a starting point the information technologies presented above, the CVM concept has been developed and successfully implemented in recent years.

Within the current information context, the Internet is on the verge of triggering a new revolution, which implies that computing resources can be easily shared and managed at world level through computer networks [5]. The *Complete Virtual Machines - CVM* (cloud computing) is the main component of this paradigm that turns the Internet into a large warehouse, where resources are available for everyone under the form of services.

The international body NIST - National Institute of Standards and Technology defines the concept of *cloud computing* as a model that allows the access through the network, conveniently and upon request, to a common pool of resources dynamically configurable. These resources can be found very fast and offered with a minimum effort through the interaction of a server provider [13]. This model has the *availability* of resources as working principle.

We have suggested a possible **CVM architecture**, where there is a specialized software that will unitarily manage different components (computing resources): more computing systems (including networks), more information applications, more servers (for data, applications, Web etc), more services. All these will be structured on several levels, dynamically managed by specialized software. Since many of the CVM components are not visible for users who do not know where they are located and how they are managed, it means they are virtual.

The CVM architecture has its components (Figure 1) structured on three levels: no.1–interfaces; no.2-services, no.3-processing.

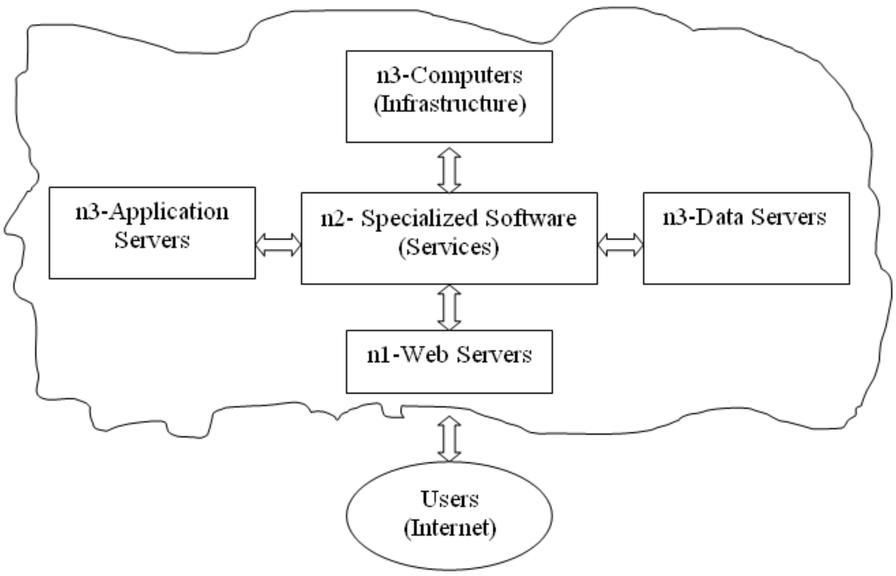


**Fig. 1.** CVM Architecture - Proposal

*Interfaces* are software components, most often Web-based, providing user access to the resources dynamically offered by CVM. The interfaces also provide users with the results obtained from the processing of retrieval requests made by him.

*Services* are software modules, built according to models that made retrieval processing applications, using existing resources in the CVM. This component has the role to monitor the entire operation of the CVM.

*Processing* is the component made up of several specialized servers (data, applications, etc.) together with technical support provided by the computing systems (including networks) - the infrastructure.

We have conducted a brief characterization of the CVM from the above architecture, by analyzing the components and functions and by studying the specialized literature.

The **main features** of the CVM are:

- *shared resources*. Classically, the user accesses his/her own necessary resources. The CVM monitor manages automatically the resources of several computers;
- *the dynamic allocation of resources*. The users ask for resources when they need them and, similarly, give them up when they don't need them. The monitor offers and releases automatically different types of resources: processors, storage media, software, applications, services;
- *multiple computing systems*. Nodes (workstations) of the CVM are usually built up using a large number of computing machines. Thus, in order to monitor CVM, a new node can easily be added, or a node which breaks down can easily be replaced;
- *automatic monitoring of resources*. This feature includes a lot of setup tasks usually handled automatically by the system: saving, restoring, setting, resource allocation and release etc.;
- *virtualization*. The CVM resources are usually virtual, being shared among several users in order to increase the system efficiency;
- *parallel computing*. There are several working environments for the use of parallel processing, leading to hundreds or thousands of processors into one CVM.

Note. All the above features are found in some form or another in the information technologies presented for the current information context. They have been adapted for the CVM.

## 3 CVM model in practice

The CVM concept is based, as we have already mentioned, on a specific model - *the cloud computing* model. It has contributed to identifying the CVM components and building its architecture. As far as the implementation of this model is concerned, there are four different types that can be inferred from the specialized literature [13]:

a) *private cloud computing* - the existing infrastructure is operated solely by a single organization and can be managed by that organization or by a third party. This model is similar to that of Grid Computing and database machines;
b) *a community computing cloud* - the existing infrastructure is shared among several organizations that have common interests or goals and can be administered by that organization or by a third party;
c) *public cloud computing* - the existing infrastructure can be accessed by any user who has the right to do it and is owned by a service provider organization;
d) *hybrid cloud computing* - the existing infrastructure is made up of two or more of the above types, which remain unique entities but are linked by standardized or customized technology that allows portability of data, applications and services.

For greater efficiency, over time, it was attempted that the whole cloud *computing technology*, both software and hardware, be integrated into a single machine that is a *Complete Virtual Machines*.

Such a solution has been materialized in the *Oracle Exalogic* product - EO (elastic cloud machine) that integrates hardware servers with middleware software to work together for maximum performance, with data centers from organizations [1].

In terms of current implementation of CVM, Oracle now offers the opportunity to provide *cloud computing-elastic* model in a private and domestic service, thus avoiding the disadvantages related to the protection of a public *cloud computing* model [14]. The advantage for the Oracle company in this approach was prompted by a longstanding expertise in *grid computing* technology (versions 10g and 11g), as well as in and database machines (Exadata Database Machines V1, V2, X2-8) [1].

### 3.1 Oracle Exalogic Elastic Cloud, a representative CVM model

Oracle Exalogic Elastic Cloud is the world's first integrated CVM in terms of both software and hardware components at the same time [6]. Oracle Exalogic was designed as a complete infrastructure to revolutionize data storage possibilities now offering companies the opportunity to gather a huge volume of disparate data with maximum reliability, availability and protection. Its high bandwidth, uniqueness, low latency interconnection and efficient operation of distributed applications are things that cannot be achieved using today's regular servers. Oracle Exalogic Elastic Cloud provides a complete infrastructure of applications, integrating a wide variety of applications and types for Java and non-Java use and meeting the most demanding requirements that such a service may generate [1].

Oracle Exalogic Elastic Cloud is a complete system: it combines 30 64-bit top processors, it uses InfiniBand technology for I/O operations, Oracle WebLogic Server for solid-state storage, different Oracle Java products (including virtual machine), it has middleware components, it offers Oracle Solaris or oracle Linux as operating systems, it supports thousands of applications, being the ideal platform for data consolidation.

In order to point out the *performances* out of the new system Oracle Exalogic Elastic Cloud, we shall present the main components of its *software* and *hardware*.

a) *Hardware* component. The Oracle Exalogic Elastic Cloud is pre-assembled and delivered standard rack size 19" 42U. Also, every product in Oracle Exalogic Elastic Cloud is actually a working capacity unit adapted to intensive workload. Each Oracle Exalogic Elastic Cloud unit contains: a number of hot-swappable notes, a cluster, a high performance subsystem for data storage management, a very large bandwidth which interconnects each individual component with other external components, several Gigabit Ethernet ports for the integration with the data center network service.

b) *Software* component. Oracle Exalogic Elastic Cloud was designed from the very beginning to provide the ideal environment for Java based applications and infrastructure. Also, the entire portfolio of Oracle Fusion Middleware and Oracle Fusion Applications are designed to allow maximum use of Oracle Exalogic Elastic Cloud. The monitor of the entire system is the Oracle Enterprise Manager component, which has two main products: Grid Control and OpsCenter. This allows any hardware component of the Elastic Cloud Oracle Exalogic system to be monitored in real time and, upon the client's request, it can be integrated into the Oracle Support option for the system maintenance. In order to have a clear picture of Oracle's Enterprise Manager, we can follow Figure 2.

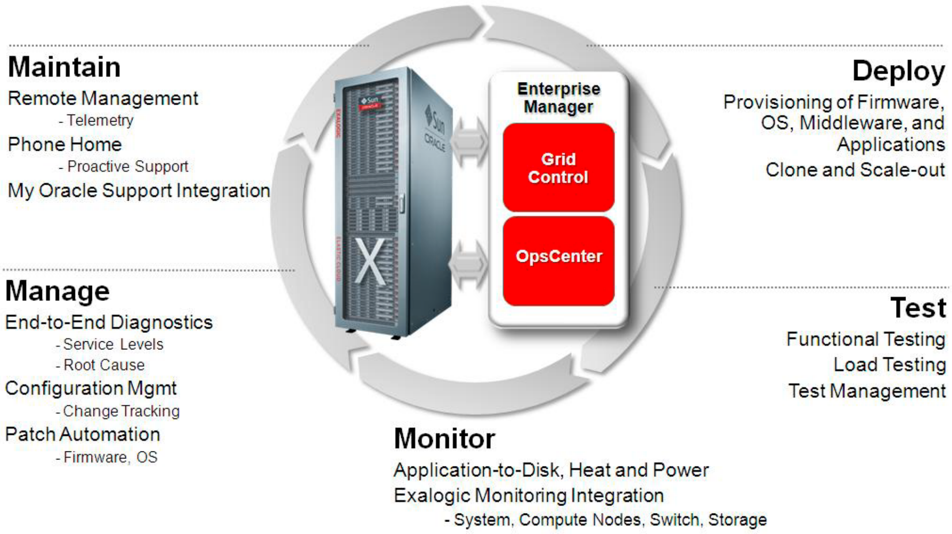


**Fig. 2.** Oracle Enterprise Manager, part of the Oracle Exalogic Elastic Cloud software component; source: [6]

Each Exalogic Oracle configuration - OE contains: a number of computing nodes, a data storage subsystem, a connecting network comprising all the switches needed for all the individual components of the configuration, as well as for the external connection of additional Exalogic machines [7].
Some *advantages* of the EO advantages that we have studied and explained are:

- integrates hardware and software which work together. This integration is also to be found in the database machines, but it now extends to the level of a complete virtual machines. The unitary management of computing resources, which was taken and adapted from Grid Computing, is also integrated here;
- maximum performance for processing Web retrieval applications. The specialization of complete virtual machines components, as well as the dynamic allocation of its resources, which is possible due to their unitary management, leads to peak performance;
- it interconnects effectively: working architectures, information applications, computing configurations. Taking over some elements of the NC architecture, complete virtual machines can interconnect natively all these components, on multiple levels;
- it revolutionizes the data center consolidation, that is it allows business organizations to gather disparate data logically, in an efficient, reliable and secure way. The existing data in different organizations can be managed unitarily and efficiently;
- the distributed applications will be able to solve retrieval applications on the Web, that cannot be addressed now, with the existing data servers. By means of integrating some CVM Web servers, the retrieval results will be used throughout the managed virtual environment;

- it integrating several already existing applications on a single performing platform. The applications that are already in service with different organizations will not be abandoned but integrated into SDV, some as such, others through conversions or transformations. This ensures the concept of reusing the existing resources, a concept used extensively in the current information context.

We have defined *the working strategy* in a CVM implementation by a few key words that summarize the essence of this concept: *completeness*, *openness*, *integration* and *performance*.

*Completeness* means that a CVM has all the hardware and software components necessary to develop and use appropriate information applications in organizations.

*Openness* refers to CVM components that are dynamic. They can be changed at any time, with very little effort, the reconfiguration being done automatically. The CVM is ready at any moment to take over "on the fly" the changes that can occur.

*Integration* refers to the information technologies included in the CVM, as well as to the unitary use and sharing of data, applications, computing resources, etc..

*Performance* is high due to the specialization of CVM components, but also due to the unitary management of computing resources: time and space.

### 3.2 Oracle Exadata Database Machine X2-8, a specialized data warehouse CVM

Exadata Database Machine is a database machine that allows the use of data warehouse and OLTP (Online Transaction Processing) applications at very high parameters, thus becoming the ideal platform for the use of *grid* or *cloud computing* technology (usually *private*). Therefore, *we can say that Exadata Database Machine X2-8 is actually a specialized „customized" data warehouse of the Oracle Exalogic Elastic Cloud*.

The Exadata Database Machine X2-8 is a complete package, consisting of: servers, storage capacity, network components and software applications. All these elements make the Exadata Database Machine X2-8 a perfectly scalable product (supporting a large loading volume), safe (in terms of security) and redundant.

The Exadata Database Machine X2-8 belongs to the Oracle Exadata Database Machine "family", being similar to Exadata X2-2 (known as V2), but having much higher performances in comparison the latter. Moreover, in terms of performances, Exadata Database Machine X2-8 can be easily "read" even by a person less specialized in the domain, following the description below:

a) *Hardware* related features:
   - 128 CPU (Central Processing Unit) and 2 TB memory, capacities which are designed for databases processing;
   - 168 CPU capacity designed for handling the stored information;
   - two database servers;
   - 14 Oracle Exadata Storage Servers units;
   - 5.3 TB Exadata Smart Flash Cache destinations;
   - QDR (Quad Data Rate, 40 Gb/sec.) InfiniBand Switches;
   - uncompressed usable capacity of up to 150 TB per rack
   - uncompressed I/O bandwidth up to 75 GB/second/rack;
   - Exadata Hybrid Columnar Compression often offers ratios between 10X-15X;
   - complete redundancy with a high degree of availability.

*b) Software related features:*
   - Exadata Smart Scans: 10X or greater reduction in data sent to database servers;
   - Exadata Storage Indexes: eliminate unnecessary I/Os to disk;
   - Hybrid Columnar Compression (HCC): efficient compression increases effective storage capacity and increases user data scan bandwidths by a factor of 10X;
   - Exadata Smart Flash Cache:
   - breaks random I/O bottleneck by increasing IOPs by 20X;

- doubles user data scan bandwidths;
- I/O Resource Manager (IORM): Enables storage grid by prioritizing I/Os to ensure predictable performance;
- Inter-leaved Grid Disks: Enables storage grid that allows multiple applications to place frequently accessed data on faster portions of the disk.

Grid is the architecture of the future it provides highest performance, lowest cost, fault tolerant, scalable on demand (see Figure 3).

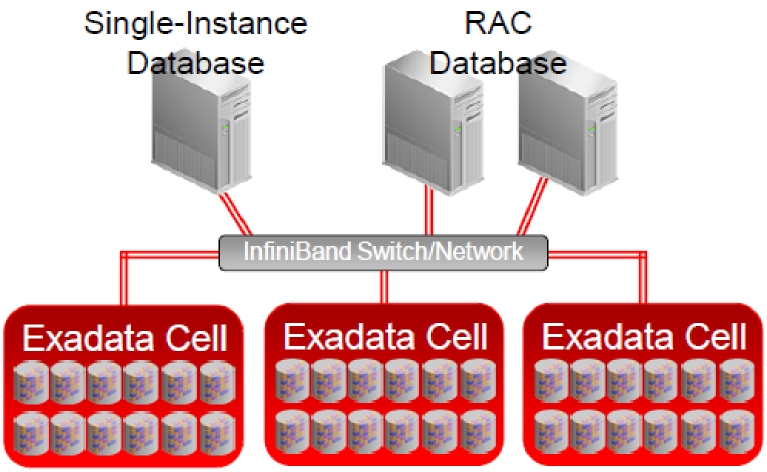


**Fig. 3.** Oracle Exadata Database Machine X2-8 architecture; source: [15]

The main features of Oracle Exadata Database Machine X2-8 architecture (Figure 3) are:
- Each Exadata Cell is a self-contained server which houses disk storage and runs the Exadata software;
- Oracle Databases are deployed across multiple Exadata Cells;
- Oracle Database enhanced to work in cooperation with Exadata Storage Server;
- No practical limit to number of Cells that can be in the grid.

Other features owed to the architecture in the image above (Figure 3) are:

a) The capability *Exadata Smart Scan*:
- Exadata cells implement scan offload to greatly reduce the data sent to database servers:
  - row filtering based on "where" predicate;
  - column filtering;
  - join filtering;
  - incremental backup filtering;
  - scans on encrypted data;
  - Data Mining model scoring;
- 10x data reduction is common;
- Completely application transparent: even if cell or disk fails during a query.

b) The capability Smart Scan Transparency:
- Smart Scans are transparent to the application:
  - no application or SQL changes required;
  - returned data is fully consistent and transactional;
  - if a cell dies during a smart scan, the uncompleted portions of the smart scan are transparently routed to other cells containing a replica of the data;
- Smart Scans correctly handle complex cases including:
  - uncommitted data and locked rows;
  - chained rows;
  - compressed tables;
  - National Language Processing;
  - date arithmetic;
  - regular expression searches;
  - partitioned tables.

Obviously, some currently unrivaled capabilities/"abilities" of this database machine are associated with the characteristics mentioned above. Moreover, even since the launch of Oracle Exadata Database Machine X2-8, in

September 2010, the potential of this product has been summed up in three simple slogans, easy to remember by any potential client who is even only partially interested:

- extreme performance for OLTP (Online Transaction Processing), data warehousing and "consolidation" of the mixed workload;
- extreme scalability (supporting a large loading volume);
- the possibility for the Oracle Exadata Database Machine X2-8 system to be ready anytime to cope with the requests from the applicants with a major importance (extreme redundancy).

Besides all these capabilities, we should also mention the fact that the Oracle Exdata Database Machine X2-8 recommends this database machine as the most reliable system in the world that "works" with databases. The explanation of the security comes from the fact that "the data decryption process is no longer performed using the software component, but the Exadata Hardware component"[8]. It is also remarkable that the Oracle Exadata Database Machine X2-8, according to the manufacturer, is "ready" to meet any type of requirement coming from the databases.

And because there is only one step from databases to data warehouse, Oracle Exdata Database Machine X2-8, is considered (according to the producer), "the best Data Warehouse machine". The features that confirm the statement above are:

- massively parallel high volume hardware to quickly process vast amounts of data: Exadata runs data intensive processing directly in storage;
- most complete analytic capabilities: OLAP, Statistics, Spatial, Data Mining, Real-time transactional ETL (Extract, Transform and Load), Efficient point queries;
- powerful warehouse specific optimizations: flexible Partitioning, Bitmap Indexing, Join indexing, Materialized Views, Result Cache;
- dramatic new warehousing capabilities.

Due to the fact that Oracle Exadata Database Machine X2-8 is still a part of the "Oracle family", it is probably obvious that this database machine can run a variety of products belonging to the same "family", such as: Oracle Database 11g, Oracle Real Application Clusters, Oracle Enterprise Manager and Oracle Exadata Software, all these products having the role to provide the Oracle Exadata Database Machine X2-8 users with "software, servers, storage capacity and access to the network"[1]. As far as the operating system is concerned, Oracle Exadata Database Machine X2-8 can run Oracle Linux and Oracle Solaris Express 11.

However, the "career" of the Oracle Exadata Database Machine X2-8 is still in the beginning, being launched, as we wrote above, at the end of September 2010, and in the absence of some real tests it is difficult to make a statement concerning the real performance rates of this product. It will fall to the future clients to decide if the manufacturer's "promises" have proved to be real totally or partially, but we should also mention the fact that the current economic crisis can greatly influence, negatively, the sales of this product, due to the "susceptibility" of the companies to improve their software and hardware performances in the absence of immediate cash. In spite of all these, "in order to obtain a competitive advantage, the companies must keep closely in touch with the new information technologies"[9].

## 4 CVM applications

*Public administration* is an area that would lend itself to the use of CVM as the new information technologies allow data storage, processing and transmitting in a cheaper and easier way, and governmental institutions should adjust the flow of their activities accordingly [10]. Therefore, news that the government or another institution decided on the implementation of a computerized system for citizens/companies or only for internal use (back-office) circulates more and more often both in the media and in the on-line environment. The need for such systems at governmental institutions is common knowledge. But it is also a well-known the fact that not all citizens are open to the use of a computer system to interact with a public institution, the main reasons being the system's poor performance and the lack of confidence in its security. However, so far a significant contribution to these shortcomings has certainly had the choice of information technology concerning the current systems of e-government, both front-office (for citizens/companies) and the back-office (for the national work of public administration).

While currently the computer systems belonging to state institutions are operating on separate servers, connected only to the internal network and / or Internet and the computers of their employees are independent units, connected, in their turn, to the internal network and / or to the Internet, we can say that now it's time for a change. A change that could bring along: *performance*, *safety* and *trust*. Obviously, we are talking about *cloud computing* technology for public administrations at national network level.

In terms of *performance*, as we stated above, the *cloud computing* model is the solution to increase the capacity or to add new resources, dynamically, without investments in a new infrastructure, in personnel training or without buying new licenses for software products [11]. Thus, using the *cloud computing*, we will definitely feel an improvement in the performance of e-government systems in public institutions. In this case, a possible answer might be Oracle Exalogic Elastic Cloud.

On the other hand, issues of *safety* and *trust* concerning the e-government information systems, regarded from the citizen's point of view, could be settled through a performing database machine. We say database machine because, when we talk about security and trust, we talk about the security and confidentiality of the information sent by means of e-government systems, which end up by being stored in a database. A potential solution in this case could be Oracle Exadata Database Machine X2-8, a product recommended by the manufacturer as the most secure system that works with databases at world level.

If the options we suggested above would be implemented, there is no doubt that the citizens' "open-mindedness" would be greater towards the e-government systems as the performance of systems and data security could be the watchwords for the transactions or the actions that they undertake. But the costs of CVM solutions must also be taken into account.

*The NASA Organization* used supercomputers in the past in order to test the sensitivity and accuracy of climate models. However, they were individual, very expensive and that is why a fast-tracking virtual network is being set up now, complete virtual machines that distribute the data processing to thousands of computers. Such an initiative eliminates the need to purchase additional physical supercomputers that use up enormous amounts of resources.

The need of a complete virtual machines appears for those organizations that have working platforms, implemented information technologies, fields of expertise, etc., that is many and heterogeneous computing resources. All these can be coordinated and managed in an integrated and effective way with the help of a CVM.

## 5 Conclusions

The need of certain organizations to use the features of complete virtual machines, such as its flexibility, meeting the demanding requirements of performance and reliability, is a new approach to IT infrastructure.

The key to success is represented by the combined design of its hardware and software which envisage performance, reliability and scalability both for homogeneous and heterogeneous environments, for operations within the Internet environment or for a large workload, based on a lot of data processing.

The construction or use of information systems customized for the different applications of organizations is inefficient and costly, while a solution with a CVM provides the best platform for running all types of applications.

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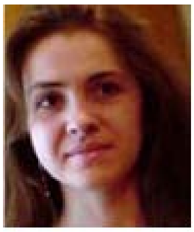
**Manole VELICANU** is a Professor at the Economic Informatics Department at the Faculty of Cybernetics, Statistics and Economic Informatics from the Academy of Economic Studies of Bucharest, Romania. He has graduated the Faculty of Economic Cybernetics in 1976, holds a Ph.D. diploma in Economics from 1994 and starting with 2002 he is a PhD coordinator in the field of Economic Informatics. He is a member of INFOREC professional association, a CNCSIS expert evaluator and a MCT expert evaluator for the program Cercetare de Excelenta - CEEX (from 2006). From 2005 he is co-manager of the master program Databases for Business Support. He participated (as director or as team member) in more than 40 research projects that have been financed from national research programs. His research activity can be observed in the following achievements: 18 books in the domain of economic informatics, 64 published articles (among which 2 articles ISI indexed), 55 scientific papers published in conferences proceedings (among which 5 papers ISI indexed and 7 included in international databases) and 36 scientific papers presented at conferences, but unpublished. His scientific fields of interest include: Databases, Design of Economic Information Systems, Database Management Systems, Artificial Intelligence, Programming languages.



**Daniela LITAN** has graduated the Academy of Economic Studies (Bucharest, Romania), Faculty of Cybernetics, Statistics and Economic Informatics in 2006. She holds a Master diploma in Databases - Support for business from 2009 and in present she is a Ph.D. Candidate in Economic Informatics with the Doctor's Degree Thesis: The integration of new technologies in the information systems of e-Government. Her research activity can be observed in the following achievements: 13 proceedings (10 papers ISI proceedings) and more than 9 articles published in scientific reviews. Her scientific fields of interest include: Databases, Database Management Systems, Programming, Information Systems and Economics.

**Larisa COPCEA (TEOHARI)** has graduated the Academy of Economic Studies (Bucharest, Romania), Faculty of Cybernetics, Statistics and Economic Informatics in 2006. She holds a Master diploma in Databases - Support for business from 2008 and in present she is a Ph.D. Candidate in Economic Informatics with the Doctor's Degree Thesis: Master data management in data warehouses. Her research activity can be observed in the following achievements: 4 proceedings (papers ISI proceedings) and 3 articles published in scientific reviews. Her scientific fields of interest include: Data warehouse, Databases, Database Management Systems, High availability solutions, Information Systems and Economics.

**Mihai TEOHARI** has graduated the Academy of Economic Studies (Bucharest, Romania), Faculty of Cybernetics, Statistics and Economic Informatics in 2004. He is a Ph.D. Candidate in Economic Informatics with the Doctor's Degree Thesis: XML technologies for databases. His research activity can be observed in the following achievements: 4 proceedings (papers ISI proceedings) and 3 articles published in scientific reviews. His scientific fields of interest include: XML, Databases, Data warehouse, Information Systems and Economics.