AARMS
Vol. 11, No. 2 (2012) 195–206

INFORMATICS

Application of cloud computing in the defense industry: An academic and practical viewpoint

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The present article aims to presents the facilities of the application of cloud computing in the field of military. First the definitions to be found in the literature are being analysed. An attempt is made to distinguish cloud computing from other distributed systems, like grid and cluster computing and to determine how they are interrelated with each other. The cloud computing can be employed in private, public, governmental and defense sector. The present paper aims to give a review about the usage of virtualized resource as service through the internet. For this the author has compiled the data 50 Cloud computing studies to be found or reported in the literature. For the purpose of the facilities of the application in defense sphere the author presents three applications used in the US Army.

1. Introduction

Evaluation of information technology is becoming more and more important, and cloud computing is mentioned frequently, by promising to deliver lots of benefits. But what do we exactly mean by cloud computing? How can we distinguish it from grid computing and cluster computing and how does it relate to the performance of military? What projects are launched to enhance a successful army? In the next section of the paper the author tries to distinguish cloud computing from grid and cluster computing, keeping in mind the area of military application.

After having discussed cloud computing from an academic aspect, the practical side is also investigated by looking into numerous projects dealing with emerging IT platforms. The review of the literature reveals that a comparison of the cloud computing application in the different modes has not been carried out yet although the use of a broader perspective could contribute to raising the quality of the individual studies.

The rest of the paper is structured as follows: after the introductory section, Section 2 gives a brief overview of the cloud computing, highlighting its strengths and weaknesses and the main features of application. Section 3 contains the comparisons of the 50 related studies found in the literature, while Section 4 presents the facilities of the application and Section 5 provides the conclusion.

Received: December 28, 2011

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2. Main paradigms promising to deliver information technology as service

Even only using our common sense, we can be aware that grid computing, cluster computing and cloud computing are all terms closely interrelated with each other. In order to give the most appropriate definition of cloud computing we have to start with looking at cluster computing. During the last three decades in the field of low-cost high-performance microprocessors, high-speed networks and distributed computing has inspired many researchers to diverge from expensive and specialized parallel supercomputers towards cheaper and general purpose clusters.

There is the strong theoretical background of the definition of clusters, which has proved its merits over the decades since it was introduced by PFISTER[1] and BUYYA[2] in 1999. They defines cluster as a "type of parallel and distributed system, which consists of a collection of inter-connected stand-alone computers working together as a single integrated computing resource". The cluster interconnection network speed is dedicated, high-end with low latency and high bandwidth. The applications are associated with science, business, enterprise computing, based on data centers.

From the early 2000s the grid computing became a popular term. Carl KESSELMANN and Ian FOSTER[3] attempted a definition "A computational grid is a hardware and software infrastructure that provides dependable, consistent, pervasive, and inexpensive access to high-end computational capabilities". While Foster lists three primary attributes,[4] namely that computing resources are not administered centrally, and open standards are used, in addition nontrivial quality of service is achieved. BUYYA[5] emphasizes the aggregation of the parallel and distributed system that enables sharing, selection of geographically distributed resources, such as supercomputers, computer clusters and storage systems. This technology has been applied to computationally intensive scientific, mathematical, and academic problems through solving large-scale compute and data intensive computing applications. Grid computing is used in commercial enterprises for such diverse applications as molecular modelling for drug design, economic forecasting, seismic analysis, brain activity analysis, and high energy physics.

After floating "Blue Cloud computing" planes[6] IBM expand its leading a joint research initiative of 13 European partners to develop technologies that help automate the fluctuating demand for IT resources in a cloud computing environment.[7] In 2008 cloud computing started gaining popularity and became emerging approach to shared infrastructure in which large pools of systems are linked together to provide IT services. Buyya defined the cloud as a type of parallel and distributed system consisting of a collection of inter-connected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resource(s) based on

service-level agreements established through negotiation between the service provider and consumers".[8] Another aspects of cloud computing are highlighted by the NIST,[i] where defines the notion a set of characteristics, delivery models, and deployment models. As set out in 5 characteristics on-demand self-service, ubiquitous network access, resource pooling, rapid elasticity, and pay per use. 3 delivery models, like Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS). In addition 4 Deployment Models, like Private Cloud, Community Cloud, public Cloud and hybrid Cloud.

The relationship between the various paradigms

It can be concluded that Cloud computing platform posses characteristics of both Grids and Clusters, with its own special attributes. With regard to hardware tools, cluster consists of a collection of inter-connected stand-alone computers, grid consists of high-end computers. cloud combines commodity computers, high-end servers and network attached storage. Supported operating system indicates clearly the two-sidedness of the notion cloud. While cluster systems are favour one of the standard Operating Systems (Linux, Windows), on the other hand in grid use any standard OS, dominated Unix. In a cloud multiple Virtual Machines can be started and stopped on demand, on which multiple Operating System run. While highlighting the differences we were intent, we can appoint identities with regard to interconnection and service negotiation.

Interconnection in the case of Clouds is dedicated with low latency and high bandwidth, as in a Cluster case. Take into consideration service negotiation, Cloud and Grid system is Service Level Agreements (SLA) based. Both offering to enable extensive operation of organizations, there are critical Quality of Service (QoS) parameters to consider in a service request, such as time, cost, reliability and security. These are provided through SLAs brokered between the providers and consumers.

The user management in Cloud system, similarly the Cluster system is centralized or can be delegated to third party services, while the resource management combining Cluster and Grid properties, could be both centralized and distributed. If we see the solutions for security of computing systems listed below, we can consider differences. The Cluster system authentication is traditional login-password based, while a Grid system public-private key pair based. Cloud Computing guarantees high security, based on virtualization, which protects both the integrity of guest virtual machines and the cloud infrastructure.

[i] National Institute of Standards and Technology, Unated States of America, Gaithersburg.

Web search Trends

Nowadays cloud computing is a way to increase the capacity or to add capabilities dynamically, without investing in new infrastructure, training new personnel, or licensing new software.

The web search popularity, as measured by Google search trends during the last 6 years, for terms "Cluster computing", "Grid computing", and "Cloud computing" is shown in Figure 1. From Google trends, it can be observed that Cluster computing was a popular term to 2000, from early 2000 Grid computing become popular, and recently Cloud computing started gaining popularity. All three computing paradigms are present in our daily life could be the principles of fourth approach. Some Laboratories, like HP[ii] and INRA[iii] aims at providing an environment, the Cloud that federates computing resources of all sorts and aggregate idle machines into high-throughput virtual Clusters, named I-Cluster Cloud.[9] Devotees of grid computing also strongly believe that some future applications will require the grid approach in order to turn this concept into a reliable, efficient and user-friendly computing platform.[10]

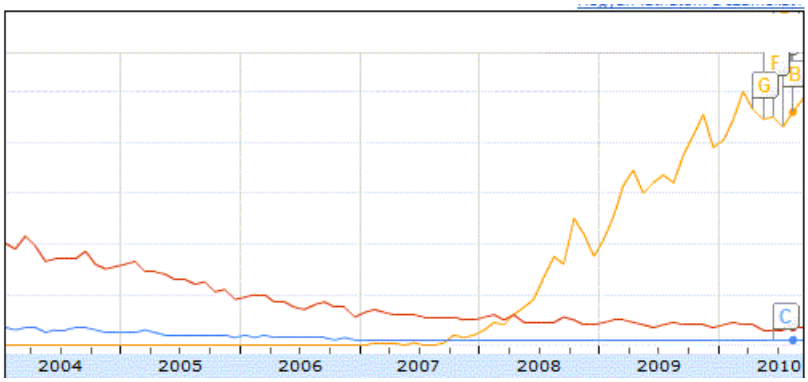

Figure 1. Google search legend for cluster, grid and cloud computing

3. A comparison of the studies related to cloud computing

Reviewing the literature to be found on the application of Cloud computing a very broad and colourful picture emerges. In this appraisal 50 studies and several web pages on the method have been gathered in order to enabling the examination of the cloud computing, and the supporting applications. These studies were elaborated either

[ii] Hewlett-Packard Laboratories Grenoble.
[iii] INRIA (ID-IMAG Laboratory, France.

directly in the papers listed in the references, or in the Internet were reported in the same articles. We have to be aware that not all the data was always available to work with, sometimes the chosen article mentioned different ways of application, or the reference to the place of application was missing. Nevertheless for most of the studies the data needed were accessible, and of course it is only this information that is included in this paper for further investigation.

Figure 2 shows the distribution of the studies among the different cloud computing matters. The majority of the studies deal with cloud platforms and applications; these represent 23% of the studies. The cloud empire enmesh the world by the Internet and researchers from India USA, Spain, Europe, Australia demonstrate the new applications in cloud computing. D. Barrett outline some of the trends that are emerging to shape virtualization and cloud computing,[11] but W. Shi at al. enabling real time 3D virtual appliances in the cloud.[12] Studies proposed a number of computing paradigms, define cloud computing and provide architecture for creating clouds, like Aneka,[13] Claudia,[14] ClouDIA.[15]

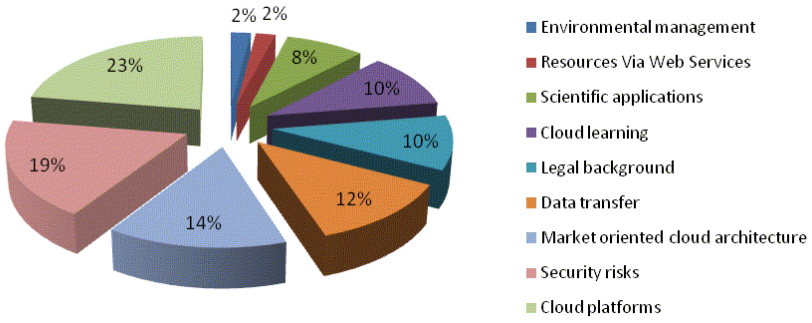

Figure 2. Ratio of the studies found in the literature

Cloud computing, which refers to an emerging computing model where machines in large data centers can be used to deliver services in a scalable manner, has become popular, but the use of cloud computing has many risks which might have impacts on the information and services supported by this technology. The studies deal with security problems also have a significant share, represents 19% of studies. According to Subashini (2010) cloud service users need to be vigilant in understanding the risks of data breaches in this new environment,[16] in addition Chonka (2010) offer a solution to protect cloud computing against HTTP-DoS and XML-DoS attacks.[17]

Cloud computing is an emerging paradigm where computing resources are offered scalable and on demand. In most clouds, charges are pay per use, based on large farms of inexpensive, dedicated servers. The 14% of the studies contend with the problems of publishing services, and costs and benefits of web services delivered from the Cloud, namely with market oriented cloud structure. Rittinghouse examines some of the popular services including Communications as a Service (CaaS), Infrastructure as a Service (IaaS). Software as a Service (SaaS), Platforms as a Service (PaaS) and Monitoring as a Service (MaaS).[18] According to Joint at al. Amazon, Microsoft, Dell, IBM, Google and Yahoo are just a few of the major IT companies who are developing or expanding their offerings to the commercial sector by giving businesses the opportunity to outsource various elements of their IT infrastructure via Internet.[19]

Significant part of the studies deal with cloud learning and scientific application; these two represent 18% of the studies. Cloud learning is an excellent alternative for educational institutions which facing budget constraints in operating their information systems effectively without spending any more capital for the computers and network devices. Universities take advantage of available cloud-based applications offered by service providers and enable their own users/students to perform business and academic tasks. Ercan proposed a cloud computing model required in the educational institutions,[20] in addition M. Ivanova use a complete teaching/learning environment, and the created model is verified in the content authoring of the Computer Graphics course for undergraduate (BA) students.[21] Since 2008 Seres at al. investigate the facilities of Cloud learning and develop some interactive educational portals, and elaborate the possibilities for employment, increasing efficiency on the role of learning.[22]

10% of the contributions handle legal aspects of application cloud computing. A contract between a Cloud provider and a customer is likely to be slightly different from an agreement between a provider of an unlike technology. There are many legal issues that might affect a Cloud-based business, and include contract law, intellectual property rights, privacy law, taxation, etc.[23]

We should not forget about the environment effects, when talking about advantages of cloud computing. 2% of the studies deal with environmental protection. The report finds that at current growth rates, data centers and telecommunication networks, the two key components of the cloud, will consume about 1,963 billion kilowatt-hours of electricity in 2020.

Figure 3 shows the distribution of the studies among the different countries showing the share of the different contents as well. The majority of the cloud computing studies can be found in USA but notable quantity of the compiled data coming from Australia and United Kingdom. The one-third of the publications comes from the USA is amount

of studies from Italy, Canada, India and China, which refers that cloud computing is researched theme in this countries. It shows growing popularity the number of related studies in Sweden, Spain, Brazil, Hungary and Turkey.

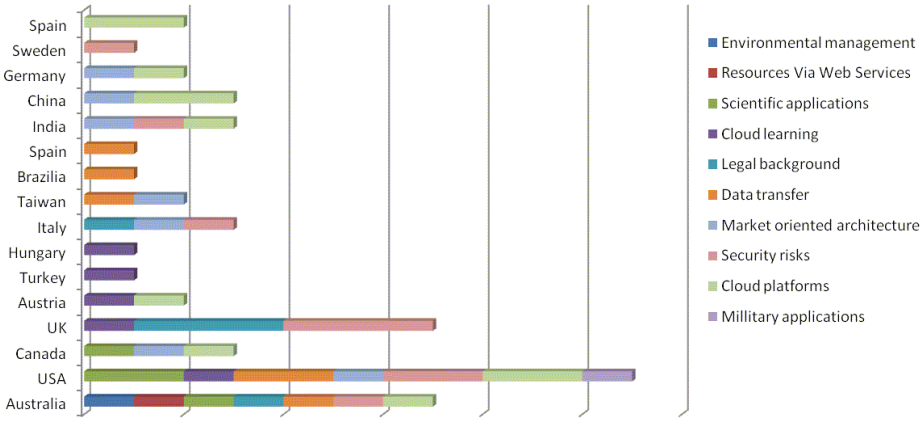

Figure 3. The distribution of the studies among countries according the modes of Cloud computing

Looking at the share of different cloud computing matters, we find that the majority of studies in USA deal with cloud platforms and scientific applications, but in UK, the examination of the legal background of cloud computing is dominant. Non-negligible that a number of Cloud Computing solutions available in the US military, but there are few studies available in this theme. In addition, the military cloud computing applications are unique, and investigated only in US.

Europe is represented with studies in Austria, Turkey, Hungary and United Kingdom, where the Cloud learning has been investigated the most. In China and Taiwan, significant part of studies deals with market oriented cloud structure. It is evident if we take into account the effected population size, which is about 1.3 billion people.

Reviewing the available literature, it can be concluded, that the most of the modes of Cloud computing is investigated in Australia and USA, what can be explained by the recent emergence of this computing model. Looking at the distributions of studies among different continents – with the exception of military applications –, we find that the curiosity into Cloud computing is nearly evenly distributed between the continents.

4. Application of Cloud Computing in defense sphere

Having established Cloud Computing solutions available only to US military, we can go further by looking at applications for practical purposes. The author of present paper reviews the spot points indicate the release of news, related to Cloud Computing in military in the US.

2009 April – Tom Greenfield from Defense Information Systems Agency (DISA)[iv] presents 4 Cloud Deployment Models, of which one is called Community Cloud. This cloud infrastructure is jointly owned by several organizations and supports a specific community that has shared concerns (e.g., mission, security requirements, policy, and compliance considerations). Figure 4 show the future deal of DISA.[24] This idea has several advantages: with help of geo-redundant and deployable data centers, a tactical content delivery network becomes feasible.

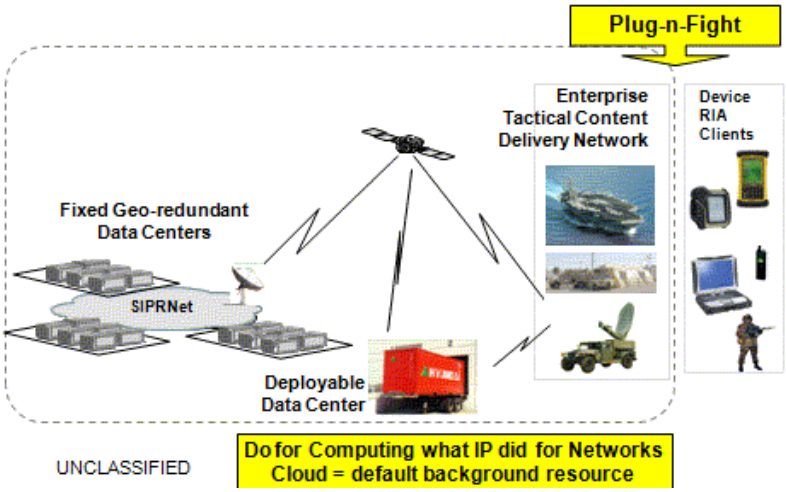

Figure 4. The DoD Vision, source: Tom Greenfield, Special Assistant to the CTO at Defense Information Systems Agency

2009 October – DISA announced that it is allowing military users to run applications in production mode on its cloud computing platform, which is called RACE for Rapid Access Computing Environment and ready to deliver cutting-edge applications to military personnel.[25]

[iv] DISA Defense Information Systems Agency.

2010 May – At the Enterprise Architecture Conference David S. Linthicum gave a keynote presentation on cloud computing – specifically, how it should work within United States Department of Defense (referred to: US DoD or DoD). The recent policy highlights to maintain or to reduce budget, while maintaining the operational effectiveness, in other words managing the DoD as a commercial enterprise. Although there is a continues focus on support for the warfighter, it is necessary to define the operational requirements, rationalize IT investment decisions, in addition to improvements to interoperability among various systems.[26]

2010 June – The moves are consistent with the Obama administration policy requiring federal agencies to devise data center consolidation plans and encouraging the use of cloud computing as a potentially cheaper and more efficient way of providing IT services to government employees. As part of its strategy, the Army is consolidating applications and virtualises its servers.[27]

2010 July – the US Army released a procurement solicitation for the Army Private Cloud. The LandWarNet strategy is an approach, which will enable the Warfighter to access information globally while reducing costs and lowering energy consumption. Cloud Computing is part of this approach and is expected to reduce cost while improving access and security. The Army cannot afford to continue doing business as usual and will embrace lessons learned from the private sector to achieve cost savings.[28]

Cloud Computing solutions available to US military

The US Army will also tap into cloud services made available by the DISA. The requirements for successfully fighting wars and keeping the peace in the 21st century are rapidly changing. To respond to asymmetric threats and unpredictable adversaries, the Department of Defense (DoD) is undergoing a historic transformation. At the core of this transformation is the Defense Information Systems Agency (DISA). DISA provides advanced information technology and immediate communications support to the President, Vice President, Secretary of Defense, military services and combatant commands.

The Command and Control (C2) systems enable information superiority on the battlefield. They provide the commander with the information to make effective decisions and they provide the warfighter the capability to access the information necessary to complete their mission. Global Command & Control System – offers vital connectivity to the systems the joint warfighter uses to plan, execute, and manage military operations. The Global Combat Support System – Provides the warfighter with a single, end-to-end capability to manage and monitor personnel and equipment through the mobilization process. Multinational Information Sharing – Facilitates information sharing among DoD components and eligible foreign nations in support of planning and execution of military operations (Figure 5).

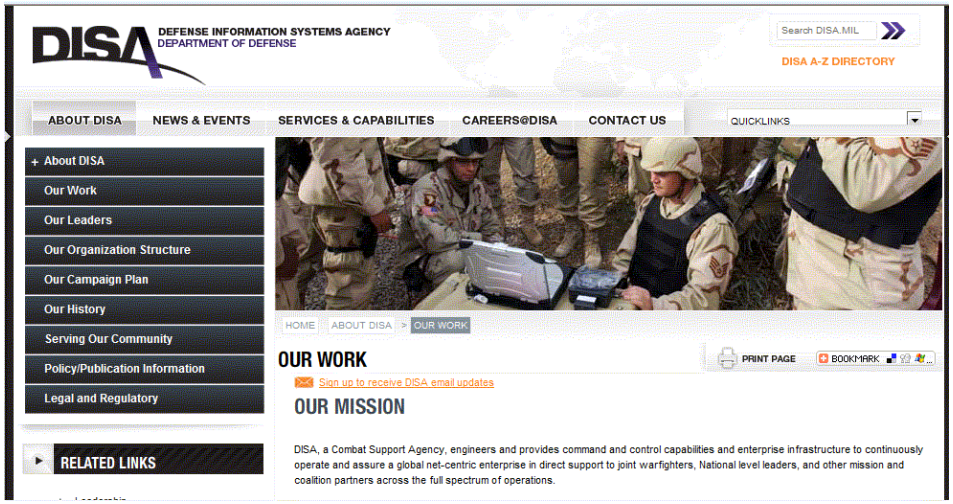

Figure 5. Disa.mil homepage, www.disa.mil

Figure 6. Forge.mil homepage, www.forge.mil

One such a service already used by the Army is Defense Connect Online (DCO), is a version of Adobe's Acrobat Connect collaboration software is running. The DCO provide users worldwide with a second option for enterprise collaboration services, in addition to web conferencing that virtually anyone can access instantly.

The Army is also using DISA's Rapid Access Computing Environment. Forge.mil is a development site to support its recently launched "Apps for the Army" development contest. Forge.mil is a family of services provided to support the DoD's technology development community. The system enables the collaborative development and use of open source and DoD community source software.

5. Conclusions

The present article has set the aim of defining the different philosophies gathered around the method of cloud computing. The author has shown that further to cluster and grid programming the foundations of cloud programming have been already set. The examination of the studies dealing with cloud computing has revealed that it is a widely applied system for the information data exchange by Internet. We have seen that there are two main questions concern the scientists: the applications and the security risks. Concerning correlation and reliability, we can conclude that the review of the literature showed that all of the themes expose an important aspect of this new programming paradigm. We have also seen that Cloud Computing solutions available only to the US Military. The events of the last two years reflect the governmental policy and the presented Cloud Computing solutions in order to satisfy the requirements for successfully fighting wars and keeping the peace in the 21st century.

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