Implementation of Virtualization Oriented Architecture: A Healthcare Industry Case Study

G Subrahmanya VRK Rao, Jinka Parthasarathi, Sundararaman Karthik, GVN Appa Rao, and Suresh Ganesan

Cognizant Technology Solutions
Chennai, India
{subrahmanyavrk.rao,parthasarathi.jinka,karthik.sundararaman, apparao.gvn,ganesan.suresh}@cognizant.com

Abstract. This paper presents a Virtualization Oriented Architecture (VOA) and an implementation of VOA for Hridaya - a Telemedicine initiative. Hadoop Compute cloud was established at our labs and jobs which require a massive computing capability such as ECG signal analysis were submitted and the study is presented in this current paper. VOA takes advantage of inexpensive community PCs and provides added advantages such as Fault Tolerance, Scalability, Performance, High Availability.

Keywords: Virtualization Oriented Architecture, Telemedicine, Technology Convergence, Cloud Computing.

1 Introduction

Distributed processing and scaling continues to gain prominence across the Information Technology (IT) infrastructure landscape. Architectural approaches which adapt this foundation offer inherent advantages, including the potential for price-performance economic benefits and greater flexibility. To address this challenge, organizations are exploring software that operates well across distributed (scale out) and centralized (scale up) resources, and offers a consistent application experience and approach across a number of heterogeneous resource types. Virtualization is one such concept that has got a set of technologies which serve the proposed need and is typically, "the provision of an abstraction between a user and a physical resource in a way that preserves for the user the illusion that he or she could actually be interacting directly with the physical resource"[1].

Virtualization Oriented Architecture (VOA) calls to mind the use of virtualization to make service oriented applications more durable and versatile. VOA is neither a technology nor a technology standard. Instead, it represents a technology-independent, high-level concept that provides a set of architectural patterns or a blueprint [2]. These patterns are focused on the componentization and composition of the enterprise application in such a way that the components are created and exposed as Virtual Services/ Jobs which run on a virtualized infrastructure through a Virtual engine of an Enterprise. These Virtual Services / Jobs are not only technically independent but also have a direct relationship to the business process and are adapted for the Virtual Infrastructure.

M. Ulieru, P. Palensky, and R. Doursat (Eds.): IT Revolutions 2008, LNICST 11, pp. 21–27, 2009.

Telemedicine is a branch of healthcare industry which assists the people in remote places to communicate information about their health to an expert physician. The information is mostly in the form of biomedical signals and images. Large storage devices and expert decision support systems can assist the physicians in storing and analyzing these medical records. Currently healthcare provision for people living in remote places is facing many problems like accessibility to the geographic location, time required for the physicians to analyze and store massive medical records and provide the necessary treatment etc. These problems could be overcome if one adopts high performance computing and communication technology which can potentially enhance patient care by providing an easy way to store and retrieve massive amount of data and transfer medical records quickly to a nearby hospital for an expert opinion and facilitate subsequent treatments.

Virtualization has the potential to make data storage and retrieval easier, cost efficient and less time intensive for healthcare industries [3]. A combination of advanced IT techniques such as Virtualization, Cloud computing, Software As A Service (SaaS) and wireless communication technology can be very useful for both the patients (who want to have easy access to the physician) and healthcare providers (who require an efficient storage, retrieval and analytical system which can save money and time).

The current paper presents ongoing work at our Research Labs. Hadoop is a software framework that supports data intensive distributed applications. We have established a Hadoop [4] Computing Cloud across inexpensive community PCs. We have developed a Virtual Engine Software. We have chosen a Compute Intensive task/job from Healthcare Industry such as ECG Signal Analysis and we submitted these compute intensive jobs to the Hadoop Cloud through our Virtual Engine Software and the current paper presents the same study.

2 Virtualization Oriented Architecture

Fig. 1 illustrates the Component View of VOA and Fig. 2 illustrates the Operational View of VOA. The current section presents descriptions of various components of VOA.

Application FrontEnds are the essential ingredients of VOA. Although they are not services themselves, they initiate all business processes and ultimately receive their results. Typical Application FrontEnds are Graphical User Interfaces (GUIs) or a Batch Process.

A *Virtual Service/Job* (Fig. 3) is the implementation of a Service that adapts to the Virtual Infrastructure/ Hardware .

Virtual Engine connects all participants of a VOA i.e., Virtual Services/Jobs, Infrastructure/Hardware and Application FrontEnds.

Virtual Service Repository captures all essential information about the Services so that the enterprise can be aware of its existence and capabilities. The Virtual Service Repository contains the service contract and additional information such asPhysical-Location, Information about the Provider, Contact Details, Technical Constraints, Security issues, and available Service Levels.

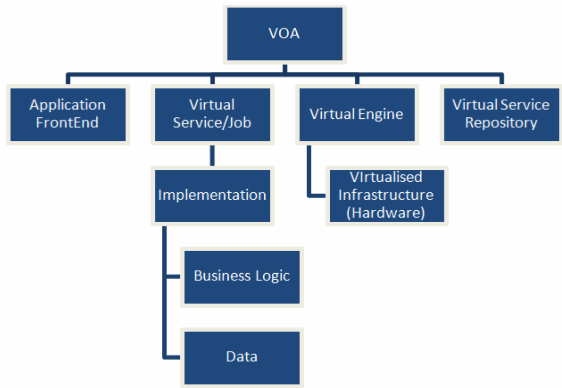


Fig. 1. Component View of VOA

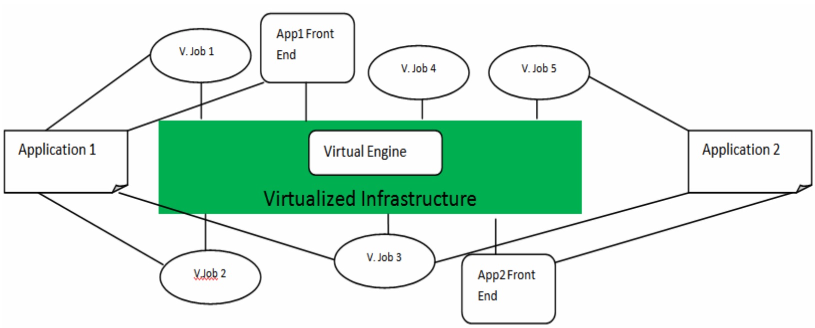


Fig. 2. Operational View of VOA

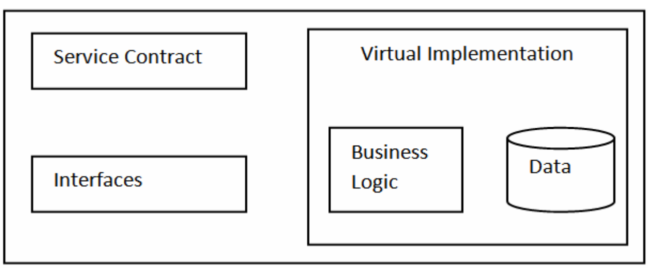


Fig. 3. Illustration of a Virtual Service / Job

3 Hridaya – A Telemedicine Application

'Hridaya' is a Tele-Medicine initiative based on a Convergence of Grid, Web 2.0, WiMax Technologies and was presented by the authors elsewhere [5].Cardiovascular disease

(CVD) is a major cause of death among humans. Rehabilitation after survival from a CVD is a long term process that includes frequent hospital visits, which could be avoided by the use of Hridaya Software on Personal Digital Assistant (PDA) and mobile phones. These devices along with Hridaya could be used by the patients to report about their health to the physicians on a schedule basis who in turn can review their health conditions. In addition, Hridaya is equipped with a knowledge base, which could be used by the patients to know more about CVD, an interface powered by technologies underlying Web 2.0 which has several advantages [6]. A VOA aids in improving Throughput, Availability, Scalability, Fault Tolerance and reduces the complexity of infrastructure management for the vendor providing Hridaya.

4 VOA Implementation of Hridaya

Usually, Hridaya receives Bio-Medical Signal from the user through User Interface and processes the same and do provide report on Body condition of the User/Patient and the report related graph. VOA implementation of Hridaya involves a Virtual Engine, which indeed runs a 'Hridaya' Service i.e., the 'core analysis' function as a 'service'. This enables processing of the Compute-Intensive Bio-Medical signals from the End User (such as a Patient or Doctor or Service Provider). The 'service' processes the incoming signals through a series of computations and returns the output to the Decision Support System (A Component of Hridaya), which analyzes the signal and returns its output/decision in turn to the Physician/End User; which would be a report on the body condition of the patient along with the related graphs. The job could be submitted to the system through a portal User Interface, as illustrated in Fig. 5.

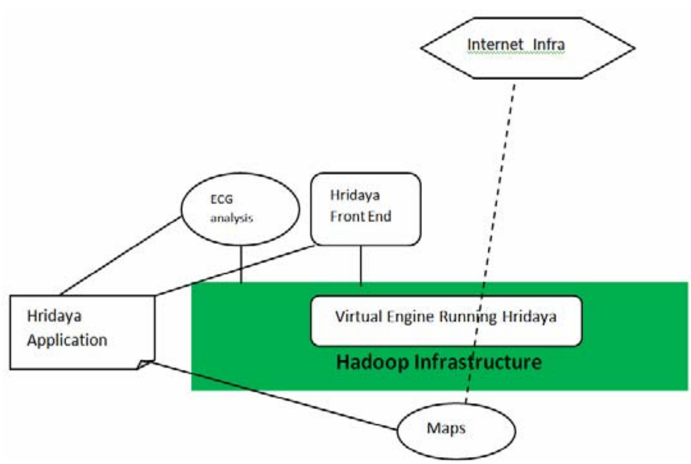


Fig. 4. VOA Implementation of Hridaya

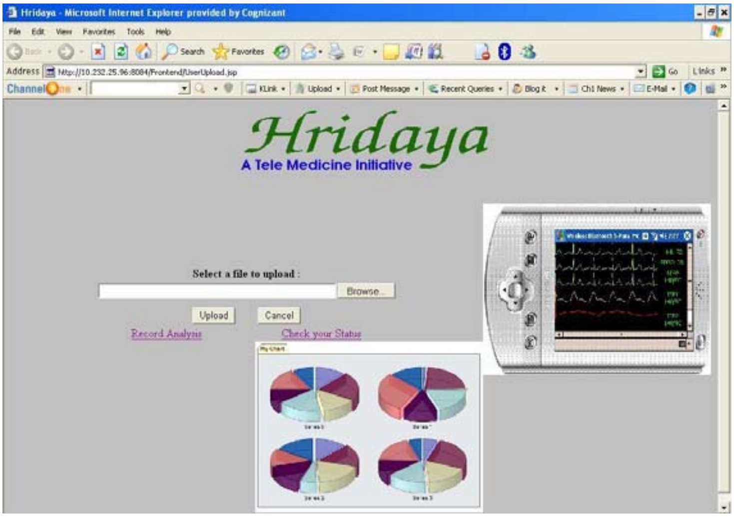
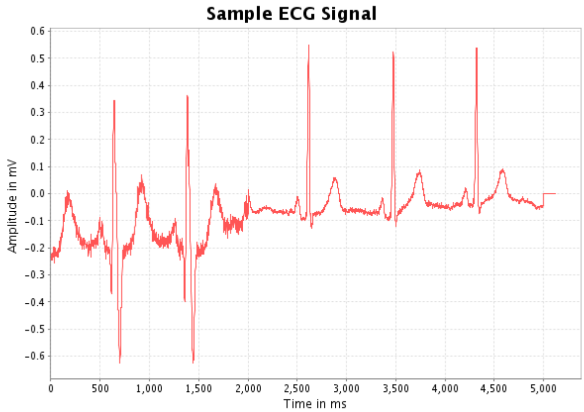
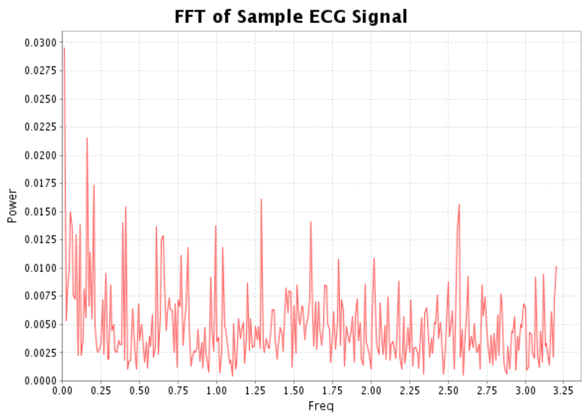


Fig. 5. Hridaya – User Interface

The service receives the signal from the user. Since the service is implemented over the Internet, we use SOAP (Simple Object Access Protocol) to attain interoperability with the user interface. SOAP is a simple XML based protocol to let applications exchange information over HTTP. The XML file acts as a carrier to transfer the signal from the user to the service. When the service receives this XML file it extracts the signal from the XML file and stores the file in the Hadoop Cluster infrastructure as shown in Fig. 4. The signals are usually stored in files. This data will be split into number of Blocks and distributed over the Hadoop cluster using Hadoop Distributed File System (HDFS). The Hadoop cluster [4] contains Namenode and Jobtracker that act as masters; Datanode and Tasktracker that act as slaves. Namenode provides information about the number of blocks obtained, number of nodes and the number of Blocks present in various nodes. Datanodes provides the information about how the blocks are received from various nodes to the corresponding node and how their storage is managed. Jobtracker provides identity for all the tasks and chooses the tasks to be performed by the particular Tasktracker. It provides information about the status of the task and saves the output in the HDFS. Tasktracker is a node containing the Block, performs Map-Reduce task assigned by the JobTracker running the Virtual Engine as shown in Fig. 4. The Map task does a Fast Fourier Transform (FFT) on the input signal Block and runs on the TaskTrackers. These map tasks generate an intermediate output which is again, an another signal. The map output is now sent to the Reducer which develops two graphs, one for the input signal as shown in Fig. 6(a) and one for the output signal in Fig. 6(b). These two graphs are part of the output that has to be sent to the user. The Reducer also performs the decision support system which correlates the signal with Pre-Recorded signals and gives a condition report which along with the graphs is sent



(a)



(b)

Fig. 6. Hridaya 'Analysis' - In Action

back to the HDFS. This report if abnormal can alert the physician to review the ECG with high priority and take necessary steps to treat the patient. The Web Service will again receive the output from the HDFS and attach the output files and data again to a XML file. The User Interface will now retrieve the graphs and the report from the XML file and display the data and the graphs required by the User as and when requires.

5 Conclusion and Future Work

VOA which is based on Virtualization Technology will leverage the inherent advantages of Cloud Computing and provide advantages such as Fault Tolerance, Scalability, Performance, High Availability. Our Research Team is working on other related use-cases across various Industry Sectors. We are also working on Maintenance and Performance etc. issues of the Hridaya system.

References

1. http://www.acmqueue.org
2. SOA Glossary of Key Concepts and Definitions, http://hssp-infrastructure.wikispaces.com/space/showimage/Microsoft+Word+-+HSSP+SOA+Key+Concepts+and+Definitiions+v0.3.pdf
3. http://t1d.www-03.cacheibm.com/industries/healthcare/doc/content/bin/Virtualization_UPMC_profile_IDC_1_07.pdf
4. http://www.hadoop.com
5. Subrahmanya, G., Rao, V.R.K., Parthasarathi, J.: Convergence of Web2.0 and Grid accelerating SaaS – An Insight. In: International conference on Convergence Information Technology, Korea (2007)
6. Karthik, S., Parthasarathi, J., Subrahmanya, G., Rao, V.R.K., Appa Rao, G.V.N.: Hridaya – A telemedicine initiative for cardiovascular through convergence of Grid, Web2.0 and SaaS, Ambient Technologies for Diagnosing and Monitoring Chronic Patients Tampere. In: 2nd International Conference on Pervasive Computing Technologies, Finland, January 29 (2008)